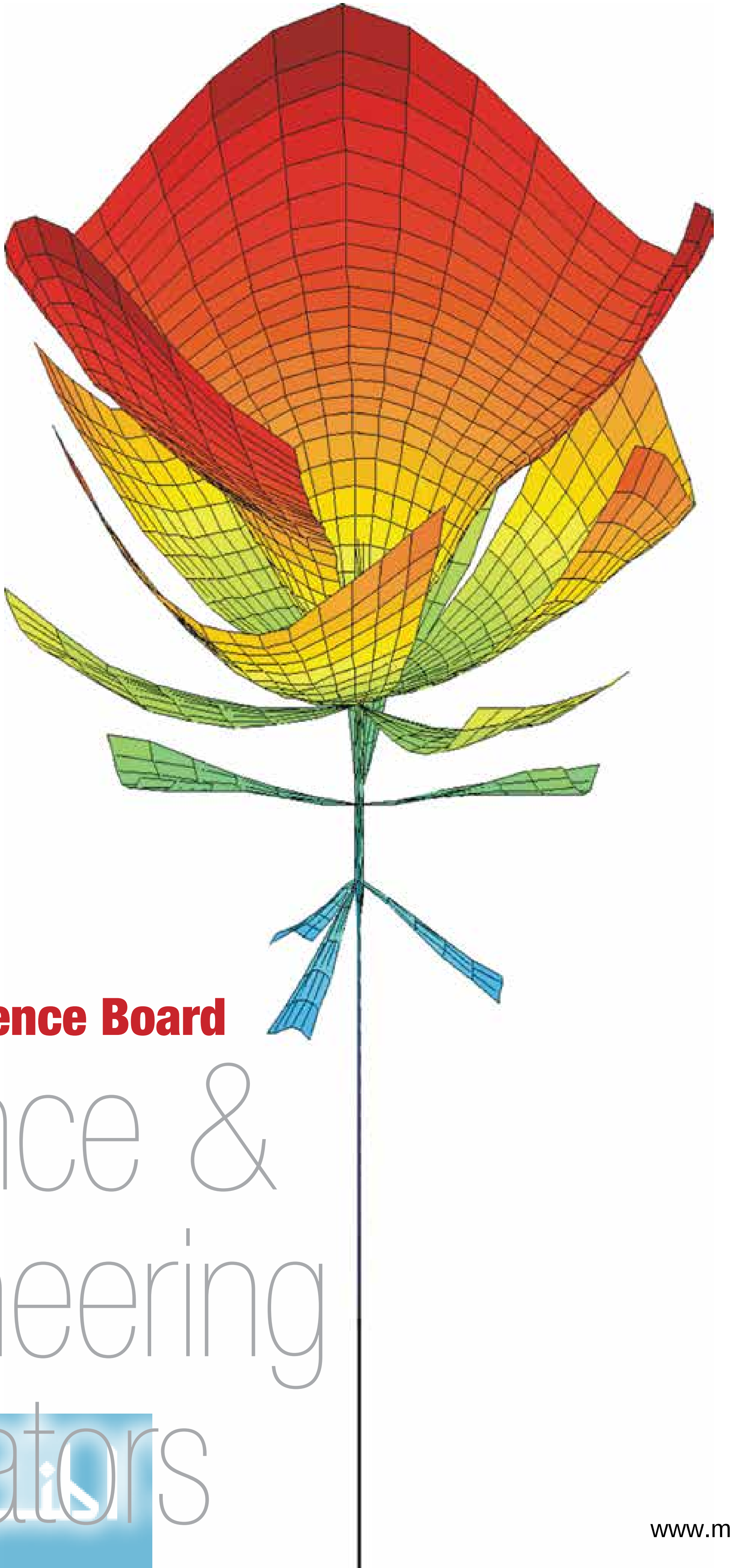
NATIONAL SCIENCE FOUNDATION

2014



National Science Board

Science & Engineering Indicators

National Science Board

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Cover Image

The flower-like structure on the cover of *Science and Engineering Indicators 2014* is a graph that illustrates potential energy surfaces in a molecule called sym-triazine. The theoretical approach behind the graph is part of a larger effort that helped explain how sym-triazine can simultaneously break into three parts. Most molecules break apart one step at a time, so the phenomenon is rare. Researchers at the University of Southern California used computational chemistry tools to produce the graph, explaining the experimental results obtained by collaborators at the University of California, San Diego. The researchers reported their findings in the August 8, 2008, issue of the journal *Science*. This work was supported by the National Science Foundation under the auspices of the iOpenShell (Center for Computational Studies of Electronic Structure and Spectroscopy of Open-Shell and Electronically Excited Species). (Credit: *Vadim Mozhayskiy and Anna I. Krylov, Department of Chemistry, University of Southern California.*)

Recommended Citation

National Science Board. 2014. *Science and Engineering Indicators 2014*. Arlington VA: National Science Foundation (NSB 14-01).

National Science Board

February 6, 2014

MEMORANDUM FROM THE CHAIRMAN OF THE NATIONAL SCIENCE BOARD

TO: The President and Congress of the United States

SUBJECT: *Science and Engineering Indicators 2014*

As Chairman of the National Science Board, it is my honor to transmit on behalf of the Board the twenty-first in the series of biennial science indicators reports, *Science and Engineering Indicators 2014*. The Board submits this report as required by 42 U.S.C. § 1863 (j) (I).

The *Indicators* series was designed to provide a broad base of quantitative information about U.S. science, engineering, and technology for use by policymakers, researchers, and the general public. *Science and Engineering Indicators 2014* contains analyses of key aspects of the scope, quality, and vitality of the Nation's science and engineering enterprise in the context of global science and technology.

The report presents information on science, technology, engineering, and mathematics education at all levels; the scientific and engineering workforce; U.S. and international research and development performance; U.S. competitiveness in high technology; and public attitudes and understanding of science and engineering. A chapter on state-level science and engineering enables state comparisons on selected indicators. An Overview chapter synthesizes selected key themes emerging from the report.

The Board hopes that the Administration and Congress find the new quantitative information and analysis in the report useful and timely for the planning of national priorities, policies, and programs in science and technology.

Dan E. Arvizu
Chairman
National Science Board

Acknowledgments

The National Science Board (NSB) extends its appreciation to the staff of the National Science Foundation and to the many others, too numerous to list individually, who contributed to the preparation of this report.

Primary responsibility for the production of the volume was assigned to Robert Bell, Director, Science and Engineering Indicators Program of the National Center for Science and Engineering Statistics (NCSES); John R. Gawalt, Director, NCSES; and the Directorate for Social, Behavioral and Economic Sciences under the leadership of Myron P. Gutmann and Joanne Tornow. The authors were:

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The volume benefited from extensive contributions from NCSES staff. NCSES senior staff and survey managers assured availability of data under often stringent deadlines: Ronda K. Britt, Mark Fiegener, John Finamore, John E. Jankowski, Kelly H. Kang, Flora Lan, Lynn Milan, Christopher Pece, Steven Proudfoot, Emilda B. Rivers, Raymond M. Wolfe, and Michael Yamaner. Stephen Cohen, Jock Black, Wan-Ying Chang, and Darius Singpurwalla provided advice with statistical or data presentation issues.

Jaquelina Falkenheim, Katherine Hale, Derek Hill, and Beethika Khan served administrative as well as authorship roles. Peter Muhlberger refined the index and helped finalize Chapters 1 and 7. Lawrence Burton, Daniel Foley, and Mark C. Regets reviewed draft material and did analytic work in support of the volume. Jacqueline Durham assisted in acquiring data from outside sources, and Jasmine Harvey provided clerical support.

Cheryl Roesel, Nirmala Kannankutty, and Robin Pentola managed production of the volume. Cheryl Roesel managed editorial, composition, and printing services; Nirmala Kannankutty developed, coordinated, and monitored the production schedule; and Robin Pentola was responsible for production, direction, and management of the website. Tanya Gore assisted with the final review of the page composition and appendix tables, and Rajinder Raut provided a technical review of the website.

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The National Science Board is especially grateful to the Committee on Science and Engineering Indicators for overseeing preparation of the volume and to the National Science Board Office, under the direction of Michael L. Van Woert, which provided vital coordination throughout the project. Matthew B. Wilson served as Board Office Liaison to the committee, and Robert Bell and Nirmala Kannankutty were the Executive Secretaries. Jean M. Pomeroy provided helpful guidance throughout the publication process.

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The following persons contributed to the report by reviewing chapters or otherwise assisting in its preparation. Their help is greatly appreciated.

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Contents

Acronyms and Abbreviations

AAAS	American Association for the Advancement of Science
ACE	American Council on Education
ACS	American Community Survey
ADP	American Diploma Project
AFT	American Federation of Teachers
AID	Agency for International Development
ANBERD	Analytical Business Enterprise R&D
AP	Advanced Placement
APL	Applied Physics Laboratory
ARRA	American Recovery and Reinvestment Act
ATP	advanced technology products
AUTM	Association of University Technology Managers
BBVA	Banco Bilbao Vizcaya Argentaria
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BRDIS	Business R&D and Innovation Survey
CCSSI	Common Core State Standards Initiative
CEO	chief executive officer
CGS	Council of Graduate Schools
CIP	Classification of Instructional Programs
CIS	Community Innovation Survey
CNSTAT	Committee on National Statistics
CPS	Current Population Survey
CRADA	cooperative research and development agreement
CSEP	Center for the Study of Education Policy, Illinois State University
DHS	Department of Homeland Security
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOT	Department of Transportation
EC	European Community
ECLS-K	Early Childhood Longitudinal Study-Kindergarten
ECS	Education Commission of the States
ED	Department of Education
EPA	Environmental Protection Agency
EP	European Patent Office
EPSCoR	Experimental Program to Stimulate Competitive Research
Esnet	DOE's Energy Sciences Network
EU	European Union
FDA	Food and Drug Administration
FDI	foreign direct investment
FDIUS	Survey of Foreign Direct Investment in the United States
FFRDC	federally funded research and development center
FY	fiscal year
GAO	Government Accountability Office
GBAORD	government budget appropriations or outlays for R&D
Gbps	gigabits per second
GDP	gross domestic product
GED	General Equivalency Diploma
GM	genetically modified
GSS	General Social Survey
GUF	general university fund
HBCU	historically black college or university
HERD	Higher Education Research and Development Survey
HHS	Department of Health and Human Services
HPC	high performance computing
HSLS	High School Longitudinal Study
HSTS	High School Transcript Study
HT	high technology
ICE	Immigration and Customs Enforcement
ICT	information and communications technologies
IDeA	Institutional Development Award
IDR	interdisciplinary research
IEA	International Energy Agency
IOF	involuntarily out-of-field
IPO	initial public offering
IRC	Internal Revenue Code
IRI	Industrial Research Institute
IRS	Internal Revenue Service
K–12	kindergarten through twelfth grade
KI	knowledge intensive
KTI	knowledge- and technology-intensive
LEHD	Longitudinal Employer-Household Dynamics
LEP	limited English proficient
LTT	long-term trend
MEP	Manufacturing Extension Partnership
MER	market exchange rate
MIT	Massachusetts Institute of Technology
MNC	multinational company
MOFA	majority-owned foreign affiliate
NAEP	National Assessment of Educational Progress
NAGB	National Assessment Governing Board
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration
NASF	net assignable square feet

NCES	National Center for Education Statistics
NCLB	The No Child Left Behind Act of 2001
NCRPA	National Cooperative Research and Production Act
NCSES	National Center for Science and Engineering Statistics
NGA	National Governors Association
NIH	National Institutes of Health
NIPA	national income and product accounts
NIST	National Institute for Standards and Technology
NLR	National Lambda Rail
NOAA	National Oceanic and Atmospheric Administration
NORC	National Opinion Research Center
NRC	National Research Council
NS&E	natural sciences and engineering
NSB	National Science Board
NSCG	National Survey of College Graduates
NSF	National Science Foundation
NSRCG	National Survey of Recent College Graduates
OECD	Organisation for Economic Co-operation and Development
OES	Occupational Employment Statistics
OSTP	Office of Science and Technology Policy
PEJ	Project for Excellence in Journalism
PISA	Program for International Student Assessment
PPP	purchasing power parity
PSM	Professional Science Master's
PUMS	Public Use Microdata Sample
R&D	research and development
R&E	research and experimentation
RA	research assistantship
RD&D	research, development, and demonstration
RDT	research, development, and testing
S&E	science and engineering
S&T	science and technology
SASS	Schools and Staffing Survey
SBIR	Small Business Innovation Research
SCI	Science Citation Index
SDR	Survey of Doctorate Recipients
SED	Survey of Earned Doctorates
SEH	science, engineering, and health
SESTAT	Scientists and Engineers Statistical Data System
SLDS	Statewide longitudinal data systems
SOI	Statistics of Income
SSCI	Social Sciences Citation Index
STEM	science, technology, engineering, and mathematics
STTR	Small Business Technology Transfer
TA	teaching assistant
TFA	Teach for America
TIMSS	Trends in International Mathematics and Sciences Study
TIP	Technology Innovation Program
U&C	universities and colleges
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	Department of Agriculture
USDIA	Survey of U.S. Direct Investment Abroad
USGS	U.S. Geological Survey
USPTO	U.S. Patent and Trademark Office
VA	Department of Veterans Affairs
WebCASPAR	Integrated Science and Engineering Resources Data System
WTO	World Trade Organization

About Science and Engineering Indicators

Science and Engineering Indicators (SEI) is first and foremost a volume of record comprising the major high-quality quantitative data on the U.S. and international science and engineering enterprise. SEI is factual and policy neutral. It does not offer policy options, and it does not make policy recommendations. SEI employs a variety of presentation styles—tables, figures, narrative text, bulleted text, Web-based links, highlights, introductions, conclusions, reference lists—to make the data accessible to readers with different information needs and different information-processing preferences.

The data are "indicators." Indicators are quantitative representations that might reasonably be thought to provide summary information bearing on the scope, quality, and vitality of the science and engineering enterprise. The indicators reported in SEI are intended to contribute to an understanding of the current environment and to inform the development of future policies. SEI does not model the dynamics of the science and engineering enterprise, and it avoids strong claims about the significance of the indicators it reports. SEI is used by readers who hold a variety of views about which indicators are most significant for different purposes.

SEI is prepared by the National Science Foundation's National Center for Science and Engineering Statistics (NCSES) under the guidance of the National Science Board (Board). It is subject to extensive review by outside experts, interested federal agencies, Board members, and NSF internal reviewers for accuracy, coverage, and balance.

SEI includes more information about measurement than many readers unaccustomed to analyzing social and economic data may find easy to absorb. This information is included because readers need a good understanding of what the reported measures mean and how the data were collected in order to use the data appropriately. SEI's data analyses, however, are relatively accessible. The data can be examined in various ways, and SEI generally emphasizes neutral, factual description and avoids unconventional or controversial analysis. As a result, SEI almost exclusively uses simple statistical tools that should be familiar and accessible to a college bound high school graduate. Readers comfortable with numbers and percentages and equipped with a general conceptual understanding of terms such as "statistical significance" and "margin of error" will readily understand the statistical material in SEI. A statistical appendix aids readers' interpretation of the material presented.

SEI's Different Parts

SEI includes an overview, seven chapters that follow a generally consistent pattern, and an eighth chapter, on state indicators, presented in a unique format. The chapter titles are as follows:

- Elementary and Secondary Mathematics and Science Education
- Higher Education in Science and Engineering
- Science and Engineering Labor Force
- Research and Development: National Trends and International Comparisons
- Academic Research and Development
- Industry, Technology, and the Global Marketplace
- Science and Technology: Public Attitudes and Understanding
- State Indicators

An appendix volume, available online at http://www.nsf.gov/statistics/indicators/, contains detailed data tables keyed to each of the eight chapters. SEI includes a list of acronyms and abbreviations and an index.

The National Science Board authors one or more companion pieces, which draw on the data in SEI and offer recommendations on issues of concern for national science and engineering research or education policy, in keeping with the Board's statutory responsibility to bring attention to such issues. In addition, the Board publishes the *Science and Engineering Indicators Digest*, a condensed version of SEI comprising a small selection of important indicators. The digest serves two purposes: (1) to draw attention to important trends and data points from across the chapters of SEI and (2) to introduce readers to the data resources available in the main volume of *SEI 2014* and associated products.

The Overview

The overview is a selective synthesis that brings together patterns and trends that unite data in several of the substantive chapters. The overview helps readers to synthesize the findings in SEI as a whole and draws connections among separately prepared chapters that deal with related topics. It is intended to serve readers with varying levels of expertise. Because the overview relies heavily on figures, it is well adapted for use in developing presentations, and presentation graphics for the figures in the overview are available on the Web. Like the core chapters, the overview strives for a descriptive synthesis and a balanced tone, and it does not take or suggest policy positions.

The Seven Core Chapters

Each chapter consists of contents and lists of sidebars, text tables, and figures; highlights; introduction (chapter overview and chapter organization); a narrative synthesis of data and related contextual information; conclusion; notes; glossary; and references.

Highlights. The highlights provide an outline of major dimensions of a chapter topic. Each highlight starts with a statement that summarizes a key point made in the chapter. Bulleted points supporting the key point follow.

Introduction. The chapter overview provides a brief explanation of the importance of the topic. It situates the topic in the context of major concepts, terms, and developments relevant to the data reported. The introduction includes a brief narrative account of the logical flow of topics within the chapter.

Narrative. The chapter narrative is a descriptive synthesis that brings together significant findings. It is also a balanced presentation of contextual information that is useful for interpreting the findings. As a descriptive synthesis, the narrative aims (1) to enable the reader to assimilate a large amount of information by putting it in an order that facilitates comprehension and retention and (2) to order the material so that major points readily come to the reader's attention. As a balanced presentation, the narrative aims to include appropriate caveats and context information such that (3) a nonexpert reader will understand what uses of the data may or may not be appropriate, and (4) an expert reader will be satisfied that the presentation reflects a good understanding of the policy and fact context in which the data are interpreted by users with a range of science policy views.

Figures. Figures provide visually compelling representations of major findings discussed in the text. Figures also enable readers to test narrative interpretations offered in the text by examining the data themselves.

Text Tables. Text tables help to illustrate and to support points made in the text.

Sidebars. Sidebars discuss interesting recent developments in the field, more speculative information than is presented in the regular chapter text, or other special topics. Sidebars can also present definitions or highlight crosscutting themes.

Appendix Tables. Appendix tables, available online (http://www.nsf.gov/statistics/indicators/), provide the most complete presentation of quantitative data, without contextual information or interpretive aids. According to past surveys of SEI users, even experienced expert readers find it helpful to consult the chapter text in conjunction with the appendix tables.

Conclusion. The conclusion summarizes important findings. It offers a perspective on important trends but stops short of definitive pronouncements about either likely futures or policy implications. Conclusions tend to avoid factual syntheses that suggest distinctive or controversial viewpoints.

Notes. Information that augments points of discussion in the text is presented as endnotes.

Glossary. The glossary defines terms used in the chapter.

References. SEI includes references to data sources cited in the text, stressing national or internationally comparable data. SEI does not attempt to review the analytic literature on a topic or summarize the social science or policy perspectives that might be brought to bear on it. References to that literature are included where they help to explain the basis for statements in the text.

The State Indicators Chapter

This chapter consists of data that can be used by people involved in state-level policy making, including journalists and interested citizens, to assess trends in S&T-related activities in their states. No interpretive narrative synthesizes overall patterns and trends. SEI includes state-level indicators to call attention to state performance in S&T and to foster consideration of state-level activities in this area.

Indicators are drawn from a range of variables, most of which are part of the subject matter of the seven core chapters. The text explains the meaning of each indicator and provides important caveats about how to interpret it. Approximately three to five bullets highlight significant findings covering a 10-year span, when available. Data for the indicators are graphically displayed in state-by-state tables, in United States maps that code states into quartiles, and in histograms that show how state values are distributed. A small number of appendix tables for this chapter can be found online. The online state data tool (http://www.nsf.gov/statistics/seind14/c8/interactive) provides additional data on state S&T over the past 20 years.

Presentation

SEI is released in printed and electronic formats. The printed volume provides the full content except for the appendix tables. The complete content of SEI is posted online at http://www.nsf.gov/statistics/indicators/ in html format and PDF, with text tables, appendix tables, and source data for each figure available in spreadsheet (MS Excel) format. In addition, selected figures are also available in presentation-style format as MS PowerPoint and JPEG files.

Overview

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Introduction

This overview of the National Science Board's *Science and Engineering Indicators 2014* highlights some major developments in international and U.S. science and engineering (S&E).

The international component of the overview is focused primarily on relatively recent changes affecting patterns in the ways science and engineering are translated into innovations with commercial and economic value. It pays particular attention to describing how the global map of science and technology (S&T)-related economic activity in the wake of the severe economic downturn in 2008–09 is different from the patterns present in data from before the downturn.

The domestic component of the overview has a significantly different focus in two respects. First, it takes a much more long-term view than the international component, counted mostly in decades rather than in years. Second, it focuses primarily on the institutions that are or have been centrally involved in producing research outputs such as publications and patents. It summarizes continuities and changes in the kinds of people who staff those institutions, the practices that characterize them, and the products they make.

Especially over the long term, the international and domestic S&E trends that *Science and Engineering Indicators* describes can be understood in light of the worldwide trend toward more knowledge-intensive economies. In this type of economy, research, its commercial exploitation, and other intellectual work are of growing importance. Such economies rely on sustained investment in research and development that produces useful innovations. They also rely on higher education that prepares students to use S&E knowledge and related research skills to develop new and better ways to make products and perform services. As a result, data on trends in R&D and human resources infrastructure feature prominently in both parts of the overview and throughout *Science and Engineering Indicators*. Knowledge-intensive economies, however, also rely on other kinds of infrastructure, including reliable and modern transportation and communications and a broadly educated and literate population, to enable them to function effectively.

The overview is not intended to be comprehensive. Numerous important topics that are addressed in individual chapters, and even some that crosscut the volume, are not covered in the overview. Major findings on particular topics can be found in the "Highlights" sections that appear at the beginning of chapters 1–7.

The indicators included derive from a variety of national, international, public, and private sources and are not always strictly comparable in a statistical sense. As noted in the text, in some cases the quality of available data is less than ideal, and the metrics and models relating them to each other and to economic and social outcomes need further development. Thus, the emphasis is on broad trends. Individual data points and findings should be interpreted with care.

Science and Technology in the World Economy

Knowledge- and Technology-Intensive Economic Activity

Knowledge- and technology-intensive (KTI) industries represent a growing portion of global S&T economic activity. KTI industries accounted for 27% of world gross domestic product (GDP) in 2012. They consist of high-technology (HT) manufacturing (e.g., aircraft and spacecraft; pharmaceuticals) and knowledge-intensive (KI) services (e.g., commercial business, financial, and communication services). These industries play a larger role in the United States than in the economy of any other large developed country, accounting for 40% of U.S. GDP.[1] KTI concentrations were in the range of 29%–30% for other large, developed regional and national economies (European Union [EU; see "Glossary" for member countries], Canada, Japan, and South Korea). The trend since 1999 indicates that, except for Japan between 2005 and 2012, the KTI share for all of these economies has been rising (figure O-1).

The KTI share of the world's developed economies grew from 29% to 32% between 1997 and 2012. This was due mostly to increases in commercial and public (education and health) KI services, indicating a continuing movement away from manufacturing and toward services in these economies.

In recent years, regional and national shares of worldwide KTI production have been shifting. Regionally, the shift has produced a growing concentration of commercial KTI economic activity in East and Southeast Asia.[2] That region is approaching a concentration of commercial KTI activity comparable to that of the world's established regional centers, North America and Western Europe.

Likewise, an increasing amount of worldwide KTI production is occurring in the developing world. To a large extent, this is due to China's large modernizing economy. Economic growth in other Asian locations, however, has contributed as well, and KTI economic activity is also growing in countries such as Brazil, Turkey, and South Africa (figure O-2).

The growth of KTI activity in the developing world is most apparent in manufacturing and is largely due to China. Between 2003 and 2012, China's HT manufacturing rose more than fivefold, resulting in its global share climbing from 8% to 24% in 2012. Even amid this shift, the United States remains the largest global provider of HT manufacturing (27% of the global total) (figure O-3).

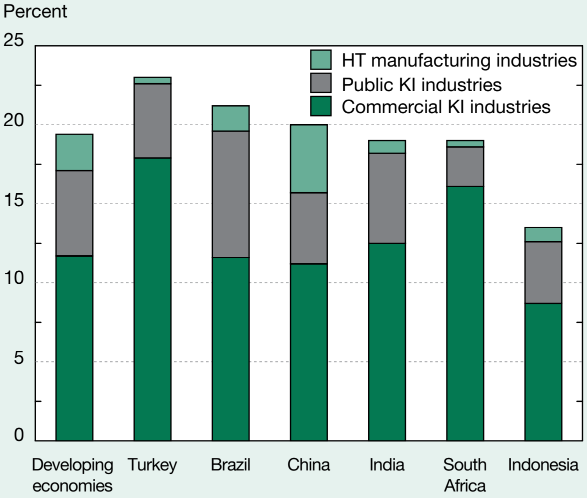
KI services, despite growth in worldwide production attributed to developing countries, remain concentrated in developed countries. The United States is the world's largest provider of commercial KI services (32%), followed by the EU (23%). China's commercial KI services account for 8% of the world total, much more than any other developing country. China is tied with Japan as the third-largest global provider of these services. The share of developed countries in worldwide production of commercial KI services fell from 90% in 2003 to 79% in 2012, due entirely to a collective 15 percentage point decline in the global shares of the United States, the EU, and Japan (figure O-4). Nonetheless, developed countries continue to dominate global trade in these industries.

The value added of commercial KI services in developed economies grew between 2003 and 2008. Due to the international economic downturn, however, these services then contracted before resuming growth in 2010. In the United States, commercial KI services' value added rebounded after 2009 and, in 2012, stood 12% higher than its level prior to the global recession. The EU fared much worse. The EU's production of commercial KI services remained stagnant between 2009 and 2012 and was below its pre-recession peak at the end of this period. As a result, following the international economic downturn, the EU's global share in these KI services industries declined considerably. In contrast, the U.S. global share not only remained steady, but employment in commercial KI services in the United States rose above levels prior to the global downturn. At the same time, commercial KI services in developing countries, and especially in China, grew rapidly.

As the distribution of commercial KTI production gradually shifted from developed to developing countries during the international economic downturn, parallel changes occurred in trade in KTI goods and services. The developed world generally lost market share in global KTI exports during this period. Japan, for example, suffered marked declines in global market share, as did the EU. But some large European economies, notably Germany and the United Kingdom (UK), fared better than other parts of the EU. The United States was more successful in maintaining its position in global KTI competition than most other long-established developed economies.

Figure O-2

Output of KTI industries as a share of GDP for selected developing economies: 2012



GDP = gross domestic product; HT = high technology; KI = knowledge intensive; KTI = knowledge and technology intensive.

NOTES: Output of KTI industries is on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. KTI industries include KI services and HT manufacturing industries classified by the Organisation for Economic Co-operation and Development. KI services include business, financial, communications, education, and health. Commercial KI services include business, financial, and communications services. Public KI services include education and health. HT manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and measuring, testing, and control instruments. Developing economies are classified by the World Bank as higher- and lower-middle income and low income.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix tables 6-3–6-7.

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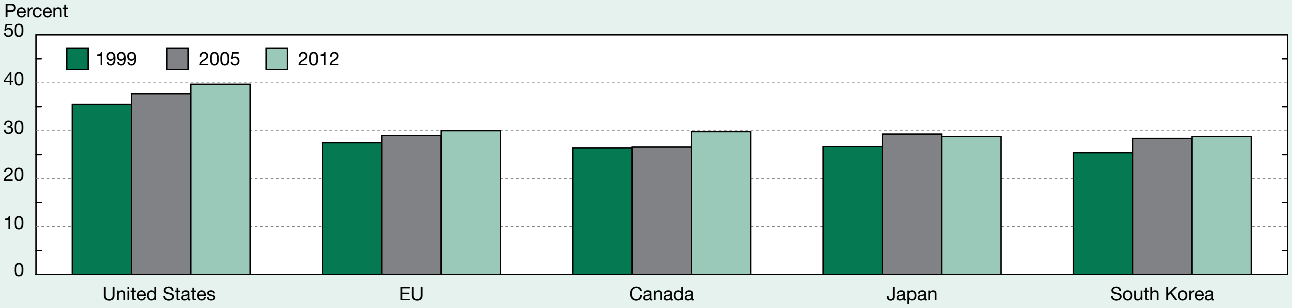
Figure O-1

KTI share of GDP, by selected country/economy: 1999, 2005, and 2012



EU = European Union; GDP = gross domestic product; KTI = knowledge and technology intensive.

NOTES: KTI industries include knowledge-intensive (KI) services and high-technology (HT) manufacturing industries classified by the Organisation for Economic Co-operation and Development. KI services include business, financial, communications, education, and health. HT manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Data are not available for EU members Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, special tabulations (2013) of the World Industry Service database. See appendix table 6-18 for a full list of countries in each region.

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R&D Performance

R&D expenditures increase human and knowledge capital, laying the groundwork for innovations, including those that fuel KTI industries. In 2011, the proportion of global R&D performance attributable to the East and Southeast Asia region, including China, was comparable (31.8%) to that in North America (32.2%) and substantially larger than that in Europe (24.0%) (figure O-5).

Among individual countries, the United States is by far the largest investor in R&D. In absolute terms, the top three R&D performing countries—the United States ($429 billion), China ($208 billion), and Japan ($147 billion)—accounted for over half of the estimated $1.44 trillion in global R&D in 2011. The U.S. share was 30% of the global total in 2011. China (15%) and Japan (10%) were the next-largest R&D performers. The total for the EU was 22% (figure O-6).

Despite growth in nominal measures of R&D, both the United States and the EU experienced substantial declines in the last decade in their shares of global R&D. Between 2001 and 2011, the U.S. share declined from 37% to 30% of the global total, while the EU share dropped from 26% to 22%. During the same period, the economies of East and Southeast Asia and South Asia—including China, India, Japan, Malaysia, Singapore, South Korea, and Taiwan—saw an increase in their combined share from 25% to 34% of the global total. The pace of growth over the past 10 years in China's overall R&D remains exceptionally high at about 18% annually adjusted for inflation, propelling it to 14.5% of the global total in 2011, up from 2.2% in 2000.

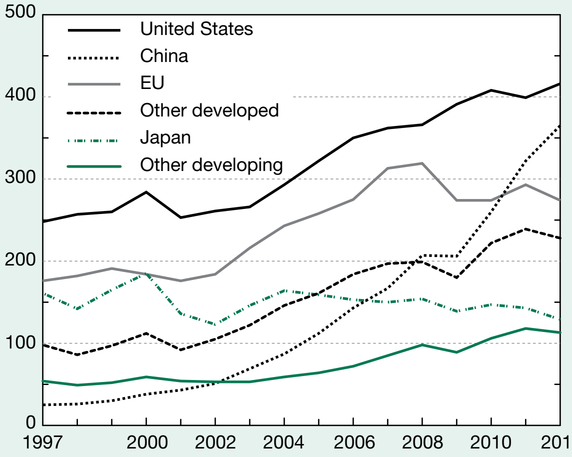
Although the United States performs far more R&D than any other individual country, several other economies have greater *R&D intensity*—that is, a higher ratio of R&D expenditures to GDP. In 2011, R&D intensity in the United States was 2.8%. Most economies with higher R&D intensity—including Israel, Finland, South Korea, Sweden, Denmark, Taiwan, and Switzerland—tend to be much smaller than the United States. More apt comparisons are with Germany, France, the UK, and Japan, which allocated, respectively, 2.9%, 2.2%, 1.8%, and 3.4% of GDP to R&D. However, relatively high R&D investments alone are no guarantee of robust economic growth, as indicated by the experience of Japan during the last decade.

Moreover, in several countries, R&D intensity has been growing rapidly (figure O-7). Along with China, South Korea is a notable example. In 1991, gross expenditure

Figure O-3

Output of HT manufacturing industries for selected regions/countries/economies: 1997–2012

Billions of dollars



EU = European Union; HT = high technology.

NOTES: Output of HT manufacturing industries is on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. HT manufacturing industries are classified by the Organisation for Economic Co-operation and Development and include aircraft and spacecraft, communications, computers, pharmaceuticals, semiconductors, and testing, measuring, and control instruments. The EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong. Developed countries classified as high-income countries by the World Bank. Developing countries classified as upper- and lower-middle-income countries and low-income countries by the World Bank.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix table 6-7.

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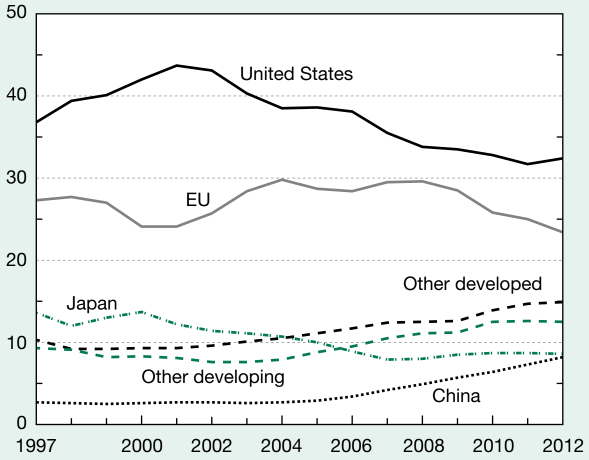
Figure O-4

Global share of commercial KI services value added for selected countries/economies: 1997–2012

Percent



EU = European Union; KI = knowledge intensive.

NOTES: Output of knowledge- and technology-intensive industries is on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. The EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong. Developed economies are classified by the World Bank as high income. Developing economies are classified by the World Bank as upper- and lower-middle income and low income.

SOURCE: IHS Global Insight, World Industry Service database (2013).

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on R&D as a share of GDP was 1.8% for South Korea. By 2011, that measure had increased to over 4.0%. A stated goal by the European Union (one of the five targets for the EU in 2020 [EC 2013]), along with many individual developed countries, is to achieve a 3% R&D-to-GDP ratio to promote innovation.

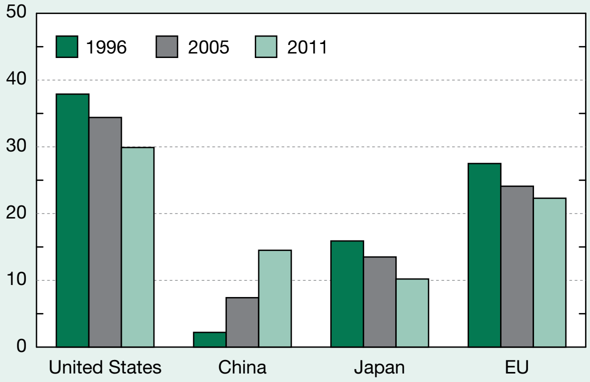
At the same time that the growth of KI economies around the world intensifies the competition among national economies, it also increases interdependencies. Taking advantage of improved worldwide capacity to perform R&D and other knowledge-oriented economic activities, multinational corporations (MNCs) have increasingly made R&D investments outside their home countries. To be sure, the bulk of R&D by U.S. MNCs is still performed in the United States (84% of their $252 billion in R&D globally in 2010) and in Europe. But rapid growth in R&D by majority-owned foreign affiliates (MOFAs) of U.S. MNCs in China, India, Brazil, and Israel is closing the gap between these emerging countries and traditional centers of U.S. MOFA investments in Europe, Canada, and Japan.

Notably, U.S. MOFA R&D performance in China more than doubled in current dollars from 2005 to 2008, with year-to-year, double-digit increases to a record $1.7 billion in 2008. This is consistent with increases in total R&D performed in China in recent years and with China's

Figure O-6

Global share of expenditures on R&D, by selected country/economy: 1996, 2005, and 2011

Percent



EU = European Union.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, estimates (August 2013), based on data from the Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1); and the United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed 2 August 2013.

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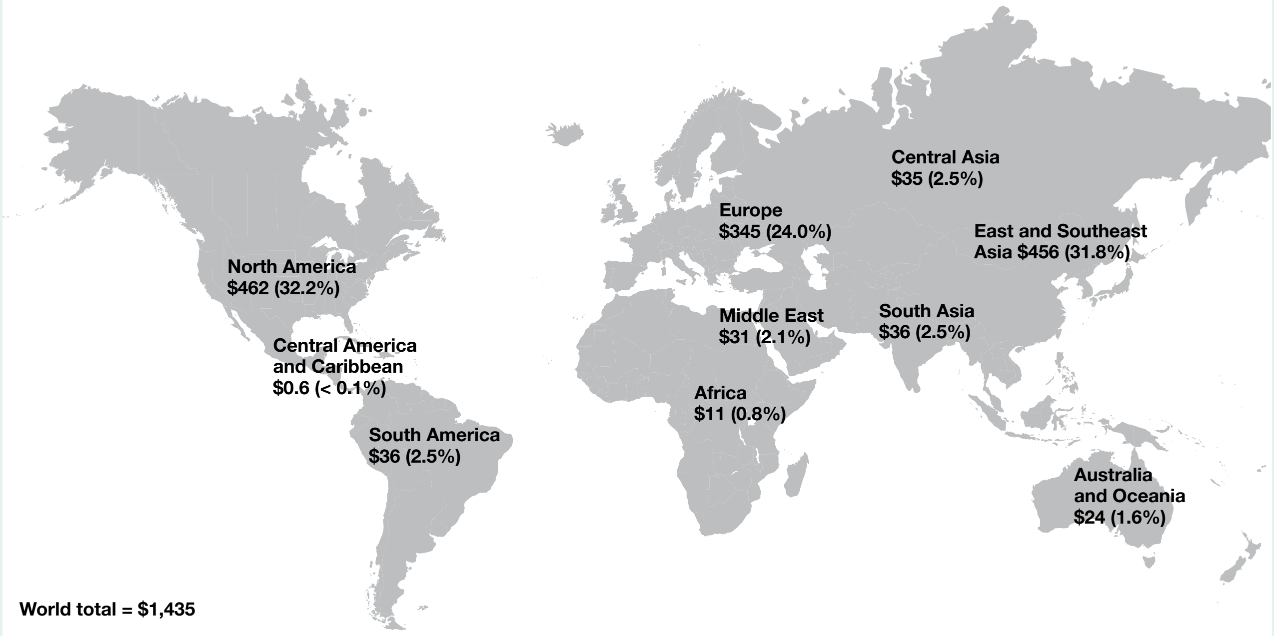
Figure O-5

Global R&D expenditures, by region: 2011

Billions of U.S. PPP dollars



PPP = purchasing power parity.

NOTES: Foreign currencies are converted to U.S. dollars through PPPs. Some country figures are estimated. Countries are grouped according to the regions described by *The World Factbook*, available at www.cia.gov/library/publications/the-world-factbook/index.html.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, estimates (August 2013). Based on data from the Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1); and the United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed 2 August 2013.

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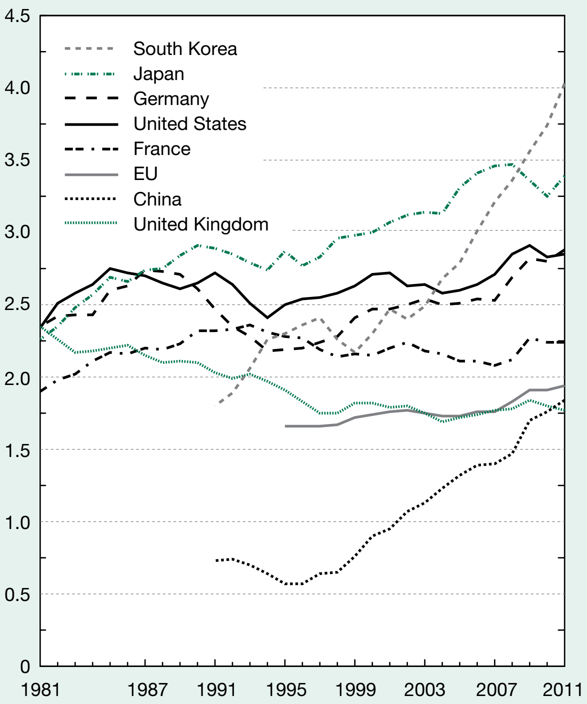
emergence as the second-largest R&D-performing country. Reported R&D activity by U.S. MOFAs tripled in India and more than doubled in Brazil from 2007 to 2010. U.S. MOFA R&D expenditures in Brazil and India are now on par with those in China.

Concurrently, affiliates of foreign MNCs located in the United States (U.S. affiliates) performed $41.3 billion of R&D in 2010, a slight increase after almost no change in 2009 and 2008. R&D by these companies has accounted for 14%–15% of U.S. business R&D performance since 2007. Three-fourths of R&D by U.S. affiliates of foreign MNCs in 2010 was performed by firms owned by parent companies based in five countries: Switzerland (22.0%), the UK (14.5%), Germany (13.8%), France (12.7%), and Japan (12.4%).

In addition to lowering R&D labor costs, MNCs' overseas R&D investments bring development work closer to emerging markets and enable product designers to take advantage of proximity to consumers and better information about whether and how consumers are likely to use new products. These investments, often encouraged by governments in developing countries, also increase local capacity for performing further R&D work (Thursby and Thursby 2006).

Figure O-7
Gross expenditures on R&D as share of GDP, for the United States, EU, and selected other countries: 1981–2011



EU = European Union; GDP = gross domestic product.

NOTES: Data are not available for all countries in all years. The table includes the top seven R&D-performing countries. Figures for the United States reflect international standards for calculating gross expenditures on R&D, which differ slightly from the National Science Foundation's protocol for tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data because of changes in methodology.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1). See appendix table 4-13.

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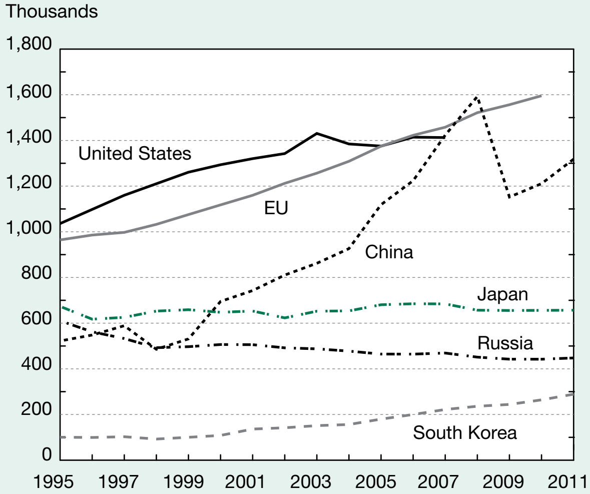
Workers with S&E Skills

The presence of workers with S&E skills is one of the key indicators of national competitiveness. Comprehensive, internationally comparable data on the worldwide S&E workforce do not exist. However, the Organisation for Economic Co-operation and Development (OECD) reports international data on professionals engaged in research. Although national differences in these data may be affected by survey procedures and interpretations of international statistical standards, the data can be used to make broad comparisons of national trends.

The United States continues to enjoy a distinct but decreasing advantage in the supply of human capital for research and other work involving S&E. In absolute numbers, the United States had one of the largest populations of researchers at the latest count, but China—which almost tripled its number since the mid-1990s—has been catching up (figure O-8).[3]

Figure O-8
Estimated number of researchers in selected countries/regions: 1995–2011



EU = European Union.

NOTES: Data are not available for all countries/regions for all years. Researchers are full-time equivalents. Before 2009, counts for China were not consistent with Organisation for Economic Co-operation and Development (OECD) standards.

SOURCE: OECD, *Main Science and Technology Indicators* (2013/1 and earlier years), http://www.oecd.org/sti/msti.htm.

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There is no doubt that the worldwide total of workers engaged in research has been growing strongly and that growth has been more robust in some countries than in others. The most rapid expansion has occurred in South Korea (which doubled its number of researchers between 1995 and 2006 and continued to grow strongly thereafter) and China (which reported tripling its number of researchers between 1995 and 2008 and likewise reported substantial growth in later years).[4] The United States and the EU experienced steady growth at lower rates, with a 36% increase in the United States between 1995 and 2007 (OECD data for the United States are not available after 2007) and a 65% increase in the EU between 1995 and 2010. Exceptions to the worldwide trend between 1995 and 2011 were the numbers of researchers in Japan (which remained flat) and in Russia (which declined).

Researchers measured as a share of employment is another indicator of national competitiveness in an international knowledge economy. Several economies in Asia have shown a sustained increase in that statistic since 1995. Foremost among them is South Korea (figure O-9), but growth is also evident in others—for example, in Singapore, Taiwan, and China. Singapore, for instance, has published estimates suggesting that its total number of workers with S&E skills will increase by nearly 50% by 2030 (NPTD 2013).[5]

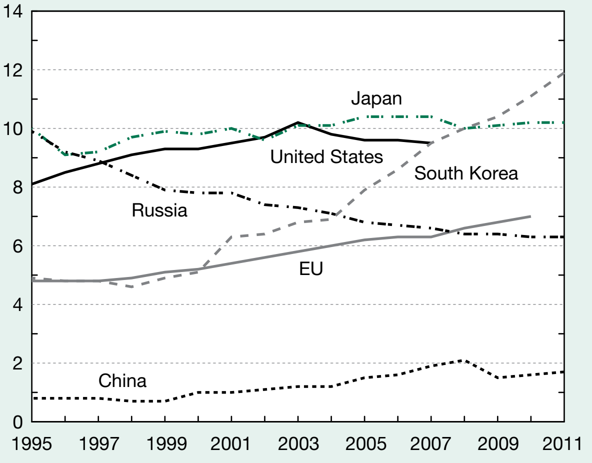
Data on recipients of higher education degrees also indicate that other countries are catching up to—and, in some respects, surpassing—the United States. Between 2001 and 2010, the number of first university degrees in the United States increased from 1.3 million to 1.7 million. During the same time period, the number of first university degrees in China grew from 0.5 million to 2.6 million. The rates of growth in the EU and in Japan, South Korea, and Taiwan were comparable to that in the United States (figure O-10).

S&E degrees, important for an innovative knowledge economy, are more prevalent in some countries than others. Globally, the number of first university degrees in S&E reached about 5.5 million in 2010. Almost a quarter of those degrees were conferred in China (24%), 17% in the EU, and 10% in the United States. In several Asian countries, these degrees comprise a larger proportion of all first university degrees than they do in the United States. Differences in engineering are especially large: whereas 5% of all bachelor's degrees awarded in the United States were in engineering, 31% of such degrees in China were in this field.

The S&E proportion of all first university degrees in Western countries has typically been stable in recent years. From 2001 to 2010, this share held steady in the United States (from 31.8% to 31.5%) and in Germany (from 37.3% to

Figure O-9
Researchers as a share of total employment in selected countries/regions: 1995–2011

Per thousand



EU = European Union.

NOTES: Data are not available for all countries/regions for all years. Researchers are full-time equivalents per thousand total employment. Before 2009, counts for China were not consistent with Organisation for Economic Co-operation and Development (OECD) standards.

SOURCE: OECD, *Main Science and Technology Indicators* (2013/1 and earlier years), http://www.oecd.org/sti/msti.htm.

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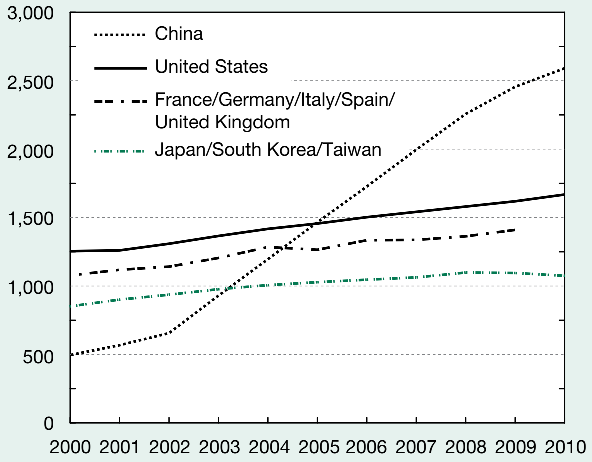
Figure O-10
First university degrees, by location: 2001–10

Thousands



NOTES: Data for first university degrees use International Standard Classification of Education, level 5A. Data not available for all locations in all years.

SOURCES: China—National Bureau of Statistics of China, *China Statistical Yearbook,* annual series (Beijing) (various years); Japan—Government of Japan, Ministry of Education, Culture, Sports, Science and Technology, Monbusho Survey of Education (annual series; various years); Taiwan—Ministry of Education, Educational Statistics of the Republic of China (annual series; various years); United Kingdom—Higher Education Statistics Agency, special tabulations (various years); United States—National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System, http://webcaspar.nsf.gov; and other countries—Organisation for Economic Co-operation and Development, OECD Stat Extracts, http://stats.oecd.org/Index.aspx.

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37.6%). In contrast, this proportion decreased considerably in several Asian countries, such as China (from 72.5% to 49.8%), Japan (from 65.6% to 59.3%), and South Korea (from 45.2% to 40.1%) (figure O-11).

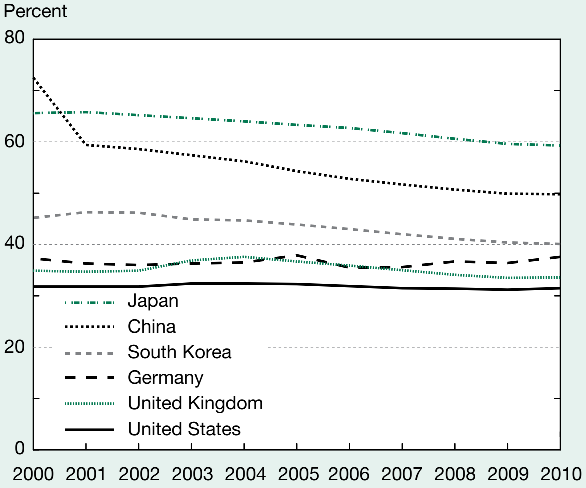
The relationship between degrees conferred in a country and future capabilities in its workforce is complicated by the fact that increasing numbers of students are receiving higher education outside their home countries. The United States remains the destination of choice for the largest number of internationally mobile students worldwide. In 2012, foreign graduate students in S&E fields (163,390) outnumbered foreign students pursuing S&E undergraduate degrees (116,640) in the United States. Other popular destinations for internationally mobile students are the UK, Australia, France, and Germany (figure O-12). Yet, due to efforts by other countries to attract more foreign students as well as increased enforcement of visa requirements for students wanting to pursue a degree in the United States (among other factors), the U.S.-enrolled share of the world's internationally mobile students fell from 25% in 2000 to 19% in 2010. While a declining share of international students in the natural sciences and engineering opted for the United States, this drop in numbers was offset by an increase in international students coming to the United States to study social and behavioral sciences.

Whereas the U.S. share of internationally mobile students fell, the actual number of foreign undergraduate students entering the United States increased, rising by 18% between fall 2011 and fall 2012. Within the S&E fields, the largest increases occurred in engineering and the social sciences. The majority of foreign students studied in non-S&E fields. Foreign undergraduates in the United States predominantly originate from China, South Korea, and Saudi Arabia.

The number of foreign graduate students in the United States increased by 3% between fall 2011 and fall 2012. A much larger share of those students (nearly 6 out of 10) was enrolled in S&E fields as compared to undergraduate students (3 out of 10). This cohort of foreign graduate students chose somewhat different fields of study from earlier years: more studied mathematics, social sciences, and psychology, and fewer studied computer science, biological sciences, and engineering.

Figure O-11

S&E first university degrees as a share of all first university degrees, by country: 2000–10



NOTE: Data for first university degrees use International Standard Classification of Education, level 5A.

SOURCES: China—National Bureau of Statistics of China, *China Statistical Yearbook,* annual series (Beijing) (various years); Japan—Government of Japan, Ministry of Education, Culture, Sports, Science and Technology, Monbusho Survey of Education (annual series; various years); Taiwan—Ministry of Education, Educational Statistics of the Republic of China (annual series; various years); United Kingdom—Higher Education Statistics Agency, special tabulations (various years); United States—National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System, http://webcaspar.nsf.gov; and other countries—Organisation for Economic Co-operation and Development, OECD Stat Extracts, http://stats.oecd.org/Index.aspx.

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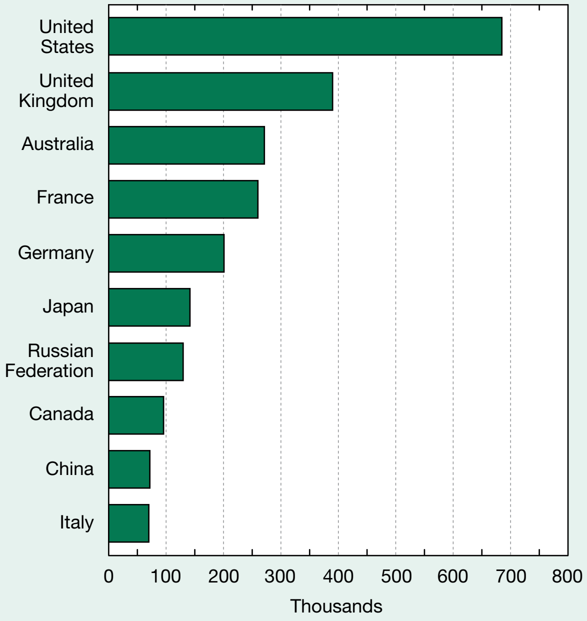
Figure O-12

Internationally mobile students enrolled in tertiary education, by selected country: 2010



NOTES: Data are based on the number of students who have crossed a national border and moved to another country with the objective of studying, i.e., mobile students. Data for Canada and the Russian Federation correspond to 2009. Data for Germany exclude advanced research programs (e.g., doctorate).

SOURCE: UNESCO Institute for Statistics, special tabulations (2013).

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Research Publications

Refereed journal articles are a tangible and readily measured output of research activity. Despite the growth in research capability abroad, the United States continues to be the world leader in the publication of S&E articles when publications are measured at the individual country level. In 2011, the United States accounted for 26% of the world's 828,000 articles.[6] Nonetheless, the U.S. share of the global total of refereed journal articles has been declining, dropping by 4 percentage points between 2001 and 2011. Similarly, shares for the EU and Japan fell from 35% to 31% and from 9% to 6%, respectively, between 2001 and 2011. This was due mainly to increased output of research articles in East and Southeast Asia and in developing countries, such as Brazil and India. China's share of refereed journal articles grew the fastest among larger developing economies during this time period, almost quadrupling from 3% to 11% of the world total (figure O-13).

Citations to refereed journal articles are an oft-used indicator of the quality and impact of research output. Researchers based in the United States continue to set the bar with respect to the production of influential research results. Between 2002 and 2012, 1.6%–1.8% of U.S.-authored S&E articles have been among the world's top 1% of cited articles, compared with 0.7%–0.9% of articles from the EU (figure O-14). The share of China's articles in the top 1% remained behind the United States and the EU but experienced a sixfold increase (0.1% to 0.6%) over the period. Overall, U.S.-authored articles represented 48% of the world's top 1% of cited articles during this time period.

Citation data can also signal the extent of collaboration among researchers, both nationally and across borders. The trend toward more collaboration varies among S&E fields, research institutions, and countries. Citation patterns, like coauthorship patterns, are strongly influenced by cultural, geographic, and language ties. Thus, U.S. articles are disproportionately cited by Canadian and UK articles. In comparison, U.S. authors cite Chinese articles much less than suggested by the overall citation trends. Within Europe and Asia (with the exception of Japan), cross-national citation is common, with most country pairs in each continent surpassing the expected number of citations.[7]

U.S. articles are highly cited across all broad scientific fields. Citations for U.S. engineering articles exhibited a slight increase between 2002 and 2012, and citations declined slightly for chemistry and social sciences. EU articles are cited more than expected in physics and agriculture. China underperformed on this measure across all science fields, with the notable exceptions of computer science and geosciences, in which China overperformed.

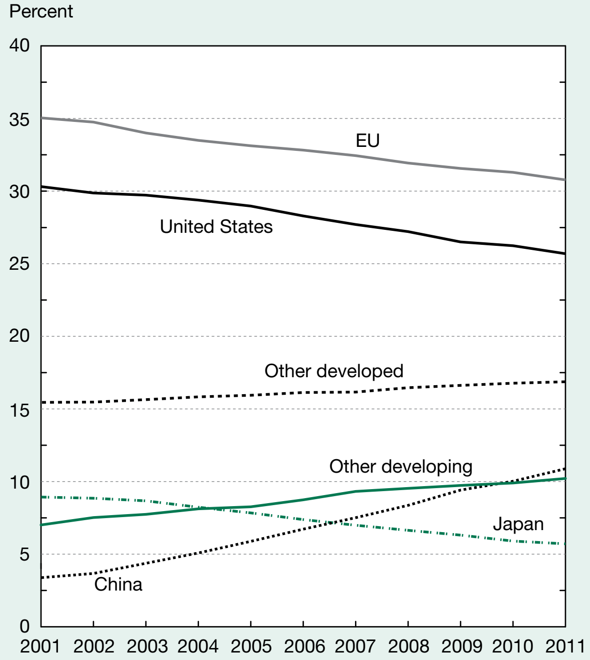
Innovation-Related Indicators

In addition to the research findings in published articles, patents are an important output often produced by S&E research. Although patents do not necessarily become commercialized or lead to practical innovations—some are accumulated to provide a basis for legal action to discourage competitors from innovating, and others are simply deemed not to be commercially viable—patent grants and applications can sometimes lead to new or significantly improved products or processes or new methods of organizing productive activities.

The United States Patent and Trademark Office (USPTO) accepts applications from and grants patents to inventors worldwide. Trends in USPTO patenting activity indicate changes in inventive activity in different parts of the world (figure O-15).

The USPTO granted more than 250,000 patents in 2012, of which 120,000 were to U.S. inventors. This represents the highest number worldwide. Japan (51,000) and the EU (36,000) posted the next-highest numbers of successful patent applications to the USPTO. Although the absolute number

Figure O-13
S&E articles, by global share of selected region/ country: 2001–11



EU = European Union.

NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on the basis of the proportion of its participating institutions). Counts for all six groups sum to the world total. Data for Bulgaria, Hungary, and Romania are included with the EU and not with developing economies.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-26.

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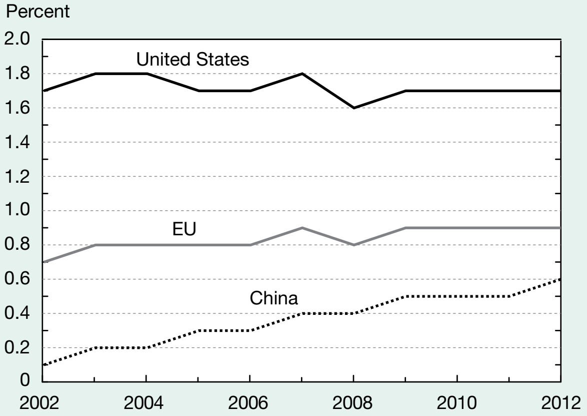
Figure O-14
Share of U.S., EU, and China S&E articles that are in the world's top 1% of cited articles: 2002–12



EU = European Union.

NOTES: Article/citation counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/regions, each country/region receives fractional credit on the basis of the proportion of its participating institutions). See appendix table 5-24 for countries included in the EU, which in this figure is treated as a single country. Citation counts are based on a 3-year period with a 2-year lag (e.g., citations for 2012 are references made in articles in the 2012 data tape to articles in the 2008–10 data tapes).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-57.

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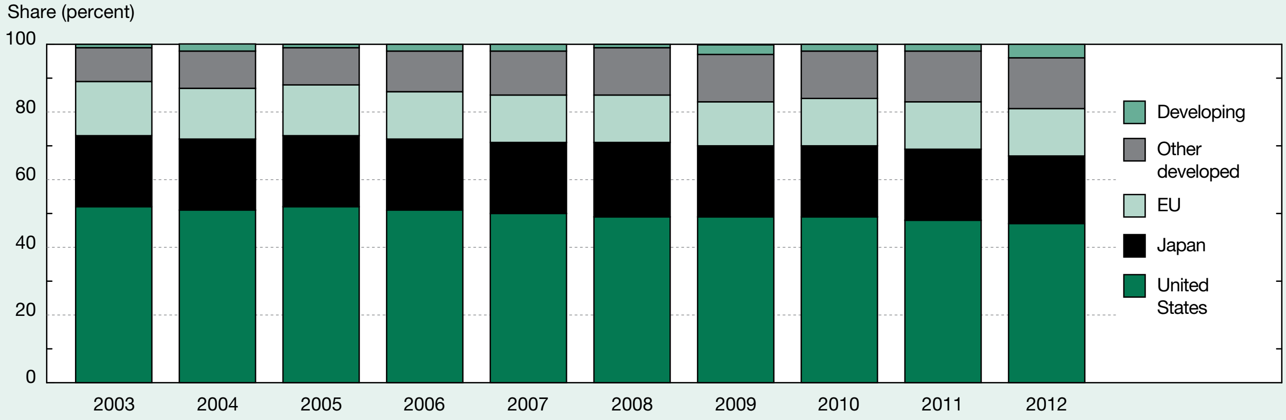
of USPTO patents granted to U.S. inventors increased from 87,000 to 120,000 between 2003 and 2012, the U.S. share declined by 5 percentage points (from 53% to 48%) in this period. This likely signals increased technological capabilities abroad, which, in a globalized marketplace, underscore the need for patent protection in foreign countries. Developing countries received 9,000 patents (less than 4% of total patents), with China and India receiving the bulk of the relatively small number of patents granted to these countries.

Data on the numbers of patents granted provide no indication of patent quality. *Triadic patents,* in which inventors simultaneously seek patent protection in three of the world's largest markets—the United States, the EU, and Japan—indicate patents expected to have high commercial value. In 2010, the number of these triadic patents was estimated to be about 49,000. The shares of the United States, the EU, and Japan stayed roughly equal (at around 30% each) during the period from 2000 to 2010. Although South Korea still produces far fewer patented inventions than the long-standing global leaders, the country made rapid and notable progress on this indicator in the last decade, doubling its filings from 2% to 4% of the global total (figure O-16).

Globally, there are indications that various economies receive the majority of their patent grants in certain technology areas (figure O-17). U.S. inventors accounted for nearly 70% of all U.S. patents granted in medical equipment and electronics, far higher than the overall U.S. share, indicating that U.S. inventors are very active in this area. In addition, the United States has slightly higher than average shares in information and communications technologies (ICT) and biotechnology and pharmaceuticals. EU inventors have a somewhat higher than average share in biotechnology and pharmaceuticals, receiving 21% of all U.S. patents in the area; an additional technology area where the EU has a slightly higher

Figure O-15
USPTO patents granted, by location of inventor: 2003–12



EU = European Union; USPTO = U.S. Patent and Trademark Office.

NOTES: Technologies are classified by The Patent Board.™ Patent grants are fractionally allocated among countries on the basis of the proportion of the residences of all named inventors.

SOURCE: The Patent Board,™ special tabulations (2013) from Proprietary Patent database. See appendix table 6-40.

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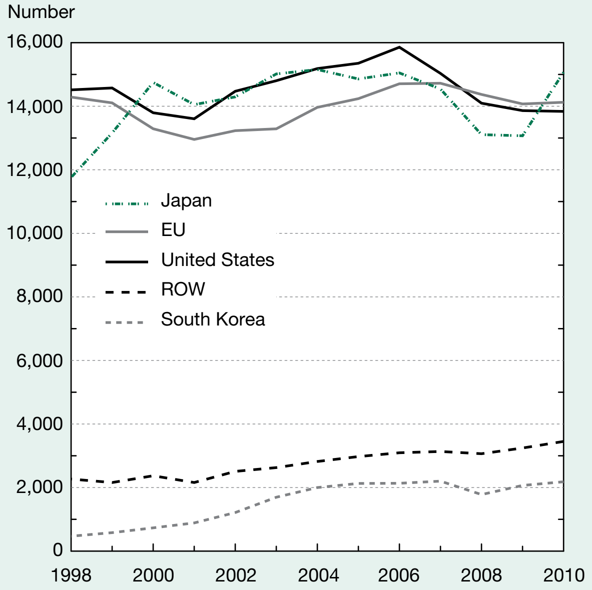
Figure O-16
Global triadic patent families, by selected region/country/economy: 1998–2010



EU = European Union; ROW = rest of world.

NOTES: Triadic patent families include patents applied in the U.S. Patent and Trademark Office, European Patent Office, and Japan Patent Office. Patent families are fractionally allocated among regions/countries/economies based on the proportion of the residences of all named inventors.

SOURCE: Organisation for Economic Co-operation and Development, Patents Statistics, http://stats.oecd.org/WBOS/index.aspx, Patents by Region database, accessed 15 January 2011. See appendix table 6-54.

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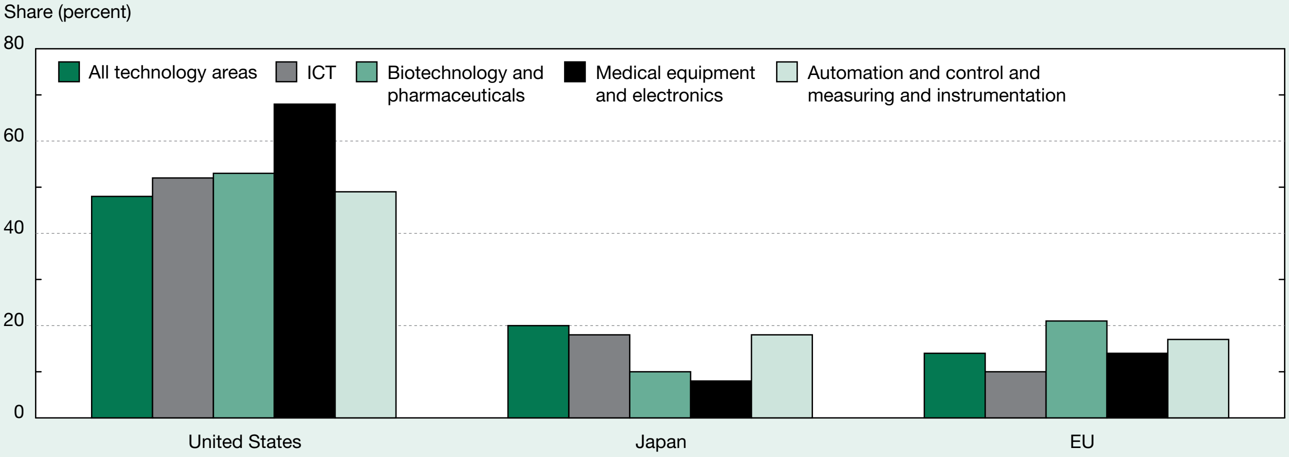
than average share is automation and control and measuring and instrumentation (17%).

KTI industries account for a large share of USPTO patent grants awarded to inventors in the United States. In 2011, HT manufacturers garnered 29,000 of the 58,000 patents granted to all U.S. manufacturing industries. U.S. commercial KI services industries accounted for 46% of the 43,000 patents issued to nonmanufacturing industries in 2011. Although HT manufacturing is a smaller part of the U.S. economy than KI services, the majority of inventions attributable to KTI industries occur on the manufacturing side.

In manufacturing, five of the six HT manufacturing industries—aircraft and spacecraft; communications; computers; pharmaceuticals; and testing, measuring, and control instruments—reported rates of product and process innovation that were at least double the manufacturing sector average. In KI services industries, software firms lead in incidence of innovation, with 69% of companies reporting the introduction of a new product or service, compared to the 9% average for all nonmanufacturing industries. Other KI services industries—such as computer systems design, data processing and hosting, and scientific R&D services—also report innovation at rates that are three to four times higher than the nonmanufacturing average.

Innovative activities and trade in intellectual property are strongly related. Intellectual property trade is measured by royalties and fees collected for licensing or franchising proprietary technologies. Although sometimes affected by different tax treatments, income from intellectual property broadly indicates which nations are producing intellectual products with commercial value. U.S. export income from royalties and fees has exhibited a strongly positive trend

Figure O-17
USPTO patents granted, by selected technology areas for selected country/economy of inventor: 2010–12



EU = European Union; ICT = information and communications technologies; USPTO = U.S. Patent and Trademark Office.

NOTES: Technologies are classified by The Patent Board.™ Patents are fractionally allocated among countries on the basis of the proportion of the residences of all named inventors.

SOURCE: The Patent Board,™ special tabulations (2013) from Proprietary Patent database. See appendix tables 6-40 and 6-43–6-53.

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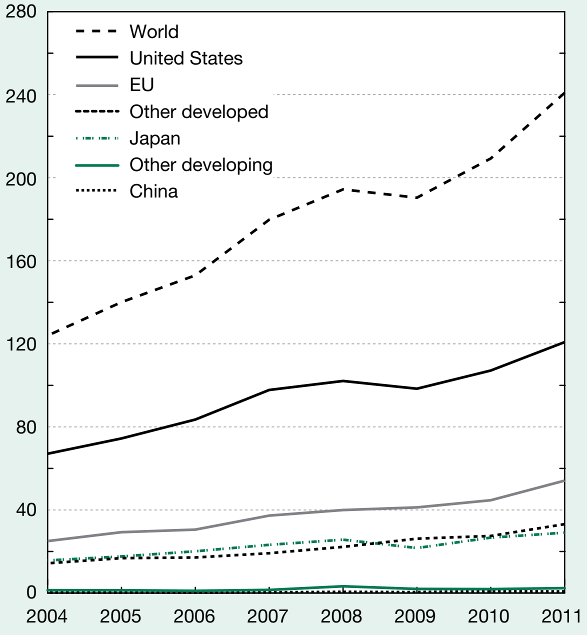
over the last decade (figure O-18). In 2011, the United States posted export income of $121 billion in royalties and fees. The EU exported intellectual property in the amount of $54 billion while accumulating a small trade deficit in this area. Like the United States, Japan, which exported $29 billion in royalties and fees, had a substantial trade surplus in this area. Three economies that import more rights to production than they export (and are, therefore, net importers of royalties and fees) are among countries that the World Bank has recently classified as developing: China, Russia (reclassified as developed in 2012), and Brazil.

The U.S. Science and Engineering Landscape

Changes in the major institutions that engage in S&E R&D and help prepare the workforce of the future usually occur gradually, typically over a longer time scale than changes in economic markets. This section describes consequential changes and continuities in the major institutions involved in U.S. S&E activity over the last two decades, focusing on institutional features that play important roles in R&D and in S&E education. Attention is devoted primarily to higher education, industry, and government, which are the largest funders and performers of R&D and the biggest employers of workers with S&E training. However, other institutions that play important niche roles (e.g., nonprofit funders and performers of research; federally funded research and development centers [FFRDCs]) are also mentioned. Other institutions that lay important foundations for a knowledge economy (e.g., K–12 education) are discussed in the body of the report.

Figure O-18
Global exports of royalties and fees, by selected region/country/economy: 2004–11

Billions of dollars



EU = European Union.

NOTES: EU exports do not include intra-EU exports. Developed countries are classified as high-income economies by the World Bank. Developing countries are classified as upper- and lower-middle income and low income by the World Bank. Sum of regions/countries/economies does not add up to total due to rounding and discrepancies.

SOURCE: World Trade Organization, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 8 August 2013.

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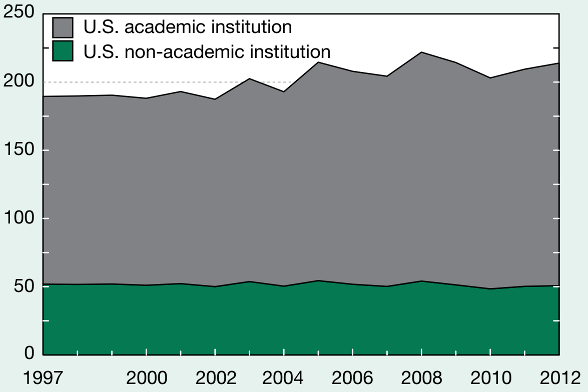
Cross-Sector Collaboration

Ironically, a focus on institutions highlights one of the most striking changes in the U.S. S&E landscape in recent years—the growth of cross-institution, cross-sector, and cross-national collaboration. Institutions and disciplines that formerly inhabited almost entirely separate worlds more frequently collaborate on projects and cross boundaries to enter previously unfamiliar territory.

Publication data show the clearest evidence of this trend. Although the distribution of S&E publication activity between academic and nonacademic institutions remained relatively stable between 1997 and 2012 (figure O-19), with academic institutions producing the large majority of

Figure O-19
U.S. academic and non-academic S&E articles: 1997–2012

Thousands of articles



NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database and are assigned to U.S. institution(s) based on the institutional address(es) listed in the article. Articles are credited on a fractional count basis; for articles with institutional addresses from multiple countries/U.S. institutions, each U.S. institution receives fractional credit on the basis of the proportion of its participating institutions.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-40.

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publications, the proportion of collaborative publications increased. The share of S&E articles with more than one named author grew, as did the percentages involving institutional and international coauthorships (figures O-20 and O-21).

From 1990 to 2012, the share of purely U.S. S&E articles with authors from multiple institutions grew from 34% to 62%. Collaborative publication was more common in the U.S. academic sector than in other U.S. institutional sectors. The share of purely U.S. academic articles with authors from multiple academic institutions rose from 16% in 1990 to 31% in 2012 (figure O-20).[8] Other U.S. institutional sectors showed a similar trend toward collaborative publication among multiple institutions during this period. The average number of authors on papers published by authors from U.S. academic institutions also increased considerably, rising from 3 authors in 1990 to 8 authors in 2012 (figure O-21).

Between 1997 and 2012, internationally coauthored articles grew from 16% to 25% of the world's total. In the United States, the trend toward more international collaboration was even stronger. The percentage of U.S. articles with coauthors from institutions in other countries almost doubled (from 19% to 35%) between 1997 and 2012. Worldwide in 2012, 59% of all S&E articles with only domestic authors were produced with coauthors at different institutions (43% in 1997). Collaborative research articles receive more citations than single-author articles, suggesting higher quality or greater impact.

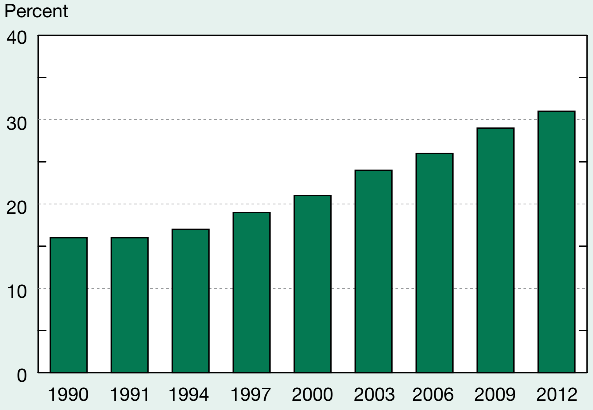
Publication data reveal increased collaboration between U.S. authors at academic institutions and other organizations that perform R&D, indicating a growing connection between the basic research performed in the academic sector and the more applied work characteristic of other sectors. In various institutional sectors—including industry, federal government, FFRDCs, and private nonprofit—the proportion of articles with academic sector coauthors increased by about 12–14 percentage points between 1997 and 2012.

The flow of funding among institutions also illustrates the trend toward collaborative research. Over the past 15 years, *pass-through funding,* in which funding for R&D at one university is shared with one or more collaborating institutions, has grown more rapidly than overall academic R&D expenditures. Between FY 2000 and FY 2009, the pass-through funds that universities provided to other universities grew by 171% (from $700 million to $1.9 billion), while overall academic R&D expenditures grew by only 82% (from $30.1 billion to $54.9 billion).

Moreover, a growing proportion of patents are citing S&E literature on their cover pages. This indicates an

Figure O-20

Share of articles authored at U.S. academic institutions that have authors from multiple U.S. institutions: Selected years, 1990–2012



NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to the U.S. academic sector on the basis of the institutional address(es) listed in the article. All article authors have U.S. academic institutional addresses.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

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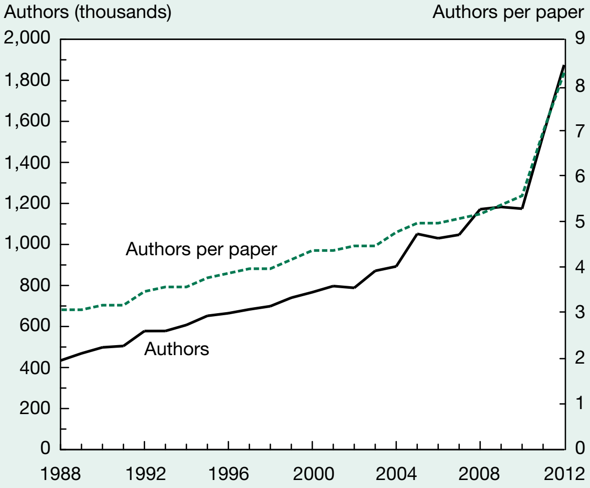
Figure O-21

Number of authors and authors per paper for U.S. academic institutions: 1988–2012



NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to the U.S. academic sector on the basis of the author institutional address(es) listed in the article. All articles have at least one U.S. academic institutional address. Authors counted are individual author names on each article, and an individual author name is counted each time it appears in the dataset.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

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increasing connection between higher education and the institutions that translate research findings into commercial innovations. Of patents awarded to both U.S. and foreign assignees, 12% cited S&E articles in 2003, and that share grew to 15% in 2012.

Just as academic research is increasingly interconnected both nationally and globally, business R&D has also been developing more international and interorganizational linkages. The rise in these kinds of linkages has coincided with the decline of large research organizations, such as Bell Labs, that performed fundamental research inside major corporations and with a concomitant drop in research publications attributed to industry (from 15,614 to 11,779 between 1990 and 2012).

U.S. Higher Education

Institutions of higher education are responsible for S&E education and training and perform the majority of U.S. basic research. In these respects, the functions of the higher education system have remained largely unchanged in recent decades.

The organization of higher education, however, has undergone significant modifications, including changes in the opportunity structure for research doctorate holders. Over the past 20 years, there has been a declining ratio of tenured to nontenured positions, even as the professoriate has aged substantially.[9] Growth in the numbers of individuals in other positions—including academic postdoctorates and nontenured full- and part-time positions—has been substantial.

Between 1995 and 2010, the proportion of S&E faculty in academia reporting research as their primary job activity edged up slightly (from 33% to 36%), and the share of those identifying teaching as their primary activity fell from 54% to 47%. Further evidence of the growing importance of research in the U.S. academic sector can be seen in the growth of research expenditures in general and in revenues from federal appropriations, grants, and contracts.

In public very high research universities,[10] inflation-adjusted research expenditures grew by about 150%, and revenues from federal awards grew by about 190% in the same period. In private very high research universities, the corresponding growth rates were approximately 160% and 140% (figure O-22).

Historically, the training of the next generation of highly skilled researchers in S&E has been concentrated in doctorate-granting institutions with very high research activity. It still is, but to a lesser extent than it once was. In 2011, these institutions awarded 74% of doctoral degrees, 42% of master's degrees, and 38% of bachelor's degrees in S&E fields. That is down from 94% (doctoral), 55% (master's), and 45% (bachelor's) in 1998. The change suggests a growing role in advanced S&E education for higher education institutions that are less centrally research- and S&E-oriented.

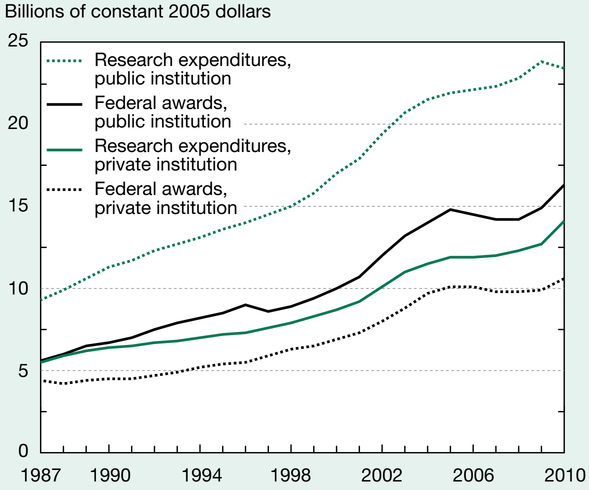
In addition, higher education institutions that are primarily oriented toward teaching, such as community colleges, play an important role in preparing students for advanced training in S&E. One-fifth of all U.S. citizens or permanent residents who received a doctoral degree from 2007 to 2011 had earned some college credit from a community or 2-year college. Moreover, the share of bachelor's degree recipients with at least some credit from community colleges increased from 43% in 1999 to 49% in 2010 (figure O-23).

Revenue and expenditure patterns for higher education institutions have also undergone significant changes over the last two decades. Between 1987 and 2010, state and local appropriations per full-time equivalent (FTE) enrolled student at public universities fell by more than 25% on average after adjusting for inflation. At the same time, inflation-adjusted net student tuition per FTE student more than doubled at these universities, in effect replacing public sources of funding with private ones. Tuition and fees for public colleges and universities grew faster than median household income during this period (figure O-24).

To acquire revenue to support research and other operating activities, higher education institutions in the United States increasingly tapped sources such as higher tuition rates that generate revenues from students from more-affluent families, foreign students who pay full tuition, and outside grant support for research activities. Increasing grant receipts, however, do not necessarily cover the full costs of grant administration, especially in S&E areas, such as biomedical research, for which universities must

Figure O-22

Federal awards and research expenditures at very high research activity institutions, by institutional control: 1987–2010



NOTES: Gross domestic product implicit price deflators are used to convert current dollars to constant 2005 dollars. Very high research activity institutions are designated by the 2005 Carnegie classification code. See The Carnegie Classification of Institutions of Higher Education, http://classifications.carnegiefoundation.org/index.php.

SOURCES: IPEDS Analytics: Delta Cost Project Database: 1987–2010 and National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Higher Education Research and Development Survey.

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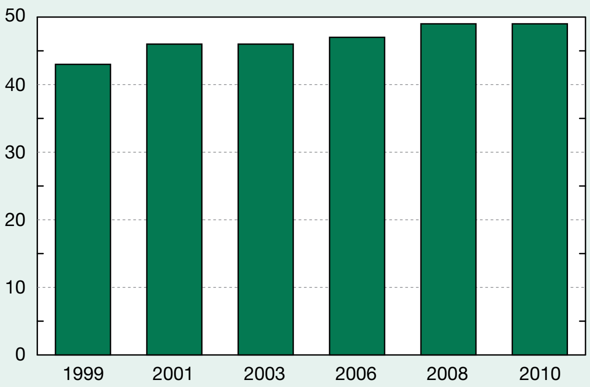
bear the significant costs of monitoring compliance with research regulations.

Finally, among various long-term changes, one feature of the higher education research landscape shows remarkable continuity. The bulk of R&D expenditures in the United States are concentrated among a small number of research-intensive institutions, and the extent of this concentration has remained very consistent over the last two decades, even as the identity of the institutions in the top groups has changed. In FY 2012, the top 10 institutions in terms of R&D performance accounted for 18.0% (18.8% in FY 1989), the top 20 for 30.6% (32.5%), and the top 100 for 78.8% (82.0%).

Figure O-23

Community college attendance among recent S&E bachelor's recipients: 1999–2010



NOTES: Recent graduates are those who earned degrees in the 2 academic years preceding the survey year or, for the 2006 survey year, in the 3 preceding academic years. For 2006, recent graduates are those who earned degrees between 1 July 2002 and 30 June 2005.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of the National Survey of Recent College Graduates.

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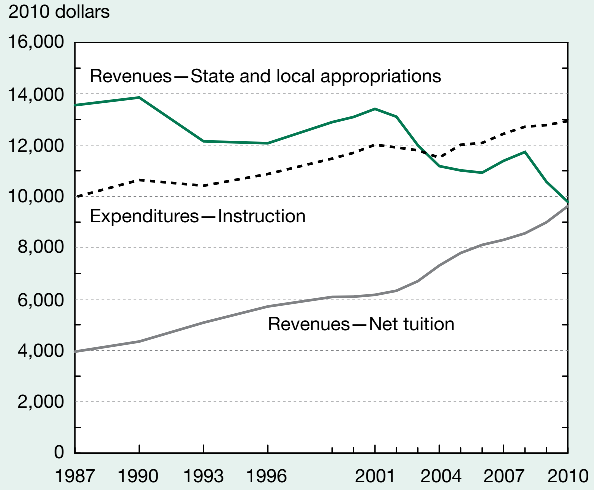
Figure O-24

Selected average revenues and expenditures at public very high research universities: 1987–2010



NOTE: Data are per full-time equivalent student.

SOURCE: IPEDS Analytics: Delta Cost Project Database, 1987–2010, special tabulations (2013).

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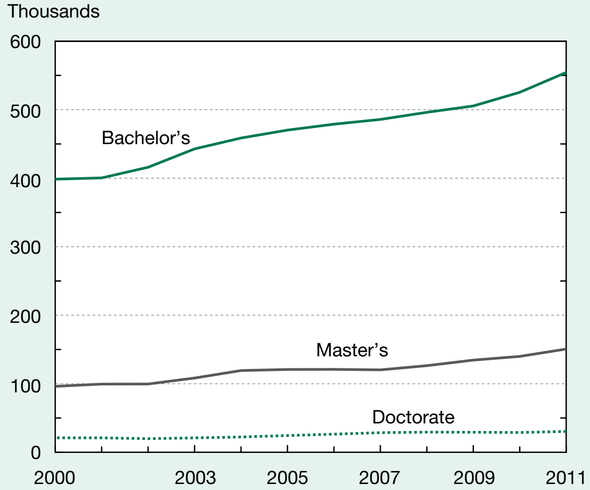
Degree Production

With the growth of a knowledge economy over recent decades, a larger number of U.S. students are getting S&E degrees and eventually finding jobs in S&E occupations. Between 2000 and 2011, there were sizeable increases in the number of earned S&E degrees at the bachelor's (+39.1%), master's (+56.6%), and doctoral levels (+35.5%) (figure O-25). These increases were similar to the corresponding increases for degrees in all fields in the same period—38.2% (bachelor's), 60.1% (master's), and 33.2% (doctoral).

As the number of S&E bachelor's degrees has grown steadily over the past 15 years (with a new peak of over half a million in 2011 [figure O-26]), increasing proportions of the graduates earning those degrees have been women or members of racial and ethnic minorities (figure O-27). Since the late 1990s, about 57% of all bachelor's degrees and half of all S&E degrees have been awarded to women. Percentages of S&E degrees awarded to women are highest

Figure O-25

S&E degrees, by level: 2000–11



NOTES: Data are based on degree-granting institutions eligible to participate in Title IV federal financial aid programs and do not match previously published data from *Science and Engineering Indicators 2008* and earlier years that were based on accredited higher education institutions. S&E doctorates exclude other health sciences because of changes in doctoral categories in the source data.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System, http://webcaspar.nsf.gov.

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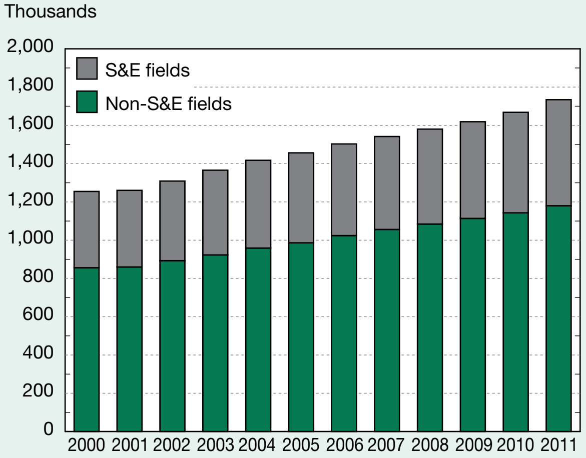
Figure O-26
Bachelor's degrees, by broad field of degree: 2000–11



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System, http://webcaspar.nsf.gov.

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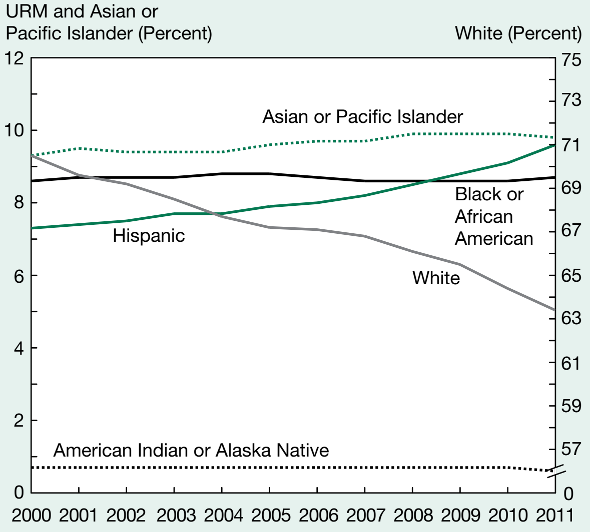
Figure O-27
Share of S&E bachelor's degrees among U.S. citizens and permanent residents, by race and ethnicity: 2000–11



URM = underrepresented minorities (black, Hispanic, and American Indian or Alaska Native).

NOTES: Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin. Percentages do not sum to 100 because data do not include individuals who did not report their race and ethnicity.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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in the biological, agricultural, and social sciences and in psychology. At the same time, for all racial and ethnic groups, the total number of bachelor's degrees earned, the number of S&E bachelor's degrees earned, and the number of bachelor's degrees in most S&E fields (except computer science) have generally increased since 2000.

For over 20 years, about one-third of U.S. bachelor's degrees have been awarded in S&E fields. Likewise, the distribution of degrees across S&E fields remained remarkably similar between 2000 and 2011. Percentages of bachelor's degrees in S&E were almost unchanged in engineering (about 14% in both years), biological and agricultural sciences (21%), and psychology (18%). Physical sciences (3.7% in 2000; 3.5% in 2011) and mathematics (2.9% in 2000; 3.3% in 2011) also did not exhibit major changes. Social sciences experienced a slight increase (28.5% in 2000; 31.1% in 2011) and computer sciences a small decrease (9.4% in 2000; 7.9% in 2011).

Demographics of the U.S. S&E Labor Force

Although the demographics of persons receiving S&E training and entering the S&E labor force remain quite different from those of the general U.S. population, there has been some general movement toward more diversity of participation in S&E occupations. Proportions of workers in minority groups have increased, while the percentage of whites has dropped from 84% in 1993 to 70% in 2010.

While women represent half of the college-educated workforce, they are underrepresented in the S&E workforce. In 2010, women accounted for only 37% of employed individuals with a highest degree in an S&E field and 28% of employed individuals in S&E occupations. Yet, these percentages represent increases since 1993, when the comparable figures were 31% and 23%, respectively (figures O-28 and O-29).

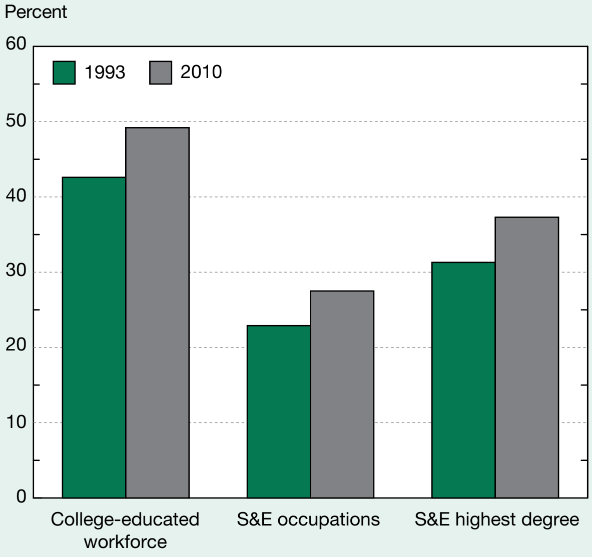
S&E participation has also risen over time among racial and ethnic minorities, particularly among Asians but also, to a lesser degree, among Hispanics and blacks (figure O-30). Despite this increase, participation varies substantially across groups. In 2010, Asians worked in S&E occupations at much higher rates (19%) than their representation in the general U.S. population (5%), whereas historically underrepresented racial and ethnic groups, particularly blacks and Hispanics, represented a much smaller proportion of the S&E workforce than their share of the U.S. population. In total, Hispanics, blacks, and American Indians or Alaska Natives account for 26% of the U.S. population age 21 and over but only for 10% of workers in S&E occupations and for 13% of S&E highest degree holders. In comparison, in 1993, Hispanics and blacks accounted for 7% of workers in S&E occupations, 8% of S&E highest degree holders, and 9% of the college-degreed workforce.

The share of workers holding a bachelor's degree or above in S&E occupations who are foreign born has increased over the last decade. Among college-educated S&E workers, the foreign-born share increased from 22.4% in 2000 to 26.2% in 2011 (figure O-31). The percentage of workers with a doctorate who are foreign born increased from 37.6% in 2000 to 43.2% in 2011. For holders of bachelor's and master's degrees, the changes were, respectively, from 16.5% to 19.0% and from 29.0% to 34.3% between 2000 and 2011.

Among foreign-born individuals with S&E doctorates living in the United States in 2010, slightly more than

Figure O-28

Women in the workforce and in S&E: 1993 and 2010



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) and National Survey of College Graduates (NSCG) (1993 and 2010), http://sestat.nsf.gov.

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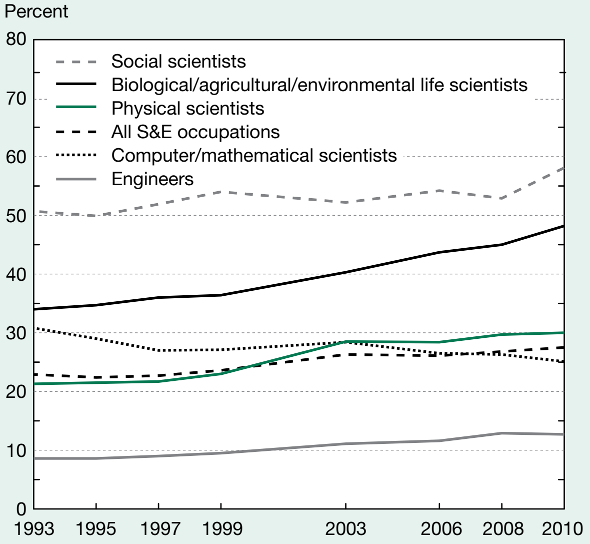
Figure O-29

Women in S&E occupations: 1993–2010



NOTE: National estimates were not available from the Scientists and Engineers Statistical Data System (SESTAT) in 2001.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (1993–2010), http://sestat.nsf.gov.

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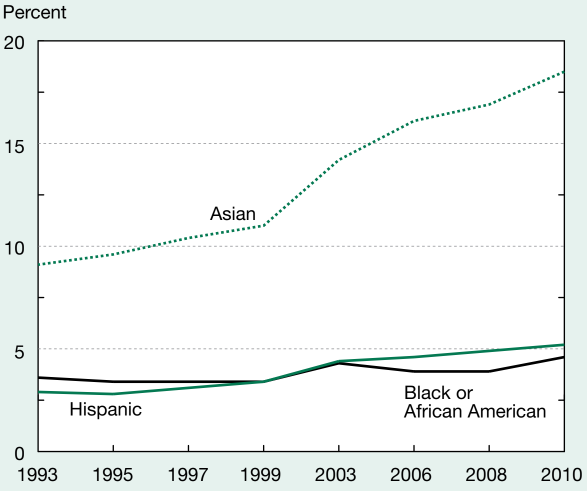
Figure O-30

Share of workers in S&E occupations, by selected race and ethnicity: Selected years, 1993–2010



NOTES: Before 2003, Asian included Native Hawaiians and Other Pacific Islanders. Hispanic may be any race. Asian and black or African American refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (1993–2010), http://sestat.nsf.gov.

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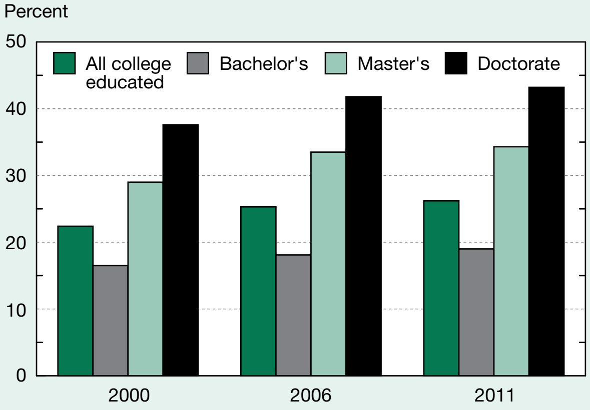
Figure O-31

Foreign-born workers in S&E occupations, by education level: 2000, 2006, and 2011



NOTES: All college educated includes professional degrees not broken out separately. These data include all S&E occupations except postsecondary teachers because these occupations are not separately identifiable in the source data files.

SOURCES: Census Bureau, 2000 Decennial Census Public Use Microdata Sample (PUMS), and American Community Survey (2006, 2011).

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one-third were born in China (23%) and India (13%) (figure O-32). After rising for most of the 2000–09 decade, the number of foreign recipients of U.S. S&E doctoral degrees declined in 2009 and 2010. Newer data indicate a slight increase, suggesting that the decline may have been temporary.

R&D Funding

Of the more than $420 billion of U.S. R&D funding, over 90% comes from either the business sector (63% in 2011) or the federal government (30% in 2011). These proportions have been relatively stable over the last decade (69% and 25%, respectively, in 2000). Consistent with the growing commercial relevance of systematic knowledge, business sector funding as a proportion of overall R&D funding increased rapidly for over 30 years beginning in 1965. In the last two decades, however, federal funding has also increased substantially, and the ratio between U.S. federal and business sector R&D funding has been relatively stable, with U.S. federal funding being somewhat less than half the size of business sector spending on R&D since the mid-1990s. Thus, although federal funding as a proportion of national R&D had declined during the decades following World War II, the federal government has continued to fund a large and generally stable share of national R&D over the last decade (figure O-33).

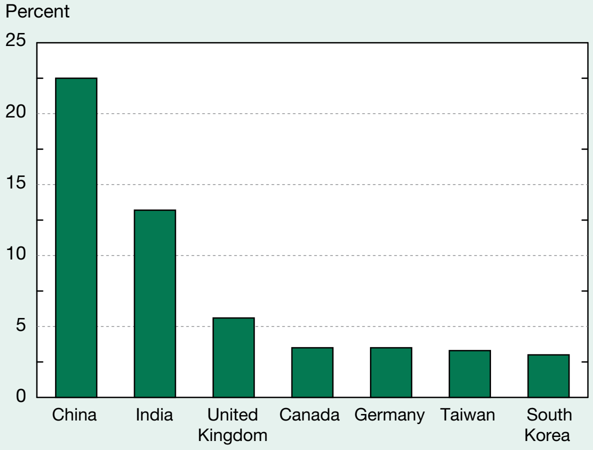
During the last two decades, the division in national R&D among basic research, applied research, and development has also been fairly stable (18%, 19%, and 63%, respectively, in 2011). Different institutions tend to perform different kinds of R&D projects. In 2011, the business sector was the largest performer of R&D activities in the United States (70%) because it performed most of U.S. applied research (57%) and development (88%). It executes relatively little basic research (17% in 2011). The academic sector, which performed only 15% of national R&D in 2011, in contrast, accounted for most U.S. basic research (55%).

In many respects, federal funding patterns show substantial continuity. Thus, the Department of Defense has continually accounted for more than half of annual federal R&D spending. Likewise, federal funding consistently has been the main source of funding for academic R&D. Over the last decade, the federally funded proportion of R&D at public academic institutions increased from 52% (1999) to 58% (2012). At private institutions, it remained roughly constant, at or around 72% (figure O-34). For all academic institutions, the share of academic R&D expenditures that is funded by the institutions themselves has increased substantially over the last four decades. It grew from about 12% in 1972 to approximately 19% in 1990 and has remained relatively stable since then.

Federal R&D spending over the last two decades has changed substantially in one respect: health-related R&D has grown sharply, going from 12% of total federal R&D budget authority in FY 1980 to 22% in FY 2011. A corresponding major shift has occurred in the distribution of academic R&D expenditures among S&E fields, which has moved away from physical sciences and toward the life sciences. Data on research space at academic institutions and publications likewise reflect a more dominant role for life sciences in academic R&D.

During the international financial crisis that started in late 2008, the three institutional sectors mainly responsible

Figure O-32
Foreign-born individuals with highest degree in S&E living in the United States, by place of birth: 2010

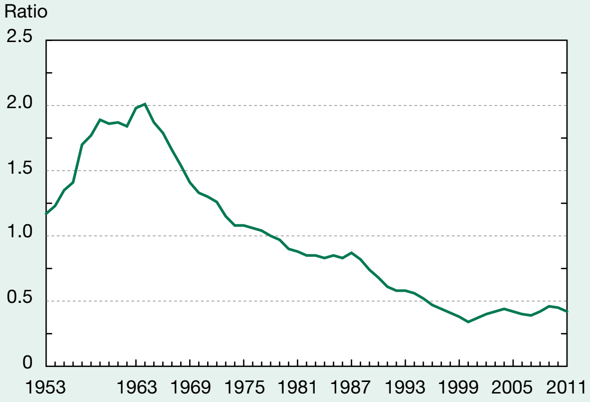


NOTE: Only countries/economies with shares of 3% or more are shown.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (2010), http://sestat.nsf.gov.

Science and Engineering Indicators 2014

Figure O-33
Ratio of U.S. federal-to-nonfederal funding for R&D: 1953–2011



NOTE: Federal R&D/gross domestic product ratios represent the federal government as a funder of R&D by all performers; the nonfederal ratios reflect all other sources of R&D funding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

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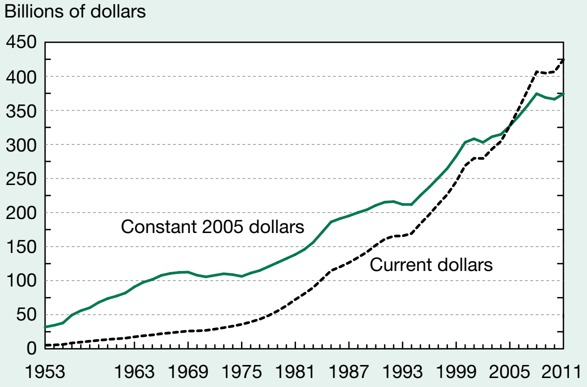
for R&D funding and performance—business, universities and colleges, and the federal government—faced budgetary challenges. Many businesses were unable to secure credit or were unwilling to make investments in view of uncertainty about the length and the intensity of the economic downturn. Universities and colleges faced steep budget cuts, prompted by declining state appropriations or shrinking endowments. Along with many governments across the world, the federal government took on unexpected and unprecedented financial commitments to guarantee the integrity of the international and national financial systems.

Consequently, R&D investments in all three sectors were curtailed and broke away from their long-term growth trend. In the United States, for the first time in 50 years, R&D expenditures remained stagnant in 2009 (figure O-35). The main reason for this was a sharp reduction in business R&D. The overall national impact was tempered by the infusion of American Recovery and Reinvestment Act of 2009 (ARRA) R&D funding during the depths of the downturn. After ARRA funding subsided, business R&D growth led a rebound in overall national R&D. Figure O-36 illustrates the expenditures by various R&D funding sectors over the 5 years ending in 2011 (figure O-36).

While R&D expenditures have recovered to some extent, the deviation from the overall long-term trend remains discernible in the data. Adjusted for inflation (in 2005 dollars), R&D expenditures in the United States for 2011 ($374.4 billion) were about the same as in 2008 ($374.5 billion).

Figure O-35

U.S. total R&D expenditures: 1953–2011



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix table 4-2.

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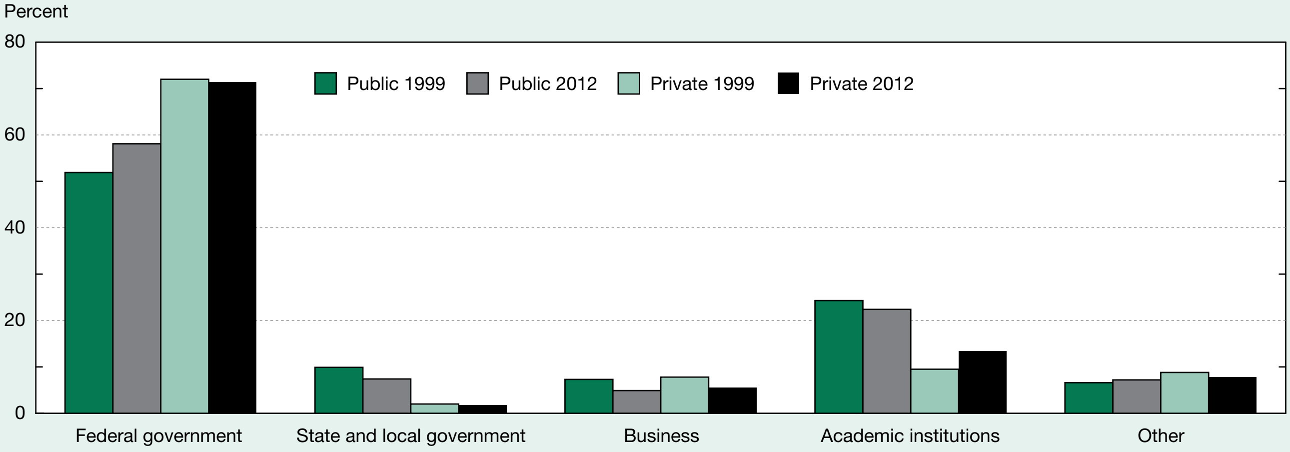
Figure O-34

Sources of S&E R&D funding for public and private academic institutions: FYs 1999 and 2012



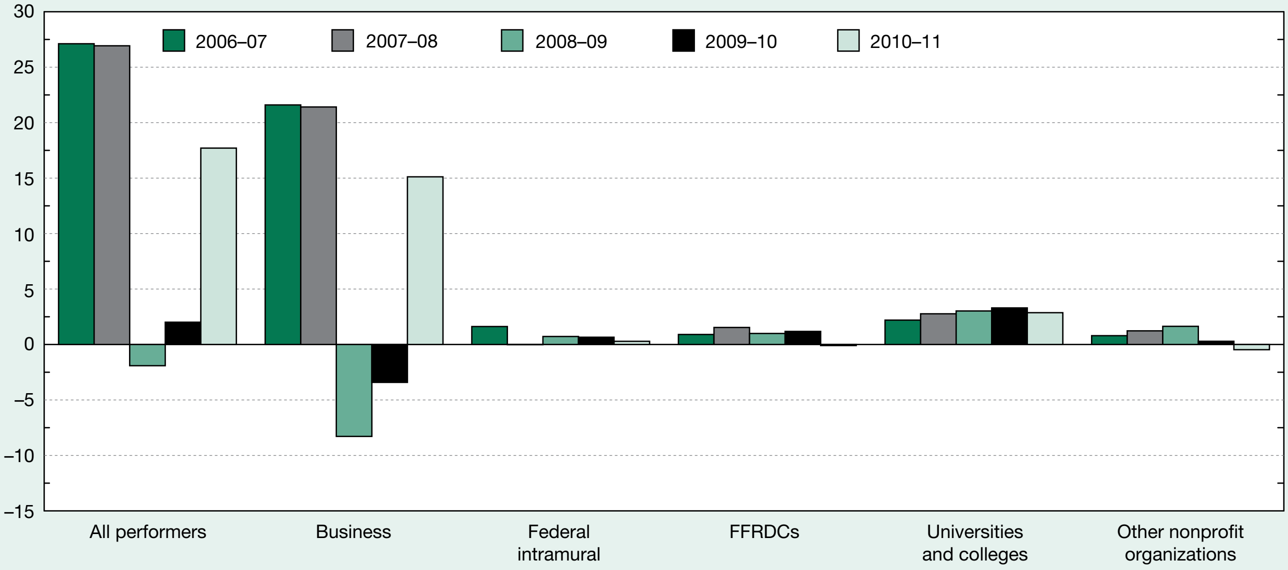
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Academic Research and Development Survey and the Higher Education Research and Development Survey (various years).

Science and Engineering Indicators 2014

Figure O-36

Year-to-year changes in U.S. R&D expenditures, by performing sector: 2006–11

Billions of current dollars



FFRDC = federally funded R&D center.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

Science and Engineering Indicators 2014

Conclusion

In recent decades, the implications of investment in science and engineering and in knowledge- and technology-intensive industries for economic prosperity have become increasingly important. This is indicated by the rise in knowledge- and technology-intensive production and trade and by increased investments in R&D across the world.

The global economic downturn had a significant impact on S&E-related trends, especially in developed economies. Its effects included increased funding uncertainty affecting R&D activities and changes in institutions of higher learning, such as more reliance on nontenured positions. During the downturn, economic activity involving S&E increased in the developing world, continuing the gradual shift in the world's knowledge-based economic activity toward developing nations and away from developed ones. The increase was pronounced in Asia but also notable in other parts of the developing world. Knowledge-intensive services in developing countries grew rapidly, especially in China.

U.S. knowledge- and technology-intensive industries, as well as the U.S. economy generally, weathered the global economic downturn better than comparable industries and economies in the EU and Japan. Smaller, more recently developed economies in South Korea and Taiwan also withstood the downturn relatively well.

Concurrent with the downturn, several emerging economies demonstrated significant growth in scientific output, as measured by publications and patents. The growth in publication output in China was striking, and the influence of China's publications also increased. In addition, rapid growth (6%–9% average annually) in three other Asian locations—South Korea, Taiwan, and Singapore—also reduced the global share of S&E publication by the United States, the EU, and Japan.

Recently developed economies are becoming better positioned to challenge the S&E leadership of developed economies. Economies such as South Korea, Taiwan, and Singapore, with their emphasis on high-quality education, are poised to narrow the gap. China, with a per capita income comparable to other developing countries, is unique among developing countries in having a global presence in knowledge- and technology-intensive economic activity and R&D performance that is comparable to or exceeds that of most long-standing developed countries.

As the world economy has changed, the U.S. S&E enterprise has also undergone substantial changes in the last two decades. The recent economic downturn disturbed the continuity of trends that had characterized the major institutions that fund and perform U.S. R&D and that provide advanced training in S&E. Such breaks in long-term patterns included lower R&D investments by businesses as well as slightly decreased stay rates of foreign recipients of advanced S&E degrees. However, many of those developments appear to have been temporary, and there are signs of a return to predownturn patterns and trends.

Nevertheless, the ongoing economic recovery has brought with it indications of emerging changes in S&E education and R&D. Potentially disruptive developments include the emergence of massive open online courses as an avenue for trying to reduce the cost of higher education and the continuing R&D budget uncertainty that accompanies a difficult fiscal environment.

As more countries around the world develop R&D and human capital infrastructure to sustain a knowledge-oriented economy, the United States, not surprisingly, is playing a less dominant role in many areas of S&E-related activity. However, it remains the world's leading nation in numerous indicators of S&E activity, such as high-value patenting, that can have a large impact on innovation and economic growth. Moreover, the increasing interconnectedness of both the global economy and the international scientific community may provide opportunities for improvements in U.S. S&E and the U.S. economy and also for increased sharing of the gains of international R&D.

Notes

1. Countries classified by the World Bank as high income are developed countries, while those classified in the other income levels—upper middle income, lower middle income, and low income—are classified as developing. Russia, which the World Bank recently classified as a developed country, reported a substantially higher proportion (54%) of KTI activity in its economy in 2012 than the United States. However, large year-to-year fluctuations in Russian estimates (e.g., from 30.7% in 2005 to 38.9% in 2006) strongly suggest that these data are not reliable.

2. The East and Southeast Asia region includes China, Indonesia, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand.

3. The rapid decline in this measure for China in 2008–09 is due to a methodological change. Since 2009, China has collected data on researchers using the international statistical system definition of researcher in the OECD *Frascati Manual*, whereas earlier Chinese data often used a more expansive United Nations Educational, Scientific and Cultural Organization (UNESCO) concept (see [OECD 2012:29]).

4. Changes in data collection practices in South Korea and China make comparisons of recent data with pre-2006 data (for South Korea) and pre-2009 data (for China) problematic.

5. The Population White Paper published in early 2013 estimates that the number of Singaporeans in "Professional, Managerial, Executive and Technical (PMET) jobs" (NPTD 2013:4), which are roughly equivalent to S&E occupations, is expected to rise by nearly 50% to about 1.25 million, compared to 850,000 today.

6. The article counts, coauthorships, and citations discussed here are derived from publications data recorded by the Science Unit of Thomson Reuters in the Science Citation Index and Social Sciences Citation Index (http://www.thomsonreuters.com/business_units/scientific/). Chapter 5 (sidebar "Bibliometric Data and Terminology") provides details about how publication indicators are tabulated.

7. If a country receives 10% of the citations in the worldwide scientific literature, its expected number of citations by any given country would be 10% of that country's total citations. Similarly, if a country is credited with authorship of 10% of the world's internationally coauthored articles, it would be expected to coauthor 10% of the international articles attributed to any other country. A more detailed explanation of citation and coauthorship indexes can be found in chapter 5 under the sidebar "Normalizing Coauthorship and Citation Data."

8. In these data, articles are attributed to different U.S. academic institutions only when the authors are from different universities or colleges, not when they come from different units of the same university or college (e.g., the engineering school and the economics department). In contrast, chapter 5 treats all articles whose authors report different institutional addresses as instances of interinstitutional collaboration, even when the addresses are part of the same university. Using the less stringent chapter 5 collaboration indicator, the increase in the proportion of U.S. academic articles involving interinstitutional collaboration shows a similar trend, rising from 34% in 1990 to 51% in 2012. International data in the overview use the chapter 5 collaboration indicator; international data unifying different addresses that can be considered part of the same institution are not currently available.

9. Full-time, tenure-track faculty positions as either senior or junior faculty continue to be the norm in academic doctoral employment. Such positions constituted about 90% of academic doctoral positions in the early 1970s but had dropped to about 80% by the mid-1990s and to about 70% by 2010.

10. The Carnegie Classification of Institutions of Higher Education considers doctorate-granting universities that award at least 20 doctoral degrees per year to be *research universities*. The 2010 Carnegie Classification includes three subgroups of research universities based on the level of research activity: very high research activity (108 institutions), high research activity (99 institutions), and doctoral/research universities (90 institutions).

Glossary

European Union (EU): As of June 2013, the EU comprised 27 member nations: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Croatia joined the EU in July 2013. Unless otherwise noted, Organisation for Economic Co-operation and Development data on the EU include all 28 members; data on the EU from other sources are limited to the 27 nations that were members as of June 2013.

High-technology (HT) manufacturing: Includes air- and spacecraft; pharmaceuticals; office, accounting, and computing machinery; radio, television, and communication equipment; and medical, precision, and optical instruments.

Knowledge- and technology-intensive (KTI) industries: They consist of high-technology manufacturing and knowledge-intensive service industries.

Knowledge-intensive (KI) services: Includes commercial business, financial, and communication services and largely publicly supported education and health services. Commercial KI services exclude education and health.

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Chapter 1

Elementary and Secondary Mathematics and Science Education

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Highlights

Student Learning in Mathematics and Science

U.S. fourth and eighth graders have made substantial gains in mathematics since 1990. Although eighth grade scores show a continuous upward trend, fourth grade scores leveled off during recent years. In science, 2011 eighth graders performed slightly better than their counterparts tested in 2009.

- The average mathematics score at grade 4 rose by 27 points from 1990 to 2007 and then remained essentially flat from 2007 to 2011.
- The average mathematics score at grade 8 increased steadily from 1990 to 2011 with a total gain of 21 points over the period.
- The average science score at grade 8 improved slightly, increasing from 150 in 2009 to 152 in 2011. (Earlier science assessment scores were not comparable with recent ones because of framework changes).

Despite improvement, relatively few students reached their grade-specific proficiency levels in mathematics and science on the 2011 National Assessment of Educational Progress.

- In mathematics, the percentage of students reaching the proficient level remained well below half in 2011: 40% of fourth graders and 35% of eighth graders performed at or above this level.
- In science, 32% of eighth graders performed at or above the proficient level for their grade in 2011.

Performance disparities in mathematics and science were evident among different demographic groups at grades K, 4, and 8. Some score gaps narrowed over time, however.

- At grades K, 4, and 8, students from low-income families or homes where the primary language used was not English had lower mathematics and science scores than their peers from more advantaged backgrounds.
- Black, Hispanic, and American Indian or Alaska Native students performed substantially lower than their white and Asian or Pacific Islander counterparts.
- Sex differences in achievement were generally small and favored boys in most cases. Among black students, however, girls performed better.
- Some gaps in mathematics narrowed over time at grade 4. Between 1990 and 2011, the score gaps decreased between white and black students (from 32 to 25 points) and between low- and high-performing students (i.e., at the 10th and 90th percentiles) (from 82 to 73 points).
- Some gaps in science also narrowed somewhat during the relatively short period of time from 2009 to 2011. The white-black gap decreased from 36 to 34 points. The white-Hispanic gap fell from 30 to 26 points. The gap between low- and high-performing students dropped from 89 to 87 points.

Although U.S. fourth and eighth graders outperformed students in many other countries/jurisdictions on the 2011 Trends in International Mathematics and Science Study (TIMSS) tests, they were not among the very top-achieving groups in the world.

- The U.S. average score on the 2011 TIMSS mathematics assessment was substantially lower than those of seven countries/jurisdictions at grade 4 and those of six countries/jurisdictions at grade 8. The top performers—Singapore, Republic of Korea, and two cities (Hong Kong and Taipei)—each scored at least 50 points higher than the United States at grade 4 (591−606 versus 541) and at least 77 points higher than the United States at grade 8 (586−613 versus 509).
- Between 1995 and 2011, U.S. fourth and eighth graders improved both their scores and international ranking in mathematics. In science, U.S. eighth graders' performance improved, but their relative international ranking was unchanged. U.S. fourth graders' science performance did not change, and their relative international position slipped.

Student Coursetaking in Mathematics and Science

Algebra 1 and biology 1 were the most common subjects taken by ninth graders in 2009.

- In mathematics, 52% of ninth graders reported enrollment in algebra 1. In addition, 29% reported enrollment in courses above algebra 1, such as geometry.
- In science, 38% of ninth graders reported enrollment in biology 1, with 32% in earth/environmental/physical science courses and 7% in courses above biology 1.
- Nearly twice as many ninth graders reported no science enrollment (18%) as reported no mathematics enrollment (10%).

Ninth grade coursetaking in mathematics and science in 2009 varied by parental education and socioeconomic status (SES).

- Students who had at least one parent with a master's degree or higher were more than twice as likely to report enrollment in a mathematics course above algebra 1 (51%) as were their peers whose parents had less than a 4-year college degree (22%).

- More than one-fourth of students in the lowest SES category reported no science enrollment (27%), compared with 11% of students in the highest SES category.
- About 17% of students in the lowest SES category reported no mathematics enrollment, compared with 6% of those in the highest SES category.

The number of students taking at least one Advanced Placement (AP) exam in mathematics or science has doubled in the past decade from 250,000 students in the class of 2002 to 500,000 students in the class of 2012.

- Calculus AB and biology were the most popular AP exams in mathematics and science, with 212,000 students in the graduating class of 2012 taking calculus AB and 153,000 students taking biology.
- Although more students in the class of 2012 were taking AP exams, the AP program in mathematics and science involved a relatively small proportion of all high school students. Just 17% of all students took an AP mathematics or science exam, with 9% passing.

Although increasing numbers of students are taking AP exams, passing rates (a score of 3 or higher out of 5) have declined or remained steady in most mathematics and science subjects.

- The overall passing rate for any AP mathematics or science exam dropped from 62% in 2002 to 54% in 2012.
- The two most popular exams, calculus AB and biology, showed the largest decreases, with average passing rates dropping by 9 percentage points for calculus AB and 13 percentage points for biology since 2002.

The proportion of male and female students in the class of 2012 taking mathematics and science exams varied by subject. Black and Hispanic students were underrepresented among AP exam takers.

- Male students were more likely than female students to take advanced AP courses, including calculus BC (59% versus 41%), physics B (65% versus 35%), and both physics C courses (about 75% versus 25%).
- Female students were more likely than male students to take AP exams in biology (59% versus 41%) and environmental science (55% versus 45%). Male students were four times more likely than female students to take the computer science A exam (81% versus 19%).
- Black students made up about 15% of the 2012 graduating class, but they represented less than 8% of students taking any AP mathematics or science exam.
- Hispanic students made up about 18% of the class of 2012, but their representation among AP exam takers ranged from a high of 15% for environmental science to a low of 8% for calculus BC and 7% for physics C: electricity/magnetism.

Teachers of Mathematics and Science

Novice science teachers—those with 2 or fewer years of experience—are more prevalent at schools with the highest proportions of low-income and non-Asian minority students.

- In 2012, 23% of science classes at schools with the highest concentrations of students eligible for free/reduced-price lunch (i.e., 75%–100% of students) were taught by novice teachers, compared with 10% of science classes at schools with the lowest concentrations of free/reduced-price lunch-eligible students (i.e., 0%–25% of students).
- Similarly, 21% of science classes at schools with the highest concentrations of non-Asian minority students were taught by novice teachers, compared with 14% of classes at schools with the lowest concentrations of non-Asian minority students.
- Students in high-poverty schools were more likely to have novice teachers in science than in mathematics: 23% of science classes compared with 14% of mathematics classes were taught by teachers with 2 or fewer years of experience.

A majority of high school mathematics and science teachers hold degrees in their teaching field or in science or mathematics education.

- In 2012, 73% of high school mathematics teachers had an undergraduate or graduate degree in mathematics or mathematics education, and 82% of high school science teachers had an undergraduate or graduate degree in science (any subject), engineering, or science education.
- A small percentage (4%–5%) of elementary school teachers of mathematics or science held a degree in mathematics or science.
- Mathematics and science classes with the highest concentrations of non-Asian minority students or the lowest-achieving students were less likely to be taught by teachers with a degree in their teaching field.

Elementary teachers are much more confident in their ability to teach mathematics than in their ability to teach science.

- In 2012, 77% of elementary teachers reported feeling very well prepared to teach mathematics, compared with 39% reporting they felt very well prepared to teach science.
- About half of mathematics and science teachers at most levels felt very well prepared to encourage the participation of female students in mathematics and science. Elementary teachers of science were an exception—only 30% felt well prepared to encourage female students to participate in science.

A majority of middle and high school mathematics and science teachers participated in at least one professional development activity that focused on mathematics or science in the 3 years prior to 2012.

- The participation rate for middle and high school mathematics and science teachers ranged from 82% to 89%.
- Among elementary school teachers, 87% participated in at least one math professional development activity, and 59% participated in at least one science professional development activity in the 3 years prior to 2012.
- In 2012, 32% of high school mathematics teachers and 36% of high school science teachers reported that they had spent more than 35 hours in subject-specific professional development activities during the prior 3 years. Far fewer elementary school teachers of mathematics (11%) or science (4%) reported participating in subject-specific professional development activities for more than 35 hours.

Overall, schools are more supportive of mathematics instruction than science instruction.

- In 2012, 82% of mathematics program representatives reported that the importance their school placed on mathematics teaching promoted effective instruction in mathematics, whereas 60% of science program representatives reported that this was the case.
- About 70% of mathematics program representatives, compared with about 50% of science program representatives, reported that school management of instructional resources promoted effective instruction in mathematics or science.
- Various problems were viewed as serious barriers to effective instruction. For mathematics instruction at the high school level, the most frequently cited problem was low student interest in mathematics. At the elementary level, low student reading abilities was the most frequently cited barrier to effective mathematics instruction.
- For science instruction, frequently cited problems included inadequate funds for purchasing equipment and lack of science facilities. At the elementary level, more than one-quarter of program representatives reported insufficient time to teach science as a serious problem for science instruction.

Secondary mathematics and science teachers had higher 3-year attrition rates than did their colleagues who taught at the elementary level or taught other fields at the secondary level.

- Among teachers who began teaching in 2007–08, one-quarter of secondary mathematics and science teachers had left teaching by 2009–10, compared with 11% of elementary teachers and 10% of secondary teachers of other fields.

Instructional Technology and Digital Learning

Access to the Internet in U.S. schools is nearly universal.

- In 2008, 98% of U.S. public school classrooms had Internet access, and the ratio of students to instructional computers was 3:1, compared with a ratio of 7:1 in 2000.

An increasing number of students have access to and are enrolling in distance education, particularly online learning.

- Online learning programs range from programs that are fully online with all instruction occurring via the Internet to hybrid or "blended learning" programs that combine face-to-face teacher instruction with online components.
- More than 1 million elementary and secondary students were enrolled in online or blended learning courses in 2007–08, a 47% increase from 2005–06.
- A recent nationally representative survey of public school districts found that providing courses not otherwise available at their schools and providing students with opportunities to recover course credits from classes missed or failed were the top reasons for offering online learning options.

Rigorous research examining the impact of instructional technology and online learning on student achievement remains limited.

- Three recent rigorous meta-analyses compared the mathematics achievement of students taught in classes using technology-assisted mathematics programs with that of students in control classes using standard methods. All three studies found small positive effects when technology was incorporated into classroom mathematics instruction.

Transition to Higher Education

Rates of students graduating within 4 years of entering ninth grade ("on-time" graduation) have increased in recent years, but differences among racial and ethnic groups persist.

- In 2010, 78% of public school students completed high school on time, up from 73% in 2006. All racial and ethnic groups made progress during this period, with improvement ranging from 3 percentage points for white students to 10 percentage points for Hispanic students.
- In 2010, Asian or Pacific Islander and white students graduated on time at a higher rate (94% and 83%, respectively) than did black, Hispanic, and American Indian or Alaska Native students (66%, 71%, and 69%, respectively).

The U.S. high school graduation rate lags behind those of many developed nations.

- The United States ranked 22nd out of 26 Organisation for Economic Co-operation and Development (OECD) countries for which graduation rate data were available in 2010, with an average graduation rate of 77% among the population of 18-year-olds, compared with the OECD average of 84%.
- The relative standing of U.S. high school graduation rates did not improve between 2006 and 2010, ranking 16th in both 2006 and 2008 and 17th in 2010 among the 21 OECD countries with available data.

The majority of U.S. high school graduates enroll in a postsecondary institution immediately after high school completion, but a sizeable percentage of entering students need remedial courses to prepare themselves for college-level work.

- Close to 70% of 2011 high school graduates had enrolled in a postsecondary institution by the October following high school completion, an increase of 17 percentage points since 1975.
- Relatively more female graduates than male graduates enrolled immediately in postsecondary education in 2011 (72% versus 65%).
- Students from high-income families enrolled at a higher rate (82%) than did students from middle-income (66%) or low-income families (53%).
- Internationally, the percentage of U.S. young adults enrolling in university-level education for the first time was 74% in 2010, above the OECD average of 62%. Among 30 OECD countries for which data were available, the United States ranked 9th.
- Half of beginning postsecondary students took some type of remedial course after entering college in 2003−04. The math remediation rate was 57% for those entering 2-year institutions and 29% for those entering 4-year institutions.

Introduction

Chapter Overview

U.S. education reform at the elementary and secondary levels continues to focus on improving students' learning. Reform goals include increasing student achievement, reducing performance gaps between students in different demographic groups, and raising the international ranking of U.S. students from the middle to the top on international tests (The White House n.d.).[1] Although policymakers have remained committed to these goals, strategies and efforts to promote them have shifted over time. Most recently, the federal government has given states seeking to meet these goals more flexibility by granting them waivers from the stringent standards required by the No Child Left Behind Act of 2001 (NCLB).[2] In exchange for the waivers, the states agreed to undertake essential reforms to raise standards, improve accountability, and enhance teacher effectiveness (U.S. Department of Education 2012a). In addition, the federal government created the Race to the Top (RTTT) grant program, inviting states to voluntarily participate in this program designed to promote state-led reform efforts (U.S. Department of Education 2009, 2011). Through grant competition, RTTT encourages states and local school districts to design and implement their own reform plans to address their unique educational challenges (see sidebar, "Race to the Top").

Concern about the ability of the United States to compete in the global economy has also lent urgency to calls for reform of science, technology, engineering, and mathematics (STEM) education (National Academy of Science 2005; NSB 2007). Federal and state policymakers and legislators have called for national efforts to develop a strong STEM pathway from high schools to colleges that eventually will expand the STEM-capable workforce in the United States (Kuenzi 2008; NGA 2011; President's Council of Advisors on Science and Technology 2012; The White House n.d). At the K–12 level, reform efforts to improve mathematics and science learning include increasing advanced coursetaking in these areas, promoting early participation in gatekeeper courses such as algebra 1, recruiting and training more mathematics and science teachers, designing new curricular standards for mathematics and science learning, and expanding secondary education programs that prepare students to enter STEM fields in college (Engberg and Wolniak 2013). Recently, the National Research Council (NRC) began working with the National Science Foundation (NSF) and the U.S. Department of Education to develop a new set of indicators that will track national progress in K–12 mathematics and science teaching and learning (see sidebar, "Monitoring Progress Toward Successful K–12 STEM Education").

Chapter Organization

To provide a national portrait of K–12 STEM education in the United States, this chapter compiles indicators of precollege mathematics and science learning based mainly on data from the National Center for Education Statistics (NCES) of the U.S. Department of Education. Table 1-1 contains an overview of the topics covered in this chapter and the indicators used to address them.

This chapter is organized into five sections. The first section begins with data from a new longitudinal study of U.S. kindergartners conducted in 2010–11. These data provide

Race to the Top

Race to the Top (RTTT) is a $4.35 billion competitive grant program funded by the U.S. Department of Education as part of the American Recovery and Reinvestment Act of 2009 (U.S. Department of Education 2009). The program provides monetary incentives for states and school districts to create conditions for education innovation and reform that would significantly improve student achievement (particularly in mathematics and science), narrow learning gaps, increase high school graduation rates, and increase the number of students admitted to college. To achieve these outcomes, RTTT focuses on reform strategies in four core areas:

- Adopting standards and designing assessments that prepare students to succeed in college and the workplace and to compete in a global economy;
- Building data systems that measure changes in student achievement and informing teachers and principals about how they can improve instruction;
- Recruiting, developing, rewarding, and retaining effective teachers and principals, especially where they are needed most; and
- Improving the performance of the lowest-achieving schools.

Since the launch of RTTT in 2009, a total of 18 states and the District of Columbia have won awards. In 2012, the Obama Administration launched an RTTT competition at the school district level. Known as Race to the Top–District, this program focuses on changes within schools and is targeted at supporting locally developed plans for improving classroom practices and resources. As of December 2012, the program made awards to 16 school districts across the nation. Additional information about RTTT is available at http://www2.ed.gov/programs/racetothetop/index.html.

Table 1-1
Indicators of elementary and secondary school mathematics and science education

Topic	Indicator
Student learning in mathematics and science	• Mathematics and science performance of first-time kindergarten students in the 2010–11 school year • Trends in fourth and eighth graders' mathematics performance from 1990 to 2011 • Eighth graders' science performance in 2009 and 2011 • International comparisons of fourth and eighth graders' mathematics and science achievement in 2011
Student coursetaking in mathematics and science	• Highest level of mathematics and science coursetaking by high school freshmen in 2009 • Trends in participation and performance in Advanced Placement program from 2002 to 2012 • High school Advanced Placement mathematics and science course offerings in 2012
Teachers of mathematics and science	• Experience, certification, and subject-matter preparation of mathematics and science teachers in 2012 • Professional development of mathematics and science teachers in 2012 • Working conditions of mathematics and science teachers in 2012 • Attrition rates of beginning public school teachers from 2007–08 to 2009–10
Instructional technology and digital learning	• Term definitions and review of emerging policies, practices, and the effects of instructional technology and distance education on student learning
Transitions to higher education	• Trends in on-time high school graduation rates from 2006 to 2010 • International comparisons of secondary school graduation rates in 2010 • Immediate college enrollment from 1975 to 2011 • Remedial coursetaking among 2003–04 beginning postsecondary students • International comparisons of college enrollment rates in 2010

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Monitoring Progress Toward Successful K–12 STEM Education

In 2011, the National Research Council (NRC 2011) articulated three goals for K–12 STEM education:

♦ Expand the number of students who ultimately pursue advanced degrees and careers in STEM fields and broaden the participation of women and minorities in those fields;

♦ Expand the STEM-capable workforce and broaden the participation of women and minorities in that workforce; and

♦ Increase science literacy for all students, including those who do not pursue STEM-related careers or additional study in the STEM disciplines.

The NRC concluded that realizing these goals would require changing the way that STEM subjects are taught. Accordingly, the NRC recommended that the United States needs to systematically monitor national progress toward achieving these goals and commissioned a group of experts to develop indicators that, taken together, could constitute a viable monitoring system. This system will be based on recommendations from national reports that provide evidence supporting "best practices." The NRC recently released a report that identifies 14 indicators for monitoring progress in STEM teaching and learning (NRC 2012b). Once fully developed, this system of indicators will measure student knowledge, interest, and participation in the STEM disciplines and STEM-related activities; track financial, human capital, and material investments in K–12 STEM education at the federal, state, and local levels; provide information about the capabilities of the STEM education workforce, including teachers and principals; and facilitate strategic planning for federal investments in STEM education and workforce development when used with labor force projections.

Working closely with the U.S. Department of Education, NSF has also undertaken several activities to build the proposed system of indicators. These activities include the following:

♦ Determining what data and data collection vehicles currently exist that could be used or modified to enable these indicators to be tabulated and reported;

♦ Fully developing operational definitions of the proposed new indicators; and

♦ Engaging stakeholders in the STEM policy community and experts in the collection of national statistical data to identify the best methods to collect these data.

a snapshot of kindergarten students' status as they enter school, including baseline measures of their mathematics and science performance. This section then covers elementary and secondary students' performance on standardized mathematics and science assessments, focusing on recent trends in student performance, changes in performance gaps among different groups, and the international standing of U.S. students vis-à-vis their peers abroad.

The second section focuses on mathematics and science coursetaking in high school. It begins by examining ninth graders' enrollment in mathematics and science courses, providing information on what courses students take as they enter high school. The section then uses data from the College Board to examine trends in participation and performance in the STEM-related Advanced Placement (AP) programs among high school graduating classes. High school course completion data from the most recent transcript studies were reported in the 2012 edition of *Science and Engineering Indicators*; no new course completion data were available for this volume. Therefore, this section is somewhat limited because of fewer data.

The third section turns to U.S. elementary, middle, and high school mathematics and science teachers in 2012, examining their experience, licensure, subject matter preparation, professional development, and working conditions. In addition, this section presents new data on beginning mathematics and science teachers' attrition in the first 3 years of teaching.

The fourth section examines how technology is used as an instructional tool in K–12 education. In the absence of nationally representative data, this section mainly provides a literature review, focusing on term definitions, emerging policies and practices, and the latest research findings on the effects of instructional technology and distance education on student learning in mathematics and science.

The last section presents indicators of student transitions from secondary to postsecondary education—the subject of chapter 2 in this volume. Updated indicators include on-time high school graduation rates, immediate college enrollment rates, and international comparisons of high school graduation rates and postsecondary enrollment. This section also includes data on remedial coursetaking by beginning postsecondary students, an indicator of the extent to which secondary schools prepare entering students for college-level work.

This chapter focuses primarily on national patterns and trends, but it also discusses variation in student performance or access to educational resources by demographic, family, and school characteristics.[3] Because of the unavailability of national data, this chapter cannot report indicators for many other activities that are important to understanding K–12 STEM education, such as use of high-quality mathematics and science curricular materials, time spent on mathematics and science learning, participation in STEM-related activities outside of school, and interest in pursuing a STEM degree and career. In addition, certain measures in this chapter may not capture the full dimension of the construct being examined (e.g., family poverty is determined by students' eligibility for free/reduced-price lunch instead of being calculated directly from family income). These limitations may impede providing a full picture of STEM education at the K–12 level.

Student Learning in Mathematics and Science

Increasing overall student achievement, especially lifting the performance of low achievers, is an essential goal of education reform in the United States. Reform efforts center on improving student learning in mathematics and science because these fields are widely regarded as critical to the nation's economy (Atkinson and Mayo 2010; President's Council of Advisors on Science and Technology 2012). This section presents indicators of U.S. student performance in mathematics and science, beginning with a snapshot of the mathematics and science test scores of a recent cohort of U.S. kindergartners. It then presents long-term trends in the mathematics and science performance of U.S. fourth and eighth graders,[4] examining more than two decades of changes in overall performance and in gaps between different groups. The section ends by placing U.S. student performance in an international context, comparing U.S. fourth and eighth graders' mathematics and science test scores with those of their peers in other nations.

Mathematics and Science Performance During the Kindergarten Year

The Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011) is a nationally representative, longitudinal study of children's development, early learning, and school progress (Mulligan, Hastedt, and McCarroll 2012). The study began with approximately 18,200 children in kindergarten in fall 2010 and will follow and test them every year until spring 2016, when most of them are expected to be in fifth grade. The study gathers information from many sources, including the students themselves, their families, teachers, schools, and before- and after-school care providers. These data provide a wealth of information on children's cognitive, social, emotional, and physical development; family and neighborhood environments; school conditions; and before- and after-school care. The longitudinal study design will enable research on how various family, school, community, and individual factors are associated with school performance over time. At the time this chapter was prepared, only data from the initial year of the study were available for analysis. This section, therefore, presents descriptive information on children when they enter school and their initial mathematics and science assessment results (mathematics and science assessment scores cannot be compared directly because scales are developed independently for each subject). This information will serve as a baseline for measuring students' progress on future assessments as they advance through elementary school. Findings from these assessments will be presented in future editions of *Science and Engineering Indicators*.

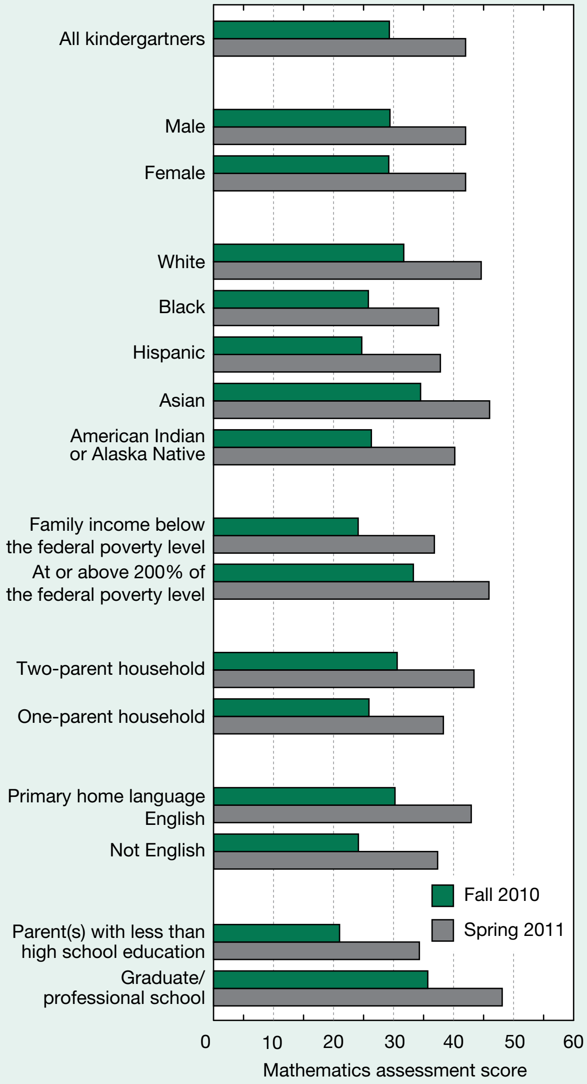
Demographic Profile of U.S. First-Time Kindergartners. In fall 2010, about 3.5 million U.S. children entered kindergarten for the first time (Mulligan, Hastedt, and McCarroll 2012). Students in this cohort came from diverse backgrounds: about two-fifths of kindergartners (38%) had at least one parent with a bachelor's degree or higher, 32% had parents who attended some college but did not earn a bachelor's degree, and 29% had parents with no more than a high school education (appendix table 1-1). About one-quarter of children were living in families with incomes below the federal poverty level (25%) or in single-parent households (22%). Fifteen percent of students came from families where the primary language used at home was not English. Nearly half (47%) were racial and ethnic minorities, with Hispanics being the largest minority group (24%), followed by blacks (13%) and Asians (4%).[5] The following analysis examines the size and direction of achievement differences among different groups at the outset of formal schooling.

Mathematics Performance.[6] Even as early as kindergarten, large gaps in mathematical understanding already exist among different subpopulations. Initial mathematics assessment scores varied by parental education level; for example, children whose parents had less than a high school education scored 15 points (on a scale of 0–75) below their peers whose parents attended a graduate or professional school (figure 1-1). Students from homes with a primary language other than English earned an average of 24 points on the initial mathematics test, compared with 30 points earned by those with a primary home language of English. Students from families with incomes below the federal poverty level scored 9 points below their peers from families with incomes at or above 200% of the federal poverty level. Those from single-parent households also did not perform as well as those from two-parent households (26 versus 31 points). The gaps were further evident among different racial and ethnic groups: black and Hispanic students lagged behind Asian students by 9 to 10 points and white students by 6 to 7 points.

By spring 2011, the overall average mathematics score of kindergartners had increased by 13 points, from 29 to 42, on the 0–75 scale (figure 1-1). All groups gained 12–13 points from fall 2010 to spring 2011. Although the performance gaps did not widen during this period, students' initial exposure to formal schooling did not help narrow these gaps either.

Science Performance. Overall, kindergartners earned an average of 11 points (on a scale of 0–20) on their initial science assessment administered several months after the beginning of the school year (appendix table 1-1). Like in mathematics, variations in science performance among kindergartners with different characteristics were evident at this early stage of schooling, and the pattern of variations was largely similar. For example, science assessment

Figure 1-1
Average mathematics assessment scores of first-time kindergartners, by child and family characteristics: Fall 2010 and spring 2011



NOTES: Mathematics assessment scores range from 0 to 75. Family's poverty level is based on 2010 U.S. Census poverty thresholds, which identify incomes determined to meet household needs given family size. For example, in 2010, a family of two was below the poverty threshold if its income was lower than $14,220. Parents' education is the highest level of education achieved by either of the parents or guardians in a two-parent household or by the only parent or guardian in a single-parent household. Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, and white refer to individuals who are not of Hispanic origin.

SOURCE: Mulligan GM, Hastedt S, McCarroll JC, *First-Time Kindergartners in 2010–11: First Findings From the Kindergarten Rounds of the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11* (ECLS-K:2011), NCES 2012-049 (2012). See appendix table 1-1.

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scores increased with parental education level, with children whose parents had less than a high school education scoring 4 points below their peers whose parents attended a graduate or professional school (9 versus 13 points). Kindergartners from homes with a primary home language other than English earned an average of 9 points on the initial science assessment, compared with 12 points earned by those with a primary home language of English. Those from households with incomes below the federal poverty level also had lower scores than their peers from households with incomes at or above 200% of the federal poverty level (10 versus 13 points). Among all racial and ethnic groups, white children earned the highest average score (12 points), followed by American Indian or Alaska Native and Asian children (about 11 points for both groups); black and Hispanic children earned the lowest average score (about 10 points for both groups).

Large gaps in student performance at the beginning of formal schooling suggest that nonschool factors play a big role in these disparities. Although a body of research has attempted to identify various factors underlying students' achievement gaps, efforts have mostly focused on school-related factors such as teacher quality, available resources, principal leadership, and school climate, or such nonschool factors as sex, race and ethnicity, and family socioeconomic status (SES) (Coleman et al. 1966; Corcoran and Evans 2008; Fryer and Levitt 2004; Greenwald, Hedges, and Laine 1996; Hanushek and Rivkin 2006; Lamb and Fullarton 2002; Leonidas et al. 2010; OECD 2005; Rivkin, Hanushek, and Kain 2005). Researchers are now turning their attention to a broader range of nonschool factors beyond students' demographic and socioeconomic backgrounds, and probing deeper into their roles in student achievement (Henig and Reville 2011) (see sidebar, "The Role of Nonschool Factors in Student Learning").

Mathematics and Science Performance in Grades 4 and 8

The National Assessment of Educational Progress (NAEP), a congressionally mandated study, has monitored changes in U.S. students' academic performance in mathematics, science, and other subjects since 1969 (NCES 2011a, 2012). NAEP has two assessment programs: the main NAEP and the NAEP Long-Term Trend (LTT).[7] The main NAEP assesses national samples of fourth and eighth graders at regular intervals, and twelfth graders on an occasional basis. These assessments are updated periodically to reflect changes in curriculum standards. The NAEP LTT assesses the performance of students ages 9, 13, and 17. Its content framework has remained the same since it was first administered in 1969 in science and in 1973 in mathematics, permitting analyses of trends over more than three decades. This section examines recent performance results using the main NAEP data only. The most recent available findings based on NAEP LTT data have been reported in previous editions of *Science and Engineering Indicators*.[8]

Reporting Results for the Main NAEP

The main NAEP reports student performance in two ways: scale scores and achievement levels. Scale scores use a continuous scale to measure student learning. For mathematics assessments, scales range from 0 to 500 for grades 4 and 8 and from 0 to 300 for grade 12. For science assessments, scales range from 0 to 300 for all grades. Scores cannot be compared across subjects because NAEP scales are developed independently for each subject.

In addition to scale scores, NAEP reports student results in terms of achievement levels. Developed by the National Assessment Governing Board (NAGB), achievement levels are intended to measure the extent to which students' actual achievement matches the achievement expected of them. Based on recommendations from panels of educators, policymakers, and the general public, NAGB sets three achievement levels for mathematics (NAGB 2010a), science (NAGB 2010b), and other subjects assessed by NAEP:

- *Basic* denotes partial mastery of materials appropriate for the grade level.
- *Proficient* indicates solid academic performance.
- *Advanced* represents superior academic performance.

Based on their test scores, students' performance can be categorized as *below basic, basic, proficient,* and *advanced*.[9] Achievement levels cannot be compared across grade levels because they were developed independently at each grade level.[10] Although the NAEP achievement levels can be helpful in understanding and interpreting student results and have been widely used by national and state officials, there is ongoing disagreement about whether they are appropriately defined (Harvey 2011). A study commissioned by the National Academy of Sciences judged the NAEP achievement levels to be "fundamentally flawed" (Pellegrino, Jones, and Mitchell 1999). In addition, the National Mathematics Advisory Panel concluded that NAEP scores for the two highest achievement categories (proficient and advanced) were set too high (NMAP 2008). Because of criticisms like these, NCES has recommended that achievement levels be used on a trial basis and interpreted with caution (NCES 2011a, 2012). The following review of NAEP results reports both average scale scores and the percentage of students performing at or above the proficient level.

Mathematics Performance from 1990 to 2011

Average Score. The average mathematics score of U.S. fourth graders increased by 27 points from 1990 to 2007, leveled off between 2007 and 2009, and then rose by 1 point from 2009 to 2011 (figure 1-2). This overall trend was reflected in almost all demographic groups,[11] across students at all performance levels (i.e., 10th to 90th percentiles[12]), and among students at both public and private schools. For example, from 1990 to 2007, the fourth grade average mathematics score increased substantially—by 28 points for white students, 34 points for black students, 27 points for Hispanic students, and 28 points for Asian or Pacific Islander students (appendix table 1-2). Average scores for these racial and ethnic groups remained unchanged between 2007 and 2009 and then increased by 1 or 2 points from 2009 to 2011.

Among U.S. eighth graders, the average mathematics score increased continuously from 1990 to 2011, with a total gain of 21 points over the period (figure 1-2). Although the scores of all demographic groups have improved substantially since 1990, not all groups have experienced this upward trend in recent years. For example, the average mathematics scores for male students, whites, Asians or Pacific Islanders, American Indians or Alaska Natives, and those attending private schools remained unchanged between 2009 and 2011 (appendix table 1-2). Groups that experienced score gains during this period included black

The Role of Nonschool Factors in Student Learning

The major national studies of student academic performance include only partial data on nonschool factors that can affect student learning. Nonschool factors often available from the major national studies used in this chapter include student's demographic characteristics (e.g., sex and race and ethnicity) and family backgrounds (e.g., family income, parental education, and the primary home language). Other nonschool factors such as personality traits, health and nutrition, and neighborhood characteristics matter for learning as well, but they are relatively difficult to measure and therefore rarely covered in the national studies on education and student achievement.

Research on nonschool factors dates back to the 1966 release of the report *Equality of Educational Opportunity* (Coleman et al. 1966), which examined the interrelationships among race and ethnicity, family characteristics, and student achievement. The authors of this report concluded that students' socioeconomic background (measured by parents' income, occupation, and education) was a far more influential factor than were school-related factors. Since then, this line of research has evolved, adding such familial factors as household structure, immigrant status, the primary home language, parenting style, and parental involvement and support as having an impact on student achievement. The findings of this research are generally consistent: students from low-income families, those whose parents have lower levels of educational attainment or are uninvolved in their children's education, and those who live in a single-parent household or a home where the primary language spoken is not English generally do not perform as well as students from more advantaged backgrounds (Aud, Fox, and KewalRamani 2010; Berliner 2009; Campbell et al. 2008; Hampden-Thompson and Johnston 2006; Jeynes 2005; Kreider and Ellis 2011; Lareau 2011; Lee and Burkham 2002; Mulligan, Halle, and Kinukawa 2012; Pong, Dronkers, and Hampden-Thompson 2003; Rothstein 2004; Schmid 2001; Spera 2005; Stockton 2011). Research further indicates that differential access to high-quality preschool care and programs, which is highly related to parental income, is a contributing factor to initial academic achievement gaps (Camilli et al. 2010; Chambers et al. 2010; Flanagan and McPhee 2009).

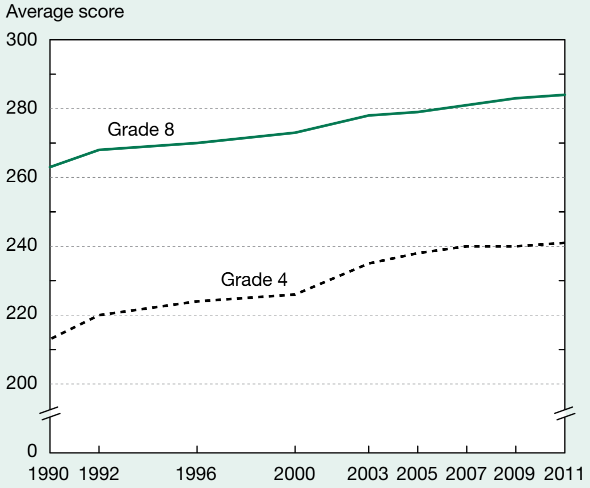
To attempt to explain more of the variation in student achievement, researchers also turned to personality traits, exploring whether and how attributes like perseverance, motivation, self-control, self-efficacy, and social skills contribute to students' academic achievement (Almlund et al. 2011; Bozick and Dempsey 2010; Dalton 2010; Duckworth et al. 2007; Heckman and Kautz 2012; Lennon 2010a, 2010b; McClelland, Acock, and Morrison 2006; Pintrich and de Groot 1990; Schunk 1981; Snyder 2001; Tough 2012; Walls and Little 2005; Webster-Stratton and Reid 2004). Though not conclusive, cumulative evidence points to persistence, motivation to learn and achieve, the ability to delay gratification and aim for long-term goals, belief in one's ability to accomplish academic tasks, and the ability to self-regulate and use self-control as being positively associated with achievement measures such as standardized test scores, grades, and high school completion.

Researchers have also examined the effects of health-related factors on student learning (Berliner 2009; Castelli et al. 2007; Chernoff et al. 2007; Conti, Heckman, and Urzua 2010; Daniels et al. 2005; Hack et al. 2002; Nihiser et al. 2007; Rothstein 2010; Stockton 2011). Low birth weight, unhealthy eating, malnutrition, environmental pollution, inadequate medical/dental/vision care, and exposure to stress and discord at home can induce a variety of physical, sociological, and psychological problems, ranging from neurological damage and attention disorders to excessive absenteeism, linguistic underdevelopment, and oppositional behavior. These problems, in turn, can adversely affect student learning outcomes.

Finally, the effects of children's home life on academic achievement can be influenced by neighborhood characteristics such as the unemployment rate, concentration of poverty, incidence of violence and gang activities, and rates of mobility and homelessness (Ainsworth 2002; Berliner 2009; Rothstein 2010). Research indicates that students living in impoverished or unsafe communities have a higher frequency of developmental and health problems than do those from more affluent or safe communities, even after controlling for family conditions, and those developmental and health problems, in turn, are associated with such academic outcomes as low test scores and dropping out of school (Arneshensal and Sucoff 1996; Brooks-Gunn et al. 1993; Catsambis and Beveridge 2001; Garner and Raudenbush 1991; Wickrama, Noh, and Bryant 2005).

female students (whose scores increased by 2 points), Hispanic male and female students (by 3 and 5 points, respectively), and low- or high-income students (by 2 and 3 points, respectively).[13]

Figure 1-2
Average NAEP mathematics scores of students in grades 4 and 8: 1990–2011



NAEP = National Assessment of Educational Progress.

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grades 4 and 8. From 1996 on, data are for students allowed to use testing accommodations

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 1990, 1992, 1996, 2000, 2003, 2005, 2007, 2009, and 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-2.

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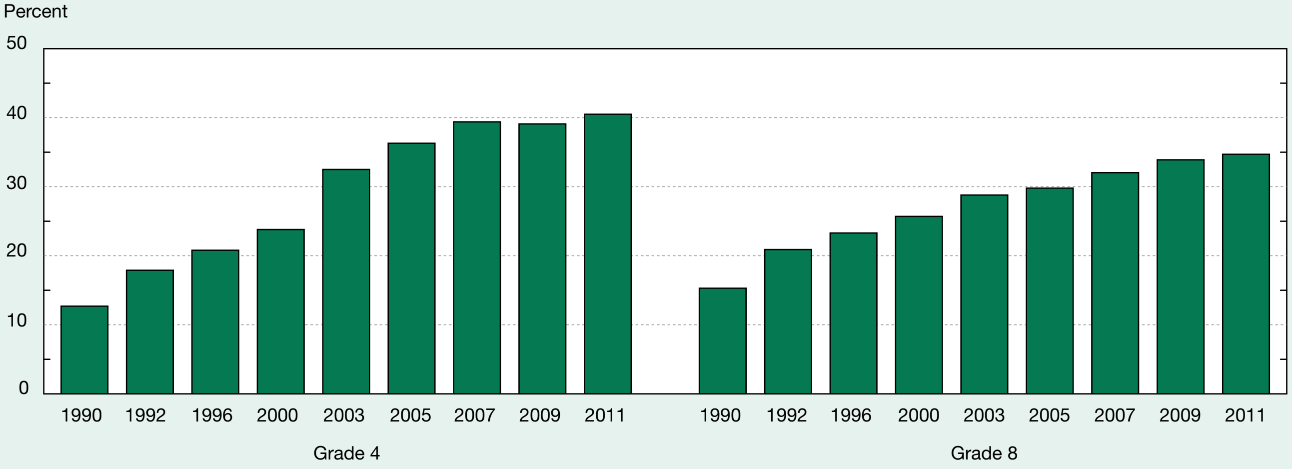
Achievement Level. Trends in the percentages of fourth and eighth graders reaching the proficient level parallel the scale score trends (figure 1-3). The percentage of fourth graders performing at or above the proficient level increased steadily through 2007 and essentially leveled off from 2009 to 2011. Eighth graders overall showed continuous improvement from 1990 to 2011, though the improvement did not persist for some groups during recent years (appendix table 1-3). Furthermore, despite overall upward trends, the actual percentage of students reaching the proficient level in mathematics remained well below half—in 2011, 40% of fourth graders and 35% of eighth graders performed at or above this level.

Science Performance from 2009 to 2011

In 2009, the framework for the main NAEP science assessment was significantly changed to reflect advances in science, curriculum standards, assessments, and research on science learning (NAGB 2010b). Because of these modifications, the results from the 2009 and 2011 assessments cannot be compared with those from the earlier assessments. Whereas the 2009 assessment included students in grades 4, 8, and 12, the 2011 assessment targeted students only in grade 8. This section, therefore, discusses the 2009 and 2011 assessment results for students in grade 8 only.[14]

Average Score. The average science score of eighth graders increased from 150 in 2009 to 152 in 2011 (figure 1-4).[15] With a few exceptions (Asian or Pacific Islander students, high-performing students [at the 90 percentile], and private school students), most demographic groups improved their science scores during this period, with score gains ranging from 1 point for female students and white students to 3

Figure 1-3
Students in grades 4 and 8 scoring at or above NAEP's proficient level in mathematics for their grade: 1990–2011



NAEP = National Assessment of Educational Progress.

NOTE: From 1996 on, data are for students allowed to use testing accommodations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 1990, 1992, 1996, 2000, 2003, 2005, 2007, 2009, and 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-3.

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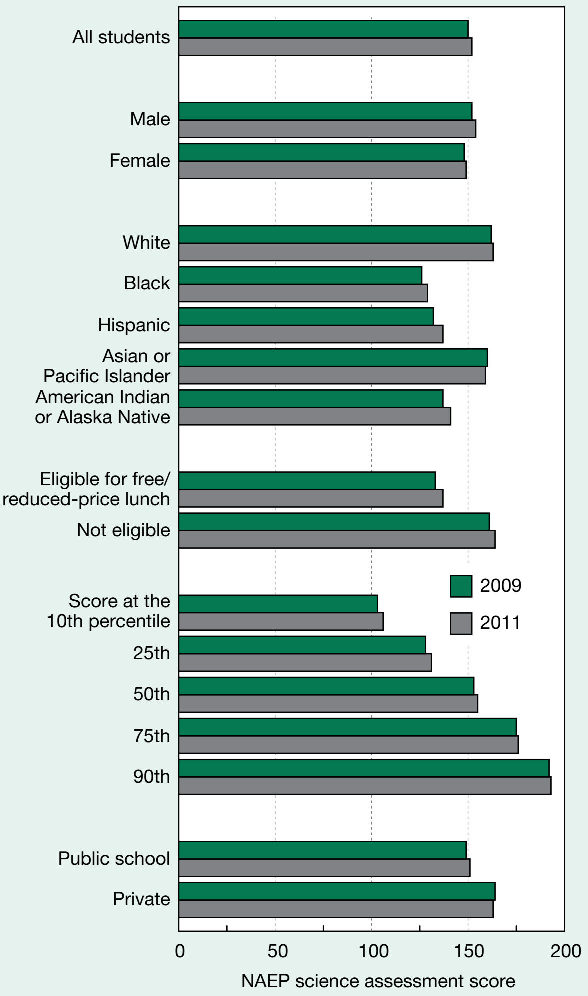
points for black students, 4 points for low-income students, and 5 points for Hispanic students (appendix table 1-4).

Achievement Level. Like scale scores, the percentage of eighth graders performing at or above the proficient level in science increased slightly from 30% in 2009 to 32% in 2011 (appendix table 1-5). Despite this improvement, the majority of students performed below the proficient level on the science assessment in both years. In 2011, for example, 68% of eighth graders failed to reach the proficient level in science. The percentage who scored below this level was especially high among black and Hispanic students (90% and 84%, respectively), particularly among female students in both groups (91% and 87%, respectively).

Figure 1-4
Average NAEP science scores of students in grade 8, by student and school characteristics: 2009 and 2011



NAEP = National Assessment of Educational Progress.

NOTES: NAEP science assessment scores range from 0 to 300 for grade 8. Scores for percentile rows are not averages but the actual scores that mark each percentile listed. For example, a score at the 10th percentile indicates that 10% of students perform at or below this score. Hispanic may be any race. American Indian or Alaska Native, black or African American, Asian or Pacific Islander, and white refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 2009 and 2011 science assessments, National Center for Education Statistics. See appendix table 1-4.

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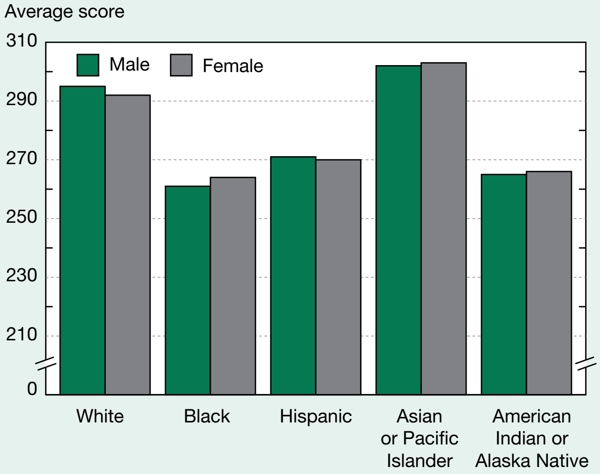
Changes in Performance Gaps in Mathematics and Science

Most performance gaps that existed in earlier years persisted in 2011, although none of these gaps have widened since 1990 (appendix tables 1-2 and 1-4). Overall, sex differences were small, with male students performing slightly better than female students in mathematics and science. Differences between male and female students, however, were not consistent across racial and ethnic groups. Although eighth grade white male students in 2011 had higher mathematics scores than their female counterparts (295 versus 292), similar sex differences were not observed among Hispanic, Asian or Pacific Islander, and American Indian or Alaska Native students (figure 1-5). Among black eighth graders, the gap was reversed: female students performed slightly better than male students (264 versus 261).

Large performance gaps existed among other groups. For both mathematics and science at grades 4 and 8, white and Asian or Pacific Islander students performed better than

Figure 1-5
Average NAEP mathematics scores of students in grade 8, by sex, race, and ethnicity: 2011



NAEP = National Assessment of Educational Progress.

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grade 8. Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-2.

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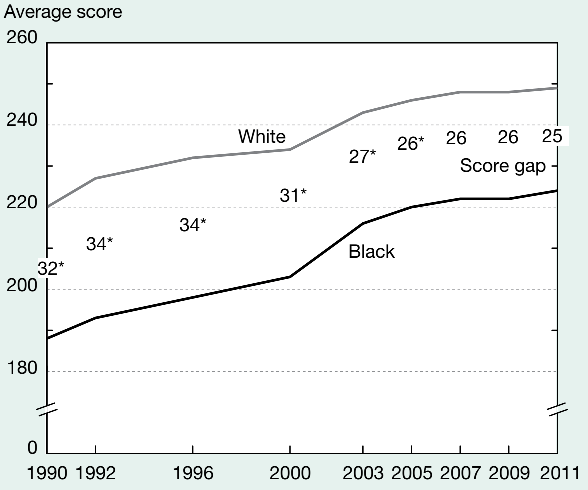
their black, Hispanic, or American Indian or Alaska Native counterparts (appendix tables 1-2 and 1-4). Students from higher-income families also had higher scores in mathematics and science than those from lower-income families. Gaps were observed by school type as well, with private school students scoring higher than public school students.[16]

Some gaps in mathematics and science scores have narrowed over time (table 1-2). In mathematics, gap reductions occurred among fourth grade students but not among eighth grade students. Specifically, the 32-point white-black gap in mathematics performance among fourth grade students decreased to 25 points between 1990 and 2011 because of larger gains by black students (figure 1-6). The reduction in the white-black gap occurred among both male and female fourth graders (table 1-2; appendix table 1-2). Further, the fourth graders' score at the 10th percentile rose more than did the score at the 90th percentile, reducing the gap between low- and high-performing students from 82 to 73 points between 1990 and 2011. None of these gap reductions was observed among eighth grade students, however.

In science, the eighth graders' average score increased more for black students (3 points) and Hispanic students (5 points) than for white students (1 point) between 2009 and 2011, narrowing the white-black gap (especially among male students) and the white-Hispanic gap (among both male and female students) (table 1-2; appendix table 1-4). Finally, the eighth graders' science score at the 10th percentile rose faster than that at the 90th percentile, reducing the gap between low- and high-performing students from 89 to 87 points.

Figure 1-6

Average NAEP mathematics scores and score gaps for white and black students in grade 4: 1990–2011



* = Gap between white and black students is significantly different from the 2011 gap.

NAEP = National Assessment of Educational Progress.

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grade 4. From 1996 on, data are for students allowed to use testing accommodations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 1990, 1992, 1996, 2000, 2003, 2005, 2007, 2009, and 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-2.

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Table 1-2

Changes in NAEP mathematics and science score gaps between selected groups of students in grades 4 and 8: 1990–2011

	Change in score gap		
	Grade 4 mathematics	Grade 8 mathematics	Grade 8 science
Score gap between selected groups of students	1990–2011	1990–2011	2009–11[a]
Males and females	≈	≈	≈
Whites and blacks	↓	≈	↓
White males and black males	↓	≈	↓
White females and black females	↓	≈	≈
Whites and Hispanics[b]	≈	≈	↓
White males and Hispanic males	≈	≈	↓
White females and Hispanic females	≈	≈	↓
Students from low-income families and those from other families[c]	≈	≈	≈
Low-performing students and high-performing students[d]	↓	≈	↓
Public school students and private school students	≈	≈	≈

≈ = no change; ↓ = decrease.

NAEP = National Assessment of Educational Progress.

[a] Changes in science score gaps for grade 8 are presented only for 2009–11 because prior assessments were not comparable with those in or after 2009.
[b] Hispanic may be any race.
[c] Information on student eligibility for subsidized lunch program, a measure of family poverty, was first collected in 1996. Changes in mathematics score gaps in 1990–2011 columns cover 1996–2011.
[d] Gap between students who scored at the 10th and 90th percentiles.

NOTE: From 1996 on, students were allowed to use testing accommodations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 1990, 1996, and 2011 mathematics assessments and of NAEP 2009 and 2011 science assessments, National Center for Education Statistics. See appendix tables 1-2 and 1-4.

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International Comparisons of Mathematics and Science Performance

Two international assessments—the Trends in International Mathematics and Sciences Study (TIMSS) and the Program for International Student Assessment (PISA)—compare U.S. students' achievement in mathematics and science with that of students in other countries. These two assessments differ in several fundamental ways, including the purpose of the study, age of the students tested, test content, and the number of participating nations.[17] Targeting students in grades 4 and 8 regardless of their age, the TIMSS tests focus on students' application of skills and knowledge to tasks akin to those encountered in school. The PISA tests, in contrast, assess the abilities of 15-year-olds to apply mathematics and science skills and information to solve real problems they may face at work or in daily life. This section compares the mathematics and science performance of U.S. students with that of their counterparts in other countries using assessment data from the latest administration of TIMSS (2011). No new data from PISA were available for this volume. The most recent PISA results showed that U.S. 15-year-olds did not perform as well as their peers in many developed countries. In 2009, the U.S. average score ranked 18th in mathematics and 13th in science out of 34 Organisation for Economic Co-operation and Development (OECD) nations participating in the assessment.[18]

First conducted in 1995, TIMSS assesses the mathematics and science performance of fourth and eighth graders every 4 years. TIMSS has been administered five times, most recently in 2011. Over 20,000 students in more than 1,000 schools across the United States took the assessment in spring 2011, joining almost 500,000 other students from 62 countries and jurisdictions (Provasnik et al. 2012).

TIMSS is designed to test students' knowledge of specific mathematics and science topics that are closely tied to the curricula of the participating education systems (Mullis et al. 2009). The assessment framework includes two dimensions: a content domain for the subject matter to be assessed within mathematics and science and a cognitive domain for the skills (e.g., knowing, applying, and reasoning) expected of students as they learn the mathematics or science content. Specifically, the content domain for fourth and eighth grade mathematics and science in TIMSS 2011 includes the following topics (see sidebar, "TIMSS 2011 Sample Items"):

TIMSS 2011 Sample Items

Sample for grade 4 mathematics:

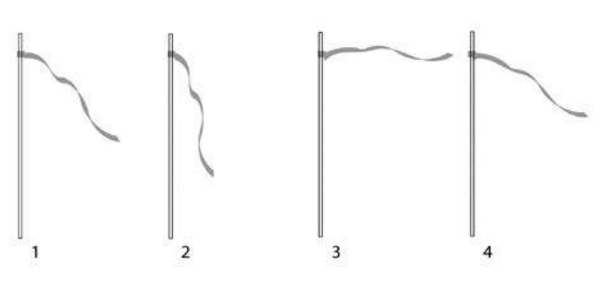
A shelf is 240 cm long. Chris is putting boxes on the shelf. Each box takes up 20 cm of shelf space. Which of these number sentences shows how many boxes Chris can fit on the shelf?

A. 240 – 20 C. 240 + 20
B. 240 ÷ 20 D. 240 x 20

Answer: B.

Sample for grade 4 science:

A ribbon is tied to a pole to measure the wind strength as shown below.



Write the numbers 1, 2, 3, and 4 in the correct order that shows the wind strength from the strongest to weakest.

Answer: 3, 4, 1, 2

Sample for grade 8 mathematics:

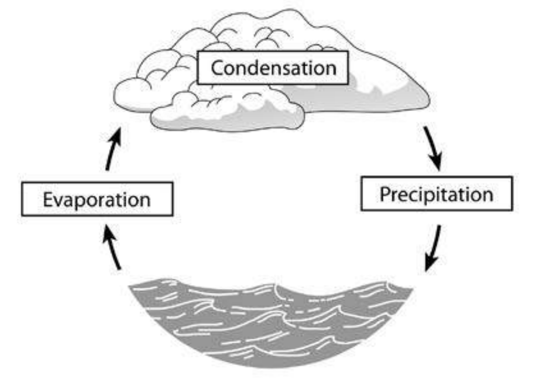
Which of these is equal to $2(x+y) - (2x-y)$*?*

A. $3y$ C. $4x + 3y$
B. y D. $4x + 2y$

Answer: A

Sample for grade 8 science:

The diagram below shows Earth's water cycle.



What is the source of energy for the water cycle?

A. The Moon C. The tides
B. The Sun D. The wind

Answer: B

The above math and science sample questions come directly from http://timssandpirls.bc.edu/timss2011/downloads/TIMSS2011_Frameworks.pdf.

Mathematics

- ♦ Number, Geometric Shapes and Measures, Data Display (Grade 4)
- ♦ Number, Algebra, Geometry, Data and Chance (Grade 8)

Science

- ♦ Life Science, Physical Science, Earth Science (Grade 4)
- ♦ Biology, Chemistry, Physics, Earth Science (Grade 8)

Within each topic in the content domain, students are assessed on several skills, including their knowledge of facts, concepts, and procedures; application of those facts, concepts, and procedures to solve problems; and reasoning (i.e., solving unfamiliar, complex, or multistep problems). Although the content differs for fourth and eighth graders, reflecting the nature and difficulty of the mathematics and science taught at each grade, the cognitive domain is the same for both grade levels and subjects. A more detailed discussion of the framework for the TIMSS 2011 mathematics and science assessments can be found at http://timssandpirls.bc.edu/timss2011/downloads/TIMSS2011_Frameworks.pdf.

Mathematics Performance of U.S. Students in Grades 4 and 8 on TIMSS

Performance on the 2011 TIMSS Mathematics Tests. The U.S. average score on the 2011 TIMSS mathematics assessment was 541 at grade 4 and 509 at grade 8 (figure 1-7). Both scores were higher than the international TIMSS average, which is set to 500 at both grades.[19] Among 50 countries/jurisdictions that participated in the 2011 TIMSS mathematics assessment at grade 4, the U.S. average mathematics score was among the top 13 (seven scored higher; five did not differ), outperforming 37 countries/jurisdictions (appendix table 1-6).[20] The top scorers—Singapore, Republic of Korea, and Hong Kong (China)—each had average scores above 600.

At grade 8, the U.S average mathematics score was below the scores of six countries/jurisdictions, not different from the scores of seven, and higher than those of 28, placing the United States among the top 14 in eighth grade mathematics. The average scores of students in the Republic of Korea, Singapore, and Taipei[21] (the top three leaders) were at least 100 points higher than the average score of U.S. eighth graders (609–613 versus 509).

Performance Trends. Over the 16 years since the first TIMSS mathematics administration in 1995, U.S. fourth and eighth graders raised their scores and international ranking.[22] At grade 4, the average mathematics score of 541 in 2011 was 23 points higher than the score of 518 in 1995 (figure 1-8). Not only did U.S. fourth graders' mathematics scores increase but also the U.S. position relative to other nations climbed from 1995 to 2011. Among the 17 countries that participated in both the 1995 and 2011 TIMSS mathematics assessment of fourth graders, 7 outscored the United States in 1995 compared with 4 in 2011 (Provasnik et al. 2012).

Figure 1-7
Average TIMSS mathematics scores of students in grades 4 and 8, by country/jurisdiction: 2011

	Grade 4		Grade 8	
Score higher than United States	Singapore	606	Republic of Korea	613
	Republic of Korea	605	Singapore	611
	Hong Kong (China)	602	Taipei (Taiwan)	609
	Taipei (Taiwan)	591	Hong Kong (China)	586
	Japan	585	Japan	570
	Northern Ireland	562	Russian Federation	539
	Belgium (Flemish)	549		
Score not statistically different from United States	Finland	545	Israel	516
	England	542	Finland	514
	Russian Federation	542	**United States**	**509**
	United States	**541**	England	507
	Netherlands	540	Australia	505
	Denmark	537	Hungary	505
			Slovenia	505
			Lithuania	502
Score lower than United States (selected countries)	Lithuania	534	Italy	498
	Portugal	532	New Zealand	488
	Germany	528	Kazakhstan	487
	Ireland	527	Sweden	484
	Australia	516	Ukraine	479
	Serbia	516	Norway	475
	Hungary	515	Armenia	467
	Slovenia	513	Romania	458
	Czech Republic	511	United Arab Emirates	456
	Austria	508	Turkey	452

TIMSS = Trends in International Mathematics and Science Study.

NOTES: Hong Kong is a Special Administrative Region of the People's Republic of China. Taipei is the capital city of Taiwan. Countries/jurisdictions are ordered by 2011 average score. Countries/jurisdictions with identical rounded estimates are listed alphabetically.

SOURCE: Provasnik S, Kastberg D, Ferraro D, Lemanski N, Roey S, Jenkins F, *Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context*, NCES 2013-009 (2012). See appendix table 1-6.

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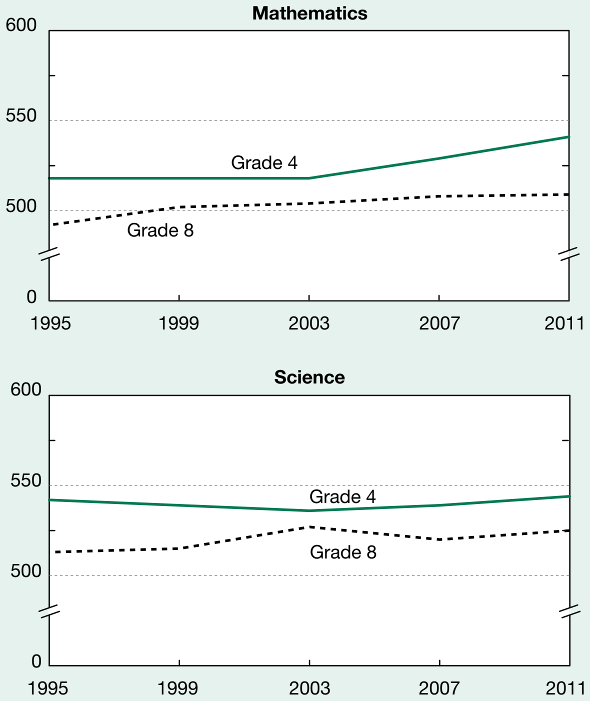
At grade 8, the U.S. average score of 509 in 2011 reflected a 17-point increase over the 1995 score (492) (figure 1-8). The relative standing of U.S eighth graders' mathematics performance has also improved over this time period: among the 16 countries that participated in both the 1995 and 2011 TIMSS mathematics assessment of eighth graders, 5 outperformed the United States in 2011, down from 8 in 1995 (Provasnik et al. 2012).

Science Performance of U.S. Students in Grades 4 and 8 on TIMSS

Performance on the 2011 TIMSS Science Tests. In 2011, the average science scores of both U.S. fourth and eighth grade students (544 and 525, respectively) were higher than the international TIMSS scale average (500) (figure 1-9). At grade 4, the United States was among the top seven countries/jurisdictions, outperforming 43 among a total of 50 participants (appendix table 1-7). Students in Republic of Korea, Singapore, Finland, Japan, Russian Federation,

Figure 1-8
Average TIMSS mathematics and science scores of U.S. students in grades 4 and 8: 1995–2011
Average score



TIMSS = Trends in International Mathematics and Science Study.

NOTES: TIMSS mathematics and science assessment scores range from 0 to 1,000 for grades 4 and 8. U.S. fourth graders did not participate in TIMSS in 1999; score is interpolated. Average mathematics and science scores of students in grade 4 and grade 8 cannot be compared directly because the test items differ across grade levels to reflect the nature, difficulty, and emphasis of the subject matter taught in school at each grade.

SOURCES: Gonzales P, Williams T, Jocelyn L, Roey S, Kastberg D, Brenwald S, *Highlights From TIMSS 2007: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context*, NCES 2009-001 (2008); Provasnik S, Kastberg D, Ferraro D, Lemanski N, Roey S, Jenkins F, *Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context*, NCES 2013-009 (2012).

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and Taipei outscored students in the United States (552–587 versus 544). At grade 8, the U.S. average science score of 525 was lower than those of 8 countries/jurisdictions, higher than those of 29, and not measurably different from those of the remaining 4.

Figure 1-9
Average TIMSS science scores of students in grades 4 and 8, by country/jurisdiction: 2011

	Grade 4	Grade 8
Score higher than United States	Republic of Korea....587 Singapore....583 Finland....570 Japan....559 Russian Federation....552 Taipei (Taiwan)....552	Singapore....590 Taipei (Taiwan)....564 Republic of Korea....560 Japan....558 Finland....552 Slovenia....543 Russian Federation....542 Hong Kong (China)....535
Score not statistically different from United States	**United States....544**	England....533 **United States....525** Hungary....522 Australia....519 Israel....516
Score lower than United States (selected countries)	Czech Republic....536 Hong Kong (China)....535 Hungary....534 Sweden....533 Austria....532 Slovak Republic....532 Netherlands....531 England....529 Denmark....528 Germany....528	Lithuania....514 New Zealand....512 Sweden....509 Italy....501 Ukraine....501 Norway....494 Kazakhstan....490 Turkey....483 Islamic Republic of Iran....474 Romania....465

TIMSS = Trends in International Mathematics and Science Study.

NOTES: Hong Kong is a Special Administrative Region of the People's Republic of China. Taipei is the capital city of Taiwan. Countries/jurisdictions are ordered by 2011 average score. Countries/jurisdictions with identical rounded estimates are listed alphabetically.

SOURCE: Provasnik S, Kastberg D, Ferraro D, Lemanski N, Roey S, Jenkins F, *Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context*, NCES 2013-009 (2012). See appendix table 1-7.

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Performance Trends. In contrast to the mathematics trends, which showed significant improvement in both grades, the average scores of U.S. students on the TIMSS science assessment have remained flat since 1995 for fourth graders and improved 12 points for eighth graders (figure 1-8). U.S. fourth and eighth graders have not improved their international position. Among 17 countries and jurisdictions that participated in both the 1995 and 2011 fourth grade TIMSS science assessments, 3 outscored the United States in 2011 compared with 2 in 1995; at grade 8, the number scoring higher than the United States was 6 in both years (Provasnik et al. 2012).

Student Coursetaking in Mathematics and Science

Mathematics and science coursetaking in high school is a strong predictor of students' overall educational success. Students who take advanced mathematics and science courses in high school are more likely to earn high scores on academic assessments, enroll in college, pursue mathematics and science majors, and complete a bachelor's degree (Bozick and Lauff 2007; Chen 2009; NCES 2010, 2011b; Nord et al. 2011). Advanced coursetaking in high school is also associated with greater labor market returns and higher job satisfaction, even when controlling for demographic characteristics and postsecondary education and attainment (Altonji, Blom, and Maghir 2012; NRC 2012c). Analysis of the NAEP High School Transcript Study (NAEP HSTS) showed that the percentage of students earning credits for mathematics and science courses has increased steadily since 1990, though gaps among different groups of students remain (NSB 2012).[23] This section draws on data from the High School Longitudinal Study of 2009 (HSLS:09) and the College Board's AP program to augment earlier findings on mathematics and science coursetaking in high school, advanced coursetaking, and differences in coursetaking among various demographic groups. The section begins with contextual information about programmatic efforts to increase mathematics and science coursetaking and to standardize the quality of these courses. This information informs the interpretation of ninth grade coursetaking patterns found in the HSLS data.

High School Graduation Requirements and Curriculum Standards

Government and education leaders from 35 states participate in the American Diploma Project (ADP), which seeks to improve student achievement by aligning high school academic content standards with the demands of college and careers and requiring all graduating students to have completed a college- and career-ready curriculum (Achieve 2012). ADP encourages states and school districts to adopt graduation benchmarks that align high school coursework with the expectations of colleges and employers. The ADP graduation benchmarks suggest that for students to be considered ready for college and career, all students should complete 4 years of mathematics coursework at least through the level of pre-calculus.[24] In science, students should complete at least 3 years of coursework, including biology, chemistry, and physics. Currently, 23 states and the District of Columbia have adopted these graduation requirements (Achieve 2012). Two reform efforts, the Common Core State Standards Initiative (CCSSI) and the Next Generation Science Standards, focus on the content of the courses that students take rather than the number or level of courses. The goal of these efforts is to ensure that academic standards across states are similar and include the rigorous content and higher-order skills necessary to prepare all students for college and careers (see sidebar, "Common Core State Standards and Next Generation Science Standards").

Common Core State Standards and Next Generation Science Standards

To provide a clear and consistent framework of the skills and knowledge students must master in grades K–12, the National Governors Association (NGA) Center for Best Practices, the Council of Chief State School Officers (CCSSO) and Achieve Inc. coordinated a state-led effort to develop the Common Core State Standards (CCSS) in English language arts and mathematics (NGA/CCSSO 2010). The standards aim to ensure that all students have "the academic knowledge and skills in literacy and mathematics needed to qualify for and succeed in entry-level, credit-bearing postsecondary coursework or postsecondary job training" (Achieve 2012).

The CCSS were developed through a rigorous drafting and review process involving three workgroups (NGA/CCSSO 2010). One workgroup, composed of experts in assessment, curriculum design, cognitive development, and child development, drafted the standards. A second group, including business representatives and classroom educators as well as scholars, revised that draft, and a validation committee of education scholars, teachers, and other experts evaluated the final draft. Leaders of the initiative then solicited opinions from other experts who had not been consulted in earlier stages and released this draft for public comment. The standards writers reviewed the nearly 10,000 comments from the public and revised the standards before the final version was published in June 2010. As of August 2013, 45 states and the District of Columbia have formally adopted the CCSS (http://www.corestandards.org).

In a recent survey, school superintendents agreed that the CCSS are more rigorous than previous standards and will improve students' English language arts and math skills (Kober and Rentner 2012). The superintendents also noted that implementing the CCSS will require substantial changes in curriculum and instruction. Whereas the majority of the participating states hoped to implement the standards fully by the 2014–15 school year, many superintendents expressed concern about having sufficient resources for such large-scale change. To assist implementation efforts, two state consortia, the Partnership for Assessment of Readiness for College and Careers and Smarter Balanced Assessment, received federal grants to create assessment systems based on the standards. Both consortia will administer these assessments in 2014–15.

In addition to the CCSS in English language arts and mathematics, Achieve Inc. has worked with the National Research Council (NRC), the National Science Teachers Association, the American Association for the Advancement of Science, and 26 states to develop K–12 science standards (http://nextgenscience.org). The Next Generation Science Standards (NGSS) are based on the *Framework for K–12 Science Education*, which identifies broad ideas and practices in the natural sciences and engineering that all students should be familiar with by the time they graduate from high school (NRC 2012a). Following a rigorous development and review process for the NGSS, similar to that followed for the mathematics and English language arts standards, science educators and experts released an initial draft, which they revised substantially after receiving public comments. The final draft was released in April 2013, and states are now considering adoption of the standards.

Ninth Grade Mathematics and Science Coursetaking

HSLS:09 provides detailed data about student coursetaking in mathematics and science in ninth grade.[25] Based on a nationally representative sample of approximately 24,000 ninth graders in 944 schools, it focuses on understanding students' trajectories from the beginning of high school into higher education and the workforce (Ingels et al. 2011). HSLS:09 includes a heightened focus on STEM coursetaking and the high school and personal factors that lead students into and out of STEM fields of study and related careers. The data reported here are based on the base year of the study, conducted in fall 2009 when participants were in the ninth grade.[26] The base year supplies data about the mathematics and science courses that ninth graders took and about variations in their coursetaking by such factors as race and ethnicity, parental education level, and SES. The data are based on students' self-report of what mathematics and science courses they enrolled in at the beginning of ninth grade, not on evidence that they successfully completed the courses.

Mathematics Coursetaking

Algebra 1 is considered a "gateway" course leading to more advanced coursetaking in mathematics and to higher levels of achievement (Loveless 2008; Tierney et al. 2009). An expert panel convened by the Institution of Education Sciences to advise high schools on how to prepare students for college recommended that at a minimum all students should pass algebra 1 by the end of their ninth grade year (Tierny et al. 2009). The HSLS data indicate that the majority of students (81%) who were ninth graders in 2009 (the graduating class of 2012) were on track to meet this benchmark (table 1-3; appendix table 1-8), with 52% reporting enrollment in algebra 1 and 29% reporting enrollment in a more advanced math course than algebra 1, such as geometry 1 or algebra 2.[27] About 20% of students were not on track to meet this benchmark, however, with 9% reporting enrollment in basic mathematics or pre-algebra and 10% reporting no enrollment in any mathematics course. Research suggests that students who do not take any mathematics in ninth grade may suffer long-term consequences in terms of their educational success in high school and their entry into college or the workforce (Aughinbaugh 2012; Finkelstein et al. 2012; Long, Conger, and Iatarola 2012).

The percentage of students taking coursework above the level of algebra 1 in ninth grade (29%) indicates that many students are taking this course before reaching high school. These self-reported data are in line with NAEP transcript data (reported in the 2012 *Science and Engineering Indicators*), which indicated that 26% of high school graduates took algebra 1 before high school in 2009, up from 20% in 2005

Table 1-3

Highest-level mathematics course in which ninth graders enrolled, by student and family characteristics: 2009

(Percent distribution)

Student and family characteristic	No mathematics	Basic mathematics/ pre-algebra[a]	Algebra 1	Above algebra 1[b]
All grade 9 students	10.3	9.0	52.1	28.7
Sex				
Male	11.1	9.2	51.7	28.0
Female	9.5	8.8	52.4	29.3
Race or ethnicity				
Asian	7.3	6.6	28.1	58.0
Black	14.1	11.4	56.0	18.5
Hispanic[c]	13.3	8.9	53.1	24.8
White	8.4	8.6	51.6	31.4
Other[d]	9.3	8.7	55.5	26.6
Parents' highest education[e]				
Less than high school	18.4	12.6	46.8	22.2
High school diploma or equivalent	11.9	10.7	55.5	21.9
Associate's degree	8.5	8.9	59.7	22.9
Bachelor's degree	7.1	5.4	46.8	40.7
Master's degree or higher	5.1	4.0	39.8	51.1

[a] Basic mathematics includes review/remedial mathematics.

[b] Above algebra 1 includes geometry 1, algebra 2, trigonometry, integrated math 2, statistics, analytic geometry, and calculus.

[c] Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

[d] Other includes Alaska Native, American Indian, Native Hawaiian, Pacific Islander, and more than one race.

[e] The highest level of education achieved by either parent.

NOTE: Detail may not sum to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-8.

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(NSB 2012). NAEP HSTS data show that nearly two-thirds of graduates who completed a rigorous high school curriculum took algebra 1 before high school (Nord et al. 2011).[28]

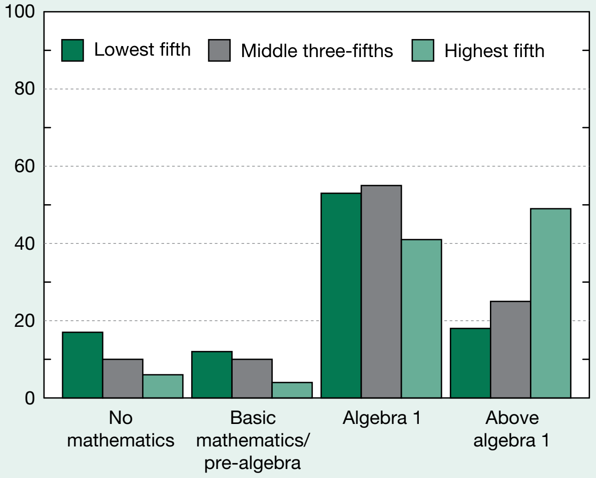
The percentage of students reporting enrollment in courses above algebra 1 varied by parental education level, SES,[29] and race and ethnicity. Students who had at least one parent with a master's degree or higher were most likely to report enrollment in a mathematics course above algebra 1 (51%), followed by students with at least one parent with a bachelor's degree (41%). About 22% of students with parents at all other education levels (associate's degree, high school diploma, and less than high school) reported enrolling in courses above algebra 1, with no significant difference among students with parents at these education levels. Nearly 50% of students in the highest SES quintile reported taking a course above algebra 1 compared with just 18% of students in the lowest SES quintile (figure 1-10). Asian students were more likely to report enrollment in courses above algebra 1 (58%) compared with white (31%), Hispanic (25%), and black (19%) students (table 1-3).

At the other end of the spectrum are students who reported no mathematics enrollment in ninth grade: 18% of students whose parents had less than a high school education reported no mathematics enrollment compared with 7% of students who had at least one parent with a bachelor's degree (table 1-3). About 17% of students in the lowest SES quintile reported no mathematics enrollment compared with 6% of those in the highest SES quintile (figure 1-10).

Science Coursetaking

Biology is the most common science subject students take in ninth grade: nearly 4 in 10 students in ninth grade (39%) reported enrollment in biology 1 (table 1-4; appendix table 1-9). About 7% reported enrollment in a science course above the level of biology 1, such as chemistry 1 or physics 1. A total of 18% of ninth graders reported no science enrollment, about twice the total of students reporting no mathematics enrollment (10%). Science coursetaking also varied by parental education level, SES, and race and ethnicity, showing similar patterns to those reported in mathematics.[30] The largest differences were in the percentage of students who reported no science enrollment. More than one-fourth of students in the lowest SES quintile (27%) reported no science enrollment compared with 11% of students in the highest SES quintile (figure 1-11). Proportionally more students who had parents with less than a high school education reported no science enrollment than did students who had at

Figure 1-10
Highest-level mathematics course in which ninth graders enrolled, by socioeconomic quintile: 2009



NOTES: Basic mathematics includes review/remedial mathematics. Above algebra 1 includes geometry 1, algebra 2, trigonometry, integrated math 2, statistics, analytic geometry, and calculus. Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal groups. Quintile 1 corresponds to the lowest one-fifth of the population, and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined to form one category.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-8.

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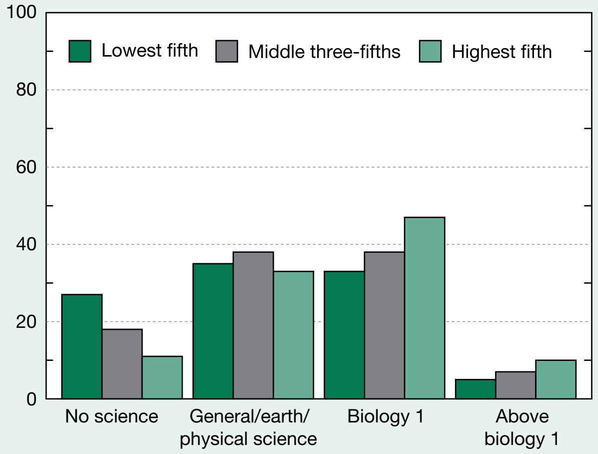
Figure 1-11
Highest-level science course in which ninth graders enrolled, by socioeconomic quintile: 2009



NOTES: Above biology 1 includes chemistry 1, physics 1, biology 2, Advanced Placement/International Baccalaureate (AP/IB) biology, chemistry 2, AP/IB chemistry, physics 2, and AP/IB physics. Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal groups. Quintile 1 corresponds to the lowest one-fifth of the population, and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined to form one category.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-9.

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Table 1-4
Highest-level science course in which ninth graders enrolled, by student and family characteristics: 2009
(Percent distribution)

Student and family characteristic	No science	General science	Earth/ environmental/ physical science	Biology 1	Above biology 1[a]
All grade 9 students	18.0	5.1	31.2	38.7	7.0
Sex					
Male	18.9	5.1	31.3	38.0	6.7
Female	17.0	5.2	31.1	39.4	7.3
Race or ethnicity					
Asian	12.9	5.4	16.7	51.2	13.9
Black	25.2	5.5	27.2	35.1	7.0
Hispanic[b]	22.1	3.9	23.1	43.9	7.1
White	15.0	5.2	36.7	36.7	6.4
Other[c]	16.2	6.9	31.2	37.9	7.8
Parents' highest education[d]					
Less than high school	29.3	5.2	23.8	38.4	3.3
High school diploma or equivalent	20.7	5.8	32.7	34.9	5.8
Associate's degree	15.2	7.2	33.8	37.3	6.6
Bachelor's degree	13.4	4.1	31.7	42.7	8.1
Master's degree or higher	10.8	3.7	27.7	47.2	10.7

[a] Above biology 1 includes chemistry 1, biology 2, Advanced Placement/International Baccalaureate (AP/IB) biology, chemistry 2, AP/IB chemistry, physics 2, and AP/IB physics.

[b] Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

[c] Other includes Alaska Native, American Indian, Native Hawaiian, Pacific Islander, and more than one race.

[d] The highest level of education achieved by either parent.

NOTE: Detail may not sum to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-9.

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least one parent with a bachelor's degree (29% versus 13%) (table 1-4). Asian students were twice as likely as other racial and ethnic groups to report enrollment in a science course above biology 1 (14% versus about 7% for all other racial and ethnic groups).

Participation and Performance in the Advanced Placement Program

Several programs offer high school students the opportunity to earn college credit while still in high school. The AP program is one of the largest and best known. Other options for students interested in earning college credit during high school include dual enrollment, with students concurrently enrolling in college courses while still in high school, and the International Baccalaureate program, which offers college credit for high school courses (Thomas et al. 2013).

In the AP program, students take college-level courses at their high school. Courses are offered in 34 different subjects and students who earn a passing score (3 or higher out of 5) on an AP exam can earn college credits, placement into more advanced college courses, or both, depending on the policy of the postsecondary institution they attend. Research suggests that students who take AP or other college-level courses in high school are more likely to enroll and persist in college than their peers who do not take these courses (Klopfenstein and Thomas 2009; Porter and Polikoff 2012). Access to AP courses is an issue, however. The College Board, the nonprofit organization that administers the AP program, notes that availability and variety of AP courses is lower in schools with higher numbers of low-income and traditionally underserved minority students (College Board 2013). Some schools, particularly small schools and schools in low-income and remote areas, may not offer any AP courses for their students (see sidebar, "Access to Advanced Placement Courses in Mathematics and Science").

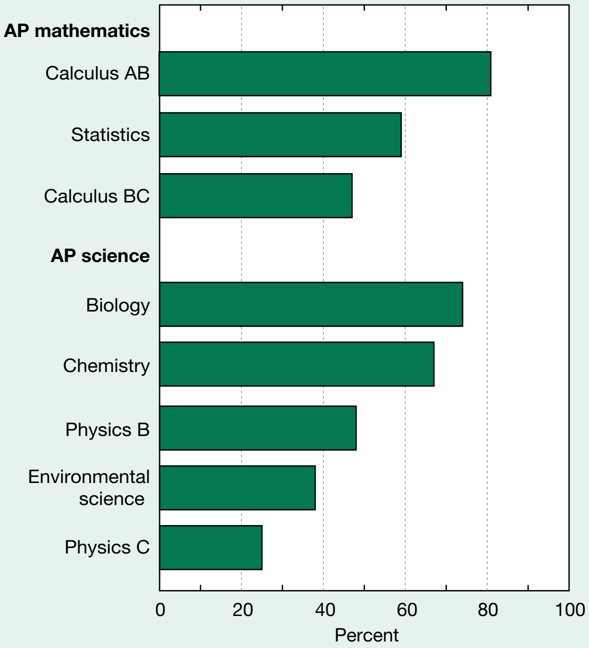
Calculus AB and biology are the most popular AP exams in mathematics and science. According to the College Board, 212,000 students in the graduating class of 2012 took calculus AB and 153,000 students took biology (appendix table 1-10). Statistics and chemistry were the next most popular, with 129,000 students taking the statistics exam and 100,000 taking chemistry. Exam taking is lower for more advanced subjects, including calculus BC (71,000) and physics B (63,000). The least common exams are computer science A (19,000) and physics C: electricity/magnetism (13,000).

The number of students taking at least one AP exam in mathematics or science has doubled in the past decade. In the class of 2012, 500,000 students took an AP mathematics or science exam during high school, up from 250,000

Access to Advanced Placement Courses in Mathematics and Science

The 2012 National Survey of Science and Mathematics Education provides information about school AP course offerings (Banilower et al. 2013). In 2012, AP calculus AB and AP biology were the most widely accessible courses in high schools, available to 81% and 74% of high school students, respectively (figure 1-A).

Figure 1-A
High school students with access to various AP mathematics and science courses: 2012



AP = Advanced Placement.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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The least accessible courses were AP calculus BC in math and AP physics C in science, available to 47% and 25% of high school students, respectively. The number of AP mathematics and science courses offered varied by school characteristics. For example, the largest schools offered an average of two AP mathematics courses and three AP science courses, whereas the smallest schools offered about one AP mathematics and one AP science course (table 1-A). The average number of both mathematics and science courses available at low-poverty schools and suburban and urban schools was about twice those available at high-poverty schools and rural schools.

Table 1-A
Average number of AP mathematics and science courses offered in high schools, by school characteristic: 2012

School characteristic	Mathematics	Science
Students in school eligible for free/reduced-price lunch		
0%–25%	1.4	2.0
25%–50%	1.1	1.5
50%–75%	0.8	1.1
75%–100%	0.7	1.1
School size		
Smallest	0.6	0.7
Second group	0.9	1.2
Third group	1.6	2.1
Largest	2.1	2.8
Community type		
Rural	0.6	0.7
Suburban	1.2	1.7
Urban	1.3	1.7

AP = Advanced Placement.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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students in the class of 2002 (table 1-5). The AP statistics test stands out as experiencing especially rapid growth: In 2002, approximately 40,000 students took the exam, rising to nearly 130,000 students in 2012. Environmental science also experienced rapid growth, rising from 18,000 exam takers in 2002 to 89,000 in 2012.

Although the number of students taking AP exams in mathematics and science has doubled, the AP program in mathematics and science involves a relatively small proportion of all high school students. For example, 17% of all students in the class of 2012 took an AP mathematics or science exam, with 9% passing (table 1-6).

As the number of students taking AP exams has increased, so has the number passing these exams. Nearly 270,000 students in the class of 2012 passed an AP mathematics or science exam in 2012 compared with about 155,000 in 2002 (table 1-5). Although increasing numbers of students are taking and passing AP exams, passing rates have declined or remained steady in most mathematics and science subjects. The overall pass rate for any AP mathematics or science exam dropped from 62% in 2002 to 54% in 2012. The two most popular exams, calculus AB and biology, showed the largest decreases, with average passing rates dropping by 9 percentage points for calculus AB and 13 percentage points for biology since 2002. In contrast, passing rates for exams in more advanced subjects have remained steady or even increased, with average passing rates remaining steady for calculus BC and physics B and increasing by about 7 percentage points for both physics C exams.

Table 1-5

Public school students who took or passed an AP exam in high school, by subject: Graduating classes 2002, 2007, and 2012

	Students who took an AP exam (number)			Students who passed an AP exam (number)[a]			Students who passed an AP exam (%)[a]		
Subject	2002	2007	2012	2002	2007	2012	2002	2007	2012
Any AP exam	471,404	694,705	954,070	305,098	424,004	573,472	64.7	61.0	60.1
Any AP mathematics or science exam	250,465	364,732	497,924	154,450	208,515	268,251	61.7	57.2	53.9
AP mathematics exam									
Calculus AB	123,388	166,239	211,570	81,293	95,338	120,469	65.9	57.3	56.9
Calculus BC	32,760	51,434	70,828	26,078	40,675	57,808	79.6	79.1	81.6
Statistics	40,207	81,992	129,403	22,569	47,578	74,478	56.1	58.0	57.6
AP science exam									
Biology	73,951	109,899	152,742	45,231	64,771	74,211	61.2	58.9	48.6
Chemistry	45,859	72,866	100,362	25,796	40,161	52,689	56.3	55.1	52.5
Environmental science	18,099	41,145	88,683	9,290	20,579	43,350	51.3	50.0	48.9
Computer science A	12,166	11,670	19,067	7,433	6,766	11,743	61.1	58.0	61.6
Physics B	28,688	43,099	63,125	16,514	25,022	36,928	57.6	58.1	58.5
Physics C: Electricity/magnetism	7,141	8,638	12,766	4,586	6,129	9,078	64.2	71.0	71.1
Physics C: Mechanics	14,717	20,672	28,923	10,065	14,570	21,892	68.4	70.5	75.7

AP = Advanced Placement.

[a] Students scoring 3, 4, or 5 on a scale of 1–5 for an AP exam.

NOTES: The College Board reports AP results by graduating class rather than by calendar year. Results include exams taken by graduates throughout their high school career.

SOURCE: The College Board, *The 9th Annual AP® Report to the Nation—Subject Supplement*. Copyright © 2013, www.collegeboard.org. Reproduced with permission.

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Table 1-6

Public school students who took or passed an AP exam as a proportion of overall student population, by subject: Graduating classes 2002, 2007, and 2012

(Percent)

	Students who took an AP exam			Students who passed an AP exam[a]		
Subject	2002	2007	2012	2002	2007	2012
Any subject	18.0	23.5	32.4	11.6	14.3	19.5
Mathematics or science[b]	9.6	12.3	16.9	5.9	7.1	9.1

AP = Advanced Placement.

[a] Students scoring 3, 4, or 5 on a scale of 1–5 for an AP exam.

[b] Includes calculus AB, calculus BC, statistics, biology, chemistry, environmental science, computer science A, physics B, physics C: electricity/magnetism, and physics C: mechanics.

NOTES: The College Board reports AP results by graduating class, rather than by calendar year. Results include exams taken by graduates throughout their high school career.

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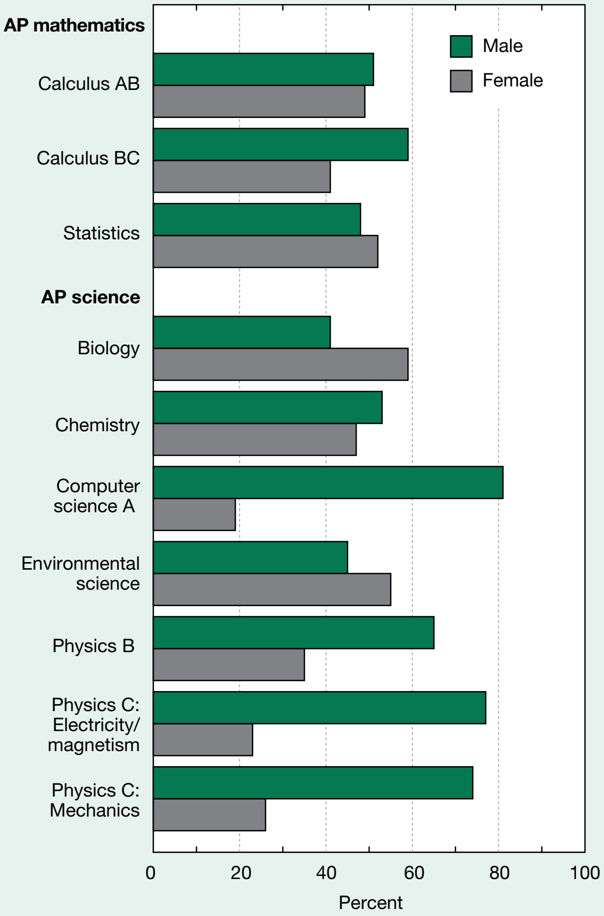
AP exams covering more advanced material, such as calculus BC and physics, are taken by fewer students, but the pass rates are much higher. For example, 70,000 students in the class of 2012 took the calculus BC exam; more than 200,000 took the relatively less demanding calculus AB exam. The pass rate for calculus BC was 82%, compared with 57% for calculus AB (table 1-5). In science, about 13,000 students in the class of 2012 took the physics C: electricity/magnetism exam; more than 150,000 students took the AP biology exam. The pass rate for physics C was 71%, much higher than the passing rate for AP biology (49%).

AP Exam Taking by Sex and Race and Ethnicity

The proportion of male and female students taking particular AP exams differs by test subject (figure 1-12). Male students are more likely than female students to take AP exams in advanced subjects, including calculus BC (59% versus 41%), physics B (65% versus 35%), and both physics C

Figure 1-12
Public school students in graduating class of 2012 who took AP exams in mathematics and science in high school, by sex



AP = Advanced Placement.

NOTES: The College Board reports AP results by graduating class rather than by calendar year. Results include exams taken by graduates throughout their high school career.

SOURCE: The College Board, *The 9th Annual AP® Report to the Nation—Subject Supplement*. Copyright © 2013, www.collegeboard.org. Reproduced with permission.

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exams (about 75% versus 25%). Similar percentages of male and female students took AP exams in calculus AB and statistics. Female students took AP exams at higher rates than male students in biology (59% versus 41%) and environmental science (55% versus 45%). Computer science A showed the largest difference in exam taking by sex, with a distribution of 81% of male students and 19% of female students.

Black and Hispanic students are underrepresented among AP exam takers. Although black students made up about 15% of the 2012 graduating class, they comprised less than 8% of students taking any AP mathematics or science exam (appendix table 1-10). Black students were particularly underrepresented in the exam-taking population for AP exams in calculus BC and both physics C exams, accounting for only about 3% of the students taking those exams. Hispanic students, who made up about 18% of the class of 2012, were also underrepresented in the AP exam-taking population. Their representation among AP exam takers ranged from a high of 15% for environmental science to a low of 8% for calculus BC and 7% for physics C: electricity/magnetism. Conversely, Asian students are overrepresented among AP exam takers. Asian students accounted for about 6% of the class of 2012 but accounted for about 30% of the exam takers in physics C: electricity/magnetism, calculus BC, and computer science A. Their lowest representation among exam takers was 13% for environmental science.

Teachers of Mathematics and Science

Teacher quality is one of the most important factors influencing student learning. Students' achievement in mathematics and science depends in part on their access to high-quality instruction in those subjects. Many factors affect teacher quality, including qualifications, ongoing professional development, attrition, and working conditions. The 2012 National Survey of Science and Mathematics Education (NSSME), the fifth in a series of surveys of mathematics and science teachers first administered in 1977, provides a comprehensive review of these topics (Banilower et al. 2013). The 2012 NSSME is a nationally representative survey based on a sample of 7,752 mathematics and science teachers in elementary and secondary schools across the United States. This section highlights the major findings of the NSSME and supplements those findings with national data on teacher attrition from the U.S. Department of Education's Beginning Teacher Longitudinal Study (BTLS).[31]

Characteristics of High-Quality Teachers

Extensive research suggests that high-quality teaching has a positive effect on student achievement (Boyd et al. 2008; Clotfelter, Ladd, and Vigdor 2007; Goe 2008; Guarino, Santibanez, and Daley 2006; Hanushek 2011; Harris and Sass 2011), but the specific teacher characteristics that contribute to student success are less clear. Some studies have cast doubt on whether commonly measured indicators, such as teachers' licensure scores or the selectivity of their undergraduate institutions, are related to their teaching effectiveness (Boyd et al. 2006; Buddin and Zamarro 2009a, 2009b; Hanushek and Rivkin 2006; Harris and Sass 2011; Sass et al. 2012). Efforts to improve measures of teaching quality have proliferated in recent years. Recent efforts have focused on "value-added" models—strategies for measuring teacher effectiveness by comparing test score gains of students in the same school who have similar backgrounds and initial scores but different teachers (Baker et al. 2010; Goldhaber, Liddle, and Theobald 2013; Hanushek and Rivkin 2006; Harris and Sass 2011; Loeb, Kalogrides, and Béteille 2012). Following this line of research, some researchers, including the Measures of Effective Teaching (MET) Project and the

National Center for Teacher Effectiveness (NCTE), have attempted to establish composite indicators for effective teaching (Kane et al. 2013; MET Project 2012; NCTE 2013).

This section reports on several indicators of teacher quality that are available from major national studies, including teaching experience, professional certification, in-field preparation (i.e., earning a postsecondary degree in the teaching field), content coursetaking, and teachers' self-assessment of their preparation. Other less easily observed characteristics may also contribute to teacher effectiveness, including teachers' abilities to motivate students, engage students in learning, maximize instruction time, and diagnose and overcome students' learning difficulties. However, these characteristics are often difficult and costly to measure and therefore are rarely included in nationally representative surveys.

Teaching Experience. In general, as teachers gain more years of experience, they become more effective in helping students learn (Boyd et al. 2006; Harris and Sass 2011; Clotfelter, Ladd, and Vigdor 2007; Rice 2010). Recent studies have found that novice teachers (i.e., teachers with 2 or fewer years of experience) are more likely than experienced teachers to work in high-poverty, high-minority schools and teach low-achieving students (Loeb, Kalogrides, and Béteille 2012; LoGerfo, Christopher, and Flanagan 2012; Sass et al. 2012). According to data from the NSSME, in 2012, the percentage of novice mathematics teachers ranged from 10% to 14% in elementary, middle, and high schools, whereas the percentage of novice science teachers ranged from 13% to 16% across the school levels (figure 1-13).

Schools with the highest proportions of low-income students were more likely than other schools to have novice science teachers. In schools with the highest concentrations of students eligible for free/reduced-price lunch (FRL) (i.e., 75%–100% of students), 23% of science classes were taught by teachers with 2 or fewer years of experience, compared with 10% of science classes in schools with the lowest concentrations of FRL-eligible students (i.e., 0%–25% of students) (figure 1-14). In contrast, the distribution of novice mathematics teachers did not vary significantly depending on a school's percentage of FRL students. Moreover, students in high-poverty schools were much less likely to have novice teachers in mathematics than in science: 14% of mathematics classes, compared with 23% of science classes, were taught by teachers with 2 or fewer years of experience.

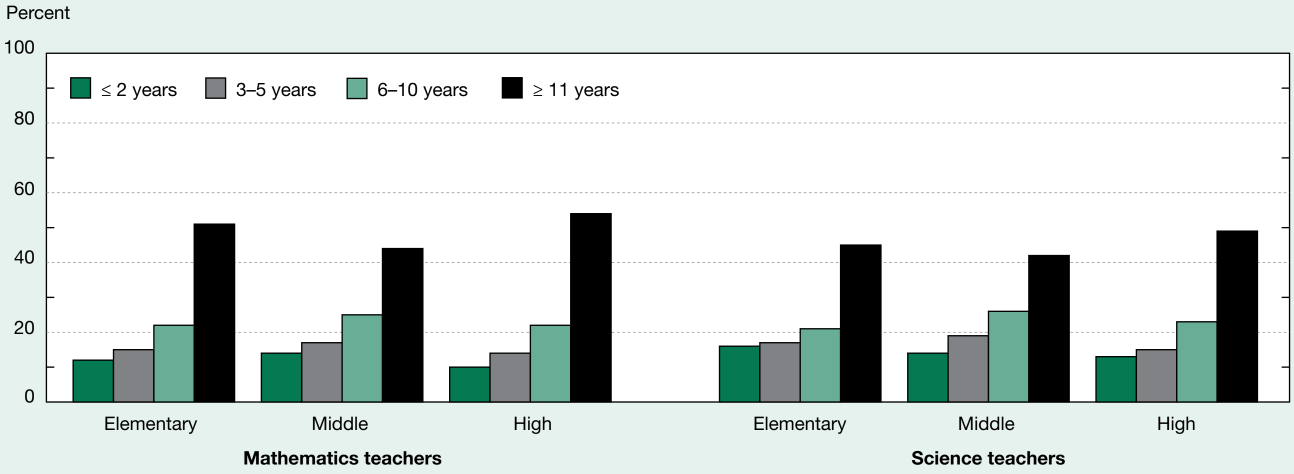
A similar pattern was seen across mathematics and science for non-Asian minority students. Science classes with the highest percentages of non-Asian minority students were more likely to have novice science teachers (21%) than were classes with the lowest percentages of non-Asian minority students (14%), but such differences were not observed for mathematics teachers (appendix table 1-11).

Higher-achieving students tended to have more experienced mathematics teachers. For example, 15% of math classes composed of mostly low achievers had mathematics teachers with 2 or fewer years of experience, whereas 8% of math classes composed of mostly high achievers had such mathematics teachers (appendix table 1-11). A similar pattern appears for science, with classes of mostly low achievers (18%) more likely than classes of mostly high achievers (12%) to have science teachers with 2 or fewer years of experience.

Certification. Each state requires public school teachers to earn a certificate that licenses them to teach. States set criteria for various types of certification; usually a full certification entails a combination of passing scores on tests, a

Figure 1-13

Mathematics and science teachers' years of experience teaching their subject, by grade level: 2012



NOTE: Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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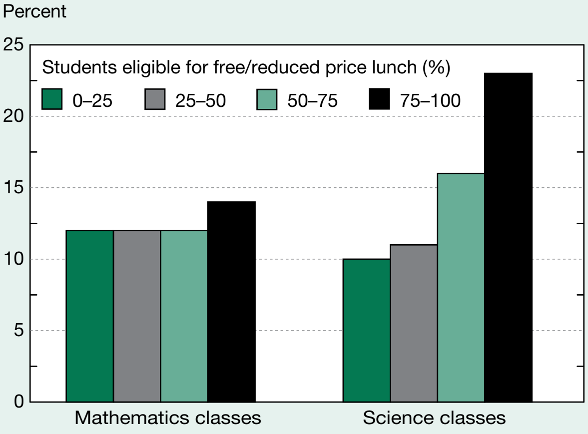
bachelor's degree with a specified number of credits in education and in the discipline taught, and supervised practice teaching experience (NCTQ 2013). Criteria for certification vary among grade levels, with elementary teachers usually certified to teach multiple subjects and high school teachers certified within subject areas. Whether middle school teachers are certified in multiple subjects or individual subjects varies across states.

Fully certified teachers are distinguished from those who are granted alternative certificates. Alternative certificates are issued to persons who must complete a certification program in order to continue teaching, those who have satisfied all requirements except the completion of a probationary teaching period, and those who require some additional coursework or need to pass a test.

Figure 1-14
Mathematics and science classes taught by teachers with 2 years or less of experience teaching their subject, by students in school eligible for free/reduced-price lunch: 2012



SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013). See appendix table 1-11.

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The NSSME reported four different paths to full and alternative certification: an undergraduate program leading to a bachelor's degree and teaching certificate; a post-baccalaureate program leading to a certificate; a master's program that also awarded a teaching certificate; and no formal teacher preparation. Elementary mathematics and science teachers were the most likely to have earned a bachelor's degree and teaching certificate as part of an undergraduate program: about 60% of elementary teachers of mathematics and science followed this path to certification, compared with 48% of high school mathematics teachers and 34% of high school science teachers (table 1-7). In contrast, high school mathematics and science teachers were more likely than their elementary counterparts to have earned a certificate through a post-baccalaureate program—30% of high school science teachers followed this path to certification, compared with 13% of elementary school science teachers. High school mathematics and science teachers were also more likely to report no formal teacher preparation (8% and 10%, respectively) than were their elementary school counterparts (1%).

Some studies have shown that fully certified mathematics and science teachers are more prevalent in low-poverty and low-minority schools (NSB 2012). Students from disadvantaged backgrounds (minority students, low-SES students, and those whose first language was not English) are more likely than their counterparts to be taught by mathematics or science teachers with alternative certification (LoGerfo, Christopher, and Flanagan 2012). The NSSME did not report data on this issue.

Degree in Field and Content Coursetaking. Over the past decade, few issues related to teaching quality have received more attention than in-field teaching in middle and high schools (Almy and Theokas 2010; Dee and Cohodes 2008; Peske and Haycock 2006). In-field teaching refers to

Table 1-7
Mathematics and science teachers, by path to certification and grade level: 2012
(Percent distribution)

Grade level	An undergraduate program leading to a bachelor's degree and a teaching credential	A post-baccalaureate credentialing program (no master's degree awarded)	A master's program that also awarded a teaching credential	No formal teacher preparation
Mathematics teachers				
Elementary	63	14	22	1
Middle	55	17	25	3
High	48	20	22	10
Science teachers				
Elementary	61	13	25	1
Middle	47	23	26	4
High	34	30	28	8

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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the assignment of teachers to teach subjects that match their training or education. To some extent, this emphasis can be traced back to the implementation of the federal No Child Left Behind Act (NCLB), which mandated that all students have teachers who demonstrate subject area competence. To determine whether teachers have subject-specific preparation for the fields they teach, recent research has focused on matching teachers' formal preparation (as indicated by degree major, certification field, or both) with their teaching field (Hill and Gruber 2011; McGrath, Holt, and Seastrom 2005; Morton et al. 2008). The NSSME followed a similar approach, using teachers' degree field and postsecondary coursework completed in mathematics and science as indicators of preparation to teach mathematics and science at the elementary, middle, and high school levels (Banilower et al. 2013).[32]

In 2012, 82% of high school science teachers and 73% of high school mathematics teachers held degrees in their teaching field or in science or mathematics education (table 1-8). High school mathematics and science teachers were twice as likely as their middle school counterparts to hold in-field degrees. Very few elementary school teachers who taught mathematics or science held an in-field degree (about 5%).

Many secondary science classes, especially at the high school level, focus on more discrete areas of science, such as biology or chemistry. In 2012, biology teachers were the most likely among high school science teachers to have a degree in their specific teaching field, with 53% having a degree in biology (appendix table 1-12). Another 37% had at least three college courses beyond introductory biology. In mathematics, 52% of high school mathematics teachers had a degree in mathematics (table 1-8). Almost all high school mathematics teachers had completed a calculus course (93%), and the vast majority of them had taken college coursework in advanced calculus (79%), linear algebra (80%), and statistics (83%) (appendix table 1-13). Other college courses completed by the majority of high school mathematics teachers included abstract algebra (67%), differential equations (62%), axiomatic geometry (55%), analytic geometry (53%), probability (56%), number theory (54%), and discrete mathematics (52%). About 77% of high school mathematics teachers had taken a course in computer science. Substantially fewer middle school teachers had taken college coursework in each of these subject areas.

According to the NSSME data, the likelihood of middle and high school classes being taught by a teacher with in-field preparation varied by the concentration of high or low achievers in both mathematics and science classes and by the percent of non-Asian minority students in mathematics classes. For example, 61% of mathematics classes and 76% of science classes composed mostly of high-achieving students were taught by teachers with an in-field degree, compared with 49% of mathematics classes and 50% of science classes composed mostly of low-achieving students (appendix table 1-14). The difference by the concentration of non-Asian minority students was large for mathematics but less so for science: 44% of classes with the highest percentage of non-Asian minority students had a mathematics teacher with an in-field degree, compared with 64% of classes with the lowest percentage of such students; for science, it was 58% and 68%, respectively. The differences among schools with the highest and lowest percentages of FRL-eligible students ranged from 58% to 68% (statistically significant) for science and from 51% to 56% (not statistically significant) for math.

Although elementary school teachers are not generally expected to have degrees in mathematics or science, both the National Council of Teachers of Mathematics (NCTM) and the National Science Teachers Association (NSTA) have recommendations for the number and types of courses that elementary teachers should take to be adequately prepared to teach these subjects (Banilower et al. 2013). The NSTA suggests that elementary science teachers have one course each in life, earth, and physical sciences. In 2012, 36% of elementary school teachers met this standard, and 38% had taken courses in two of the three areas (figure 1-15). Six percent of elementary teachers had no college courses in science. For mathematics, the NCTM recommends that elementary school teachers take college coursework in five areas, including numbers and operations, algebra, geometry,

Table 1-8
Mathematics and science teachers with an undergraduate or graduate degree in mathematics or science, by grade level: 2012
(Percent)

	Mathematics teachers' degree				Science teachers' degree			
Grade level	Mathematics	Mathematics education	Mathematics or mathematics education	None of these fields	Science or engineering	Science education	Science, engineering, or science education	None of these fields
Elementary.....	4	2	4	96	4	2	5	95
Middle...........	23	26	35	65	26	27	41	59
High...............	52	54	73	27	61	48	82	18

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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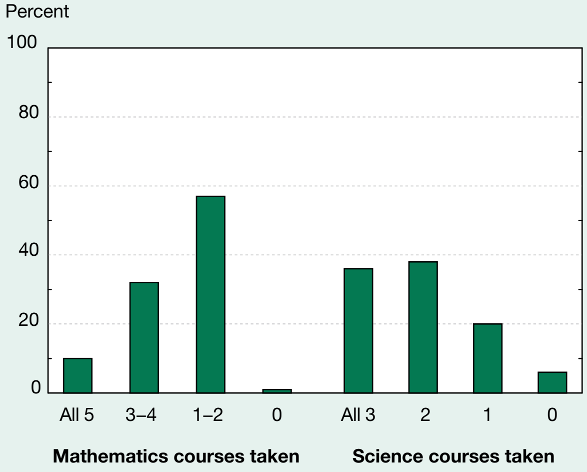
Figure 1-15

Elementary teachers meeting NCTM- and NSTA-recommended college-level coursework in mathematics and science: 2012



NCTM = National Council of Teachers of Mathematics; NSTA = National Science Teachers Association.

NOTES: NCTM recommended that elementary teachers take college-level courses in number and operations, algebra, geometry, probability, and statistics. NSTA recommended that elementary teachers take college-level courses in life science, earth science, and physical science. Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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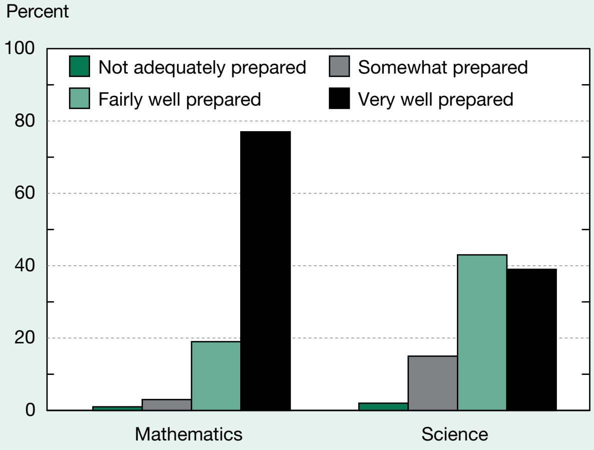
probability, and statistics. In 2012, 10% of elementary teachers met the standard of having coursework in all five of these areas, 57% had courses in one to two of these areas, and 1% had no courses in these areas.

Self-Assessment of Preparedness to Teach. Elementary teachers were much more confident in their ability to teach mathematics than in their ability to teach science: 77% of elementary teachers felt very well prepared to teach mathematics, but just 39% reported being very well prepared to teach science (figure 1-16). Within mathematics, elementary teachers felt most prepared to teach numbers and operations; three-quarters reported that they felt very well prepared to teach this topic, compared with approximately half who felt very well prepared to teach measurement, geometry, and early algebra (appendix table 1-15). Within science, elementary teachers felt most prepared to teach life and earth science, with about one-fourth reporting feeling very well prepared to teach these topics. In contrast, just 17% reported feeling very well prepared to teach physical science, and 4% reported feeling very well prepared to teach engineering.

Figure 1-16

Elementary teachers' self-assessment of their preparedness to teach mathematics and science: 2012



NOTE: Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013). See appendix table 1-15.

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Middle and high school teachers of mathematics and science who were surveyed in the NSSME were asked about their perceived level of preparedness to teach subtopics within their major subject areas. High school chemistry teachers were the most likely to report feeling very well prepared to teach topics in their discipline, ranging from 66% for properties of solutions to 83% for elements, compounds, and mixtures (appendix table 1-16). Overall, high school science teachers felt more prepared to teach biology, chemistry, and physics than middle school science teachers, but no difference was found in levels of preparedness between grade levels for teaching earth or environmental science. Both middle and high school science teachers reported very little preparedness for teaching engineering, with 6% of middle school and 7% of high school teachers reporting they felt very well prepared.

In mathematics, high school teachers were generally more likely than middle school teachers to report feeling very well prepared to teach most topics. For example, 91% of high school teachers reported feeling very well prepared to teach algebraic thinking, compared with 76% of middle school teachers (appendix table 1-17).

Self-Assessment of Preparedness for Tasks Associated with Instruction. In the NSSME, mathematics and science teachers were also asked how well prepared they felt to manage tasks associated with instruction, including handling classroom discipline and encouraging underrepresented groups to participate in their subject. The majority of respondents felt very well prepared to handle classroom discipline, with elementary school teachers most likely to feel prepared (about 70% compared with about 60% of middle and high school teachers) (table 1-9). About half of mathematics and science teachers at most levels felt very well prepared to encourage the participation of female students in mathematics and science. Elementary teachers of science were an exception—only 30% felt well prepared to encourage female participation

Table 1-9

Mathematics and science teachers considering themselves very well prepared for various tasks associated with instruction, by grade level: 2012

(Percent)

Grade level	Manage classroom discipline	Encourage students' interest in mathematics or science	Encourage participation of females in mathematics or science	Encourage participation of low-SES students in mathematics or science	Encourage participation of racial or ethnic minorities in mathematics or science
Mathematics teachers					
Elementary	69	48	56	52	50
Middle	61	46	56	53	48
High	58	39	51	40	39
Science teachers					
Elementary	72	25	30	31	30
Middle	60	39	46	36	36
High	59	53	55	44	44

SES = socioeconomic status.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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in science. In mathematics, about half of elementary teachers felt very well prepared to encourage students from low-SES groups and racial or ethnic minorities to participate in their subject, compared with about 40% of high school mathematics teachers. This pattern was reversed among science teachers, with high school teachers more likely to feel very well prepared to encourage participation among students from these groups (about 45% at the high school level compared with about 30% at the elementary level). Teachers of science at the elementary level felt the least prepared overall to encourage interest in science among all students, with just 25% reporting feeling well prepared to do so.

Teacher Professional Development

Professional development enables teachers to update their knowledge, sharpen their skills, and acquire new teaching techniques, all of which may enhance the quality of teaching and learning (Davis, Petish, and Smithey 2006; Richardson and Placier 2001). Research indicates that teacher professional development can have measurable effects on student performance. For example, an analysis examining outcomes across 16 studies of professional development for mathematics and science teachers found that professional development had significant effects on student performance in mathematics (CCSSO 2009). The 2012 NSSME collected data on how recently mathematics and science teachers participated in subject-specific professional development and how many hours they spent on professional development in the past 3 years.

Recent Participation. A majority of middle school and high school mathematics and science teachers participated in at least one professional development activity focused on mathematics or science in the last 3 years. The rates for middle and high school science teachers ranged from 82% to 89% (table 1-10). Teachers responsible for elementary science instruction were far less likely to participate in a science-focused professional development activity, with 59% reporting participation in at least one such activity in the past 3 years and 15% reporting that they had never participated in a science-focused professional development activity (compared with 3%–6% of teachers at all other levels and subjects).

Time Spent. In the NSSME, teachers were asked to report the number of hours that they had spent on subject-specific professional development in the past 3 years. About 36% of high school science teachers and 32% of high school mathematics teachers reported that they had spent more than 35 hours participating in subject-specific professional development activities in the past 3 years (table 1-11). Elementary science teachers were the least likely to have spent time participating in subject-specific professional development: 65% reported participation in less than 6 hours of professional development, compared with 35% of elementary mathematics teachers and 22%–30% of middle school and high school mathematics and science teachers.

Teachers' Working Conditions

Teachers' perceptions of their working conditions play a role in determining the supply of qualified teachers and influencing their decisions about remaining in the profession (Darling-Hammond and Sykes 2003; Hanushek, Kain, and Rivkin 2004; Ingersoll and May 2012; Ladd 2009; Johnson et al. 2004). Mathematics and science teachers are more likely than other teachers to cite job dissatisfaction as a reason for leaving teaching (Ingersoll and May 2012). Safe

Table 1-10
Mathematics and science teachers, by most recent participation in subject-focused professional development and grade level: 2012
(Percent distribution)

Grade level	In the past 3 years	4–6 years ago	7–10 years ago	More than 10 years ago	Never
Mathematics teachers					
Elementary	87	7	1	1	3
Middle	89	4	1	2	4
High	88	6	2	1	4
Science teachers					
Elementary	59	16	5	5	15
Middle	82	6	3	4	6
High	85	7	2	1	5

NOTE: Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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Table 1-11
Mathematics and science teachers spending time in subject-focused professional development in the past 3 years, by grade level: 2012
(Percent distribution)

Grade level	< 6 hours	6–15 hours	16–35 hours	> 35 hours
Mathematics teachers				
Elementary	35	35	20	11
Middle	22	24	23	31
High	23	24	22	32
Science teachers				
Elementary	65	22	8	4
Middle	30	24	20	27
High	23	20	21	36

NOTE: Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, Report of the 2012 National Survey of Science and Mathematics Education (2013).

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environments, strong administrative leadership, cooperation among teachers, high levels of parent involvement, and sufficient learning resources can enhance teachers' commitment to their schools, promote job satisfaction, and improve teachers' effectiveness (Berry, Smylie, and Fuller 2008; Brill and McCartney 2008; Guarino, Santibanez, and Daley 2006; Ingersoll and May 2012). Among the working conditions that contribute to teachers' dissatisfaction are lack of administrative support, low parent involvement, and student discipline problems (Ingersoll and May 2012; Guarino, Santibanez, and Daley 2006). Moreover, teacher job satisfaction and retention rates tend to be lower in schools with high proportions of minority, low-income, or low-achieving students (Berry, Smylie, and Fuller 2008; Hanushek, Kain, and Rivkin 2004; Ingersoll and May 2012).

The NSSME provides extensive data on working conditions that affect teachers' perceptions of their school environments. Mathematics and science program representatives at each school site were asked to identify which school factors inhibited or promoted effective instruction in their subject area. Mathematics program representatives were more likely to report that their schools were supportive of math instruction than science program representatives were to report that their schools were supportive of science instruction. For example, 82% of mathematics program representatives reported that the importance their school placed on subject teaching promoted effective instruction in mathematics, whereas 60% of science program representatives reported so for instruction in science (appendix table 1-18). About 70% of mathematics program representatives and 53% of science program representatives agreed that school management of instructional resources promoted effective instruction in their subject. Many of the representatives (52%–65%) also agreed that district professional development policies and practices promoted effective teaching in their subject area. Relatively lower percentages of respondents (56% for mathematics and 44% for science) agreed that the time provided for teacher professional development promoted effective instruction in their subject area.

School program representatives were also asked to rate the extent to which several factors were problems for instruction. These included student factors such as high absenteeism, lack of student interest, low reading ability, and inappropriate behavior; teacher factors such as lack of teacher interest and insufficient time to share ideas; and school factors such as inadequate funds for equipment. Representatives were asked to classify issues on a scale, ranging from "not a significant problem" to "a serious problem."

For science instruction, one of the most frequently cited problems was inadequate funds for purchasing equipment: about 30% of program representatives in elementary, middle, and high schools reported this as a serious problem for science instruction (table 1-12). At the middle and high

Table 1-12
School program representatives reporting various issues as serious problems for mathematics and science instruction, by school level: 2012
(Percent)

	Mathematics instruction			Science instruction		
Issues	Elementary	Middle	High	Elementary	Middle	High
Student issues						
High student absenteeism	8	13	16	8	13	13
Inappropriate student behavior	10	16	10	9	15	8
Low student interest in mathematics or science	14	25	30	5	11	13
Low student reading abilities	22	24	20	16	19	19
Teacher issues						
Insufficient time to teach mathematics or science	13	12	10	27	17	10
Lack of opportunities for teachers to share ideas	15	14	9	20	16	13
Lack of teacher interest in mathematics or science	2	1	2	4	3	2
School issues						
Inadequate funds for purchasing equipment and supplies	12	18	16	30	32	28
Lack of parental support	15	17	15	10	14	9

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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school levels, 19% of respondents cited low student reading abilities as a serious problem for science instruction in their schools; 16% of elementary program respondents cited low reading ability as a serious problem. Several other problems were reported more frequently in elementary schools than in high schools, including insufficient time to teach science (27% versus 10%) and lack of opportunities for science teachers to share ideas (20% versus 13%). Low student interest in science was cited as a serious problem for instruction among 5% of respondents in elementary schools and 13% of those in high schools. For mathematics instruction at the elementary level, the most frequently cited problem was low student reading abilities (22%), which was mentioned substantially more often than low student interest in mathematics (14%). At the high school level, this pattern was reversed: 30% of respondents mentioned low student interest in math as a serious problem but only 20% mentioned low student reading ability. At the middle school level, percentages of respondents mentioning these two problems were similar (about 25%).

In the NSSME data, both mathematics and science teachers in high-poverty schools found student behavior problems to be a greater barrier to effective instruction than did teachers in low-poverty schools (Banilower et al. 2013). Teacher behavior was also more frequently seen as a problem in high-poverty schools compared with low-poverty schools, though to a far lesser extent than student behavior.

Mathematics and Science Teacher Attrition

In view of the potential for large numbers of teachers to retire in the next few years and the importance of improving students' mathematics and science achievement, both government (The White House 2012) and advocacy organizations (see sidebar "100Kin10") seek to prepare more new mathematics and science teachers to ensure that there is an ample supply of highly qualified teachers in these subjects. If, however, new teachers leave the profession within a few years of beginning teaching, attrition may negate efforts to expand the teaching force (Ingersoll and Perda 2010). A recent study found that teacher attrition varied greatly among schools, and that high-poverty, high-minority, and urban public schools had the highest mathematics and science teacher turnover (Ingersoll and May 2012).

Annual attrition rates among public school teachers, measured by the Teacher Follow-up Survey six times since 1988–89, indicate that mathematics and science teachers leave the profession at about the same rates as all teachers do (NSB 2012). Eight percent of all 2007 teachers had left the profession by 2008, and the corresponding rates for mathematics and science teachers were similar (8% and 9%, respectively) (NSB 2012).

The Beginning Teacher Longitudinal Study (BTLS) expands the ability to measure teacher attrition from 1-year rates to cumulative rates for each of the first 5 years of teaching. It focuses specifically on the attrition rate of beginning teachers rather than yearly attrition rates for all teachers. Beginning teachers who entered the profession in 2007–08 were surveyed in their first year and again in each of the next

100Kin10

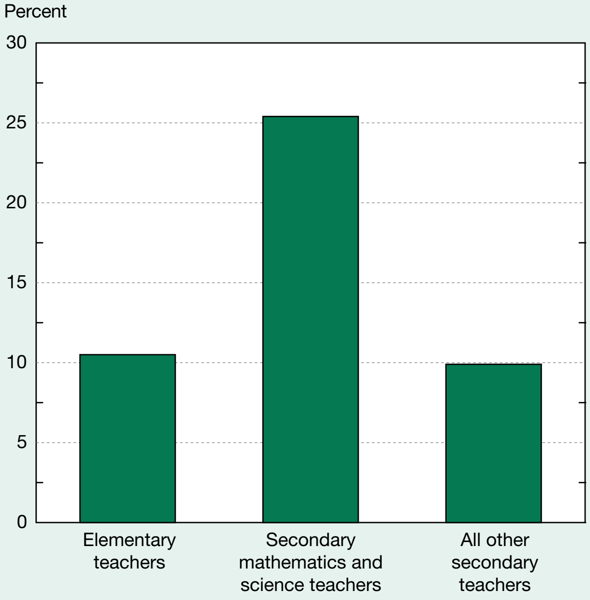
100Kin10 aims to ensure that all U.S. students have the STEM literacy needed to prepare them for employment and citizenship. In 2011, President Obama set a goal of training 100,000 well-qualified mathematics and science educators over the next 10 years. 100Kin10 was launched to meet this goal by improving STEM teacher training and retention. Begun through the efforts of the Carnegie Corporation of New York and Opportunity Equation, the program brings funders together with partners from a variety of sectors (e.g., federal and state government agencies, corporations, universities, and nonprofits) to contribute toward the overall goal. 100Kin10 aims to build long-term capacity for training and retaining STEM teachers by evaluating the implementation of programs and identifying and disseminating best practices. The University of Chicago (Urban Education Institute and Center for Elementary Mathematics and Science Education) is developing methods and tools that will allow partners to view emerging data, measure the impact of their investments, and create opportunities for partners to work with and learn from each other.

As of August 2013, 26 funders have pledged more than $52 million toward the work of 100Kin10 partner organizations. More than 150 partner organizations have been selected to participate and have currently committed to training 40,000 STEM teachers by 2016. More information about 100Kin10 and current partners can be found at http://www.100kin10.org/.

4 years to gather information on their early careers. This section reviews data from the first 3 years of the study.

Although rates of attrition after the first year of teaching in the BTLS were not significantly different among mathematics and science teachers and teachers of other subjects at the secondary level, the situation changed by the third year of teaching. At the secondary level, beginning mathematics and science teachers' rates of attrition by their third year of teaching were higher than the rates of those who taught other subjects. Whereas 10% of other secondary-level teachers had left the profession by 2009−10 (their third year of teaching), 25% of secondary mathematics and science teachers had departed by then (figure 1-17; appendix table 1-19). Beginning secondary mathematics and science teachers' attrition rates as of the third year also exceeded those of beginning elementary teachers (11%). Although statistically significant, these results are based on a small sample of teachers and should be interpreted with caution. Data from years 4 and 5 of the study will enable more conclusive findings about the attrition rates of secondary mathematics and science teachers compared with secondary teachers of other subjects.

Figure 1-17
Beginning public elementary and secondary teachers (2007–08) who had left teaching by 2009–10



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of Beginning Teacher Longitudinal Study (BTLS), First Through Third Wave Preliminary Data File, 2007–08, 2008–09, 2009–10, National Center for Education Statistics. See appendix table 1-19.

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Instructional Technology and Digital Learning

Federal and state policies encourage greater use of instructional technology, increasingly referred to as "digital learning" or "digital education." The Alliance for Excellent Education defines digital learning as "any instructional practice that is effectively using technology to strengthen the student learning experience" (Alliance for Excellent Education 2012). Digital learning encompasses a broad array of tools and practices, including online courses, applications of technology in the classroom, computer-based assessment, and adaptive software for students with special needs. In 2010, the U.S. Department of Education released a National Education Technology Plan (NETP) calling for the use of advanced technologies throughout the education system to improve student learning, accelerate implementation of effective practices, and enable schools to use data and information for continuous improvement (U.S. Department of Education 2010). Since publication of the NETP, reports about and initiatives involving digital education have proliferated (Alliance for Excellent Education 2011, 2012; Staker and Horn 2012; Watson et al. 2012; Wicks 2010).

The National Council of Teachers of Mathematics, for example, strongly endorsed the use of educational technology in mathematics education, saying that it is "essential" and "enhances student learning" (National Council of Teachers of Mathematics 2011). Findings from a number of studies have shown that the strategic use of technology tools in mathematics and science education, in particular, can support the learning of mathematical and scientific procedures and skills as well as the development of advanced proficiencies such as problem solving and reasoning (Hegedus and Roschelle 2013; Pierce et al. 2011; Rutten, van Joolingen, and van der Veen 2012). Proponents suggest that computer applications and technological tools, either alone or in concert with traditional instruction, may improve student achievement in mathematics and science by tailoring lessons and skill practice to individual students' needs or by offering students additional opportunities to interact with information through computer simulations or other methods. In addition, computerized assessment may provide more precise and efficient feedback on student learning, allowing teachers to adapt instruction to student needs more effectively (Tucker 2009). Instruction through technology may also motivate students' interest in mathematics and science.

This section focuses specifically on instructional technology, defined as technology products and tools designed to assist teaching and learning, in elementary and secondary schools. It distinguishes between the use of technology as an instructional tool and online learning, a special form of distance education. The section begins by discussing recent research on the effectiveness of technology as an instructional tool. It then updates national estimates of access to computers and the Internet and examines the current state of distance education, specifically online learning. This section ends with an overview of the research on the effectiveness of online learning.

Technology as an Instructional Tool

The use of instructional technology in K–12 classrooms has been growing at a rapid pace. Many school districts have invested in technology such as computers, mobile devices, and interactive whiteboards. In 2009, NCES surveyed a nationally representative sample of teachers to determine the availability and use of educational technology among teachers in public elementary and secondary schools. Teachers reported having the following technology devices either available as needed or in the classroom every day: LCD (liquid crystal display) or DLP (digital light processing) projectors (36% available as needed and 48% in the classroom every day), interactive whiteboards (28% and 23%, respectively), and digital cameras (64% and 14%, respectively) (table 1-13). Among teachers who reported that these devices were available to them, one-half or more also reported that they used these devices for instruction sometimes or often: 72% of teachers used LCD or DLP projectors, 57% used interactive whiteboards, and 49% used digital cameras (Gray, Thomas, and Lewis 2010).

The 2012 NSSME surveyed teachers about the adequacy of the instructional technology (e.g., computers, calculators, probes/sensors) available to them (Banilower et al. 2013). High school mathematics teachers were the most likely to indicate that their instructional technology resources were adequate (69%), whereas elementary and middle school science teachers were the least likely to indicate so (35%) (Banilower et al. 2013).

Research on Instructional Technology

Despite the rapid growth in the use of technology in classrooms, a substantial base of rigorous research on the effectiveness of technology in improving student achievement is lacking. Few national studies are available and many

Table 1-13
Public school teachers reporting the availability and frequency of use of technology devices, by school level: 2009
(Percent)

School level	Digital projector			Interactive whiteboard			Digital camera		
	Availability		Used for instruction sometimes or often[a]	Availability		Used for instruction sometimes or often[a]	Availability		Used for instruction sometimes or often[a]
	As needed	In classroom every day		As needed	In classroom every day		As needed	In classroom every day	
All public school teachers[b]	36	48	72	28	23	57	64	14	49
Elementary	37	44	68	31	23	58	67	14	53
Secondary	33	56	78	23	23	58	57	13	41

[a] Based only on teachers reporting that the device was available as needed or in the classroom every day.

[b] Data for teachers in combined schools (i.e., those with both elementary and secondary grades) are included in All public school teachers but are not shown separately.

SOURCE: Gray L, Thomas N, Lewis L., *Teachers' Use of Educational Technology in U.S. Public Schools: 2009*, NCES 2010-040 (2010).

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studies that have been conducted are often of brief duration and are product-specific studies based on small samples and nonrigorous research designs. The Office of Educational Technology has issued a report outlining the problems with current research into digital education and providing a framework for how research evidence can be improved (U.S. Department of Education 2013).

Three recent meta-analyses reviewed studies that compared the mathematics achievement of students taught in elementary and secondary classes using technology-assisted mathematics programs with that of students in control classes using alternative programs or standard methods (Cheung and Slavin 2011; Li and Ma 2010; Rakes et al. 2010). All three studies found small positive effects on student achievement when technology was incorporated into classroom mathematics instruction.[33]

One recent study used a randomized control trial design to examine the effectiveness of a technology-based algebra curriculum in a wide variety of middle schools and high schools in seven states (Pane et al. 2013). Participating schools were matched into similar pairs and randomly assigned to either continue with the current algebra curriculum for 2 years or to adopt a technology-assisted program using a personalized, mastery-learning, blended-learning approach. Schools assigned to implement the program did so under conditions similar to schools that independently adopted it. Analysis of posttest outcomes on an algebra proficiency exam found no effects in the first year of implementation but found strong evidence in support of a positive effect in the second year. The estimated effect was statistically significant for high schools but not for middle schools; in both cases, the magnitude was sufficient to improve the average student's performance by approximately 8 percentage points.

An earlier national study of the effectiveness of instructional technology failed to find any statistically significant effects of several specific instructional technologies on student achievement (Dynarski et al. 2007). Researchers tested three grade 6 math products in 28 schools and three algebra products in 23 schools. Teachers in selected schools volunteered to participate and were randomly assigned to use or not use the educational software. Researchers compared students' test results and other outcomes. No effects on sixth grade mathematics or algebra achievement were observed. During the second year of the evaluation, two grade 6 math products and two algebra products were tested, and again researchers observed no significant effects on student achievement (Campuzano et al. 2009). No science products were tested.

Several small-scale studies of specific instructional technology applications suggest that educational computer programs and video games may promote student engagement and learning when they make use of proven pedagogical techniques (Barab et al. 2007; Ketelhut 2007; Nelson 2007; Neulight et al. 2007; Steinkuehler and Duncan 2008). One study found that the use of interactive whiteboard technology was associated with increased motivation in mathematics among elementary school students (Torff and Tirotta 2010). Another study of a popular algebra program found that students randomly assigned to computer-aided instruction using the algebra program scored higher on a test of pre-algebra and algebra skills than students assigned to traditional instruction (Barrow, Markman, and Rouse 2009).

Internet Access

Access to the Internet is nearly universal in public elementary and secondary schools in the United States. In 2008, 100% of public schools had instructional computers with Internet access (Gray, Thomas, and Lewis 2010). Student access to the Internet via instructional computers at school has increased substantially since 2000. In 2008, the average public school had 189 instructional computers compared with 110 in 2000. There were three students per computer with Internet access in 2008 compared with seven students per computer with Internet access in 2000. Mobile devices are also enhancing students' access to the Internet. Nearly 50% of high school students and 40% of middle school students now own or have access to a smartphone or tablet, marking a 400% increase since 2007 (Project Tomorrow 2012).

Although Internet access is nearly universal, connection speeds and adequate bandwidth are areas of concern (Fox et al. 2012). A 2010 Federal Communications Commission survey of schools with federal funding for Internet access found that most had access to some form of broadband service (Federal Communications Commission 2010). Nearly 80% of survey respondents, however, reported that their broadband connections were inadequate and slow Internet connection speeds were the primary problem. Bandwidth availability and connection speed affect which online content, applications, and functionality students and educators are able to use effectively in the classroom (Fox et al. 2012).

Distance Education and Online Learning

In addition to potentially enhancing learning in the classroom, technology can also enable students to receive instruction remotely through distance education or online learning. Distance education may include videoconferencing and televised or audiotaped courses, but Internet courses (hereafter referred to as online learning) are the most widespread and fastest-growing mode of delivery (Queen and Lewis 2011). Online learning programs range from programs that are fully online with all instruction occurring via the Internet to hybrid or "blended learning" programs that combine face-to-face teacher instruction with online components (Picciano and Seaman 2009; Staker and Horn 2012; Watson et al. 2011).

The United States is experiencing rapid growth in online learning at the K–12 level. The Sloan Consortium estimates that more than 1 million elementary and secondary students were enrolled in online or blended learning courses in 2007–08, a 47% increase from the 2005–06 school year.[34] These estimates are based on two national surveys of public school districts (Picciano and Seaman 2009). Based on this level of growth, the International Association for Online K-12 Learning (iNACOL) estimates that more than 1.5 million K–12 students participated in some form of online learning in 2010 (Wicks 2010). A nationally representative survey of public school districts conducted by NCES in 2009 found that providing courses not otherwise available at their schools and giving students opportunities to recover course credits for classes missed or failed were the top reasons for offering online learning options (Queen and Lewis 2011). The survey found that credit recovery is especially important for urban schools: 81% indicated this was a very important reason for making online learning opportunities available (table 1-14).

Research on Effectiveness of Online Learning

Policymakers and researchers (Bakia et al. 2012; Watson et al. 2012; U.S. Department of Education 2010) cite numerous potential benefits of online learning:

- Increased access to quality educational resources and courses, particularly for students in rural or other remote locations;
- Differentiated instruction based on student need and preferred pace of learning;
- Personalized learning to build on students' interests and increase motivation;
- Reduced costs for school facilities as students access educational resources from home or other community spaces;
- Access to a wider variety of courses, including AP, higher-level math and science, and foreign languages;
- Credit recovery options to assist struggling students and those who need an additional course to graduate;
- Access to international experts to increase knowledge and understanding of careers; and
- Increased access to simulations and virtual field trips.

Table 1-14
Public school districts with students enrolled in distance education courses indicating how important various reasons were for having distance education courses in their district, by district characteristic: School year 2009–10
(Percent)

District characteristic	Provide courses not available at school	Provide opportunity for students to recover course credits from classes missed or failed	Offer Advanced Placement or college-level course	Reduce student scheduling conflicts	Provide opportunities for students who are homebound or have special needs	Provide opportunity for students to accelerate credit accumulation for early graduation
All public school districts with students enrolled in distance education courses	64	57	41	30	25	15
District enrollment size						
< 2,500	69	49	45	28	22	12
2,500–9,999	53	72	33	31	30	20
≥ 10,000	47	81	29	47	41	25
Community type						
City	37	81	23	30	41	29
Suburban	52	66	30	36	35	19
Town	60	60	40	26	30	18
Rural	73	49	48	30	17	11
Region						
Northeast	75	46	39	36	24	11
Southeast	74	65	51	42	25	18
Central	61	59	38	27	26	11
West	56	56	42	26	25	22
Poverty concentration						
< 10%	64	60	36	31	24	15
10%–19%	62	55	43	29	26	14
≥ 20%	65	57	42	31	24	18

NOTES: Response options in the questionnaire were "not important," "somewhat important," "very important," and "don't know." Only the "very important" responses are shown in the table. Percentages are based on the 55% of public school districts with students enrolled in distance education courses in the 2009–10 school year. Poverty estimates for school districts were based on Title I data provided to the U.S. Department of Education by the U.S. Census Bureau.

SOURCE: Queen B, Lewis L, *Distance Education Courses for Public Elementary and Secondary School Students: 2009–10*, NCES 2012-008 (2011).

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Despite the many potential benefits of online learning envisioned by policymakers and researchers, few rigorous studies have addressed the effectiveness of online learning compared with that of traditional school models at the K–12 level (Means et al. 2010). A systematic search of the research literature from 1994 through 2008 identified only five studies published between 1994 and 2008 that rigorously assessed online learning at the K–12 level and only one study (O'Dwyer, Carey, and Kleiman 2007) that assessed the impact of technology on mathematics learning in an elementary classroom in the United States (Means et al. 2010). O'Dwyer et al. (2007) used a quasi-experimental design to compare the learning of 231 students participating in the Louisiana Algebra I Online initiative with the learning of 232 students in comparison classrooms that had similar demographics but used traditional instruction. Scores on matched pretests and posttests showed that the online students performed as well as their peers in conventional classrooms. Other recent studies have found some positive effects for online learning, but researchers stress that teacher training and the way in which online components are integrated into the curriculum are important variables that could affect outcomes and need to be the subject of more rigorous research (Norris, Hossain, and Soloway 2012; Tamin et al. 2011).

Transition to Higher Education

Ensuring that students graduate from high school on time (i.e., within 4 years) and are ready for college or the labor market has been an important goal of high school education in the United States for decades.[35] Increasingly, skills learned in high school do not guarantee access to jobs that support families, because most of the fastest-growing, well-paying jobs in today's labor market require at least some postsecondary education (Carnevale, Smith, and Strohl 2010). About a quarter of U.S. public school students do not graduate from high school with a regular diploma within the expected period of 4 years (Chapman et al. 2011). Among those who do graduate from high school, many go to college or combine school with work, but some enter the labor market without pursuing additional education, at least in the short term (Ingels et al. 2012).

This section updates several indicators related to U.S. students' transitions from high school to college, including on-time high school graduation rates, long-term trends in immediate college enrollment after high school, the high school graduation and postsecondary entry rates of U.S. students relative to those of students in other countries, and remediation rates among students entering postsecondary institutions across the United States. Together, these indicators present a broad picture of the transition of U.S. students from high school to postsecondary education, the topic of chapter 2.

Completion of High School

High school completion in the United States can be defined and measured in a variety of ways (Seastrom et al. 2006). Based on a relatively inclusive definition—receiving a regular high school diploma or earning an equivalency credential, such as a General Educational Development (GED) certificate—about 83% of the U.S. population ages 18–24 had completed a high school education in 2009 (Snyder and Dillow 2012).

Beginning with the 2011–12 school year, the U.S. Department of Education required all states to use a more restricted definition, emphasizing on-time graduation and considering only recipients of diplomas (Curran and Reyna 2010; Chapman et al. 2011). Under this definition, the high school graduation rate is calculated as the percentage of students in a freshman class who graduate with a regular diploma 4 years later (Seastrom et al. 2006). This rate requires student-level data over time. Because not all states had these longitudinal data prior to the 2011–12 school year, the U.S. Department of Education currently uses one of the best estimates—the Averaged Freshman Graduation Rate (AFGR)—to measure on-time high school graduation rates (Seastrom et al. 2006). The AFGR calculation divides the aggregate count of the number of diplomas in a particular year by the estimated size of the incoming freshman class 4 years earlier.[36] Starting with the 2011–12 school year, the U.S. Department of Education required all states to use a measure that is based on student-level data over time in order to increase the accuracy of on-time graduation rates (U.S. Department of Education 2012b). To facilitate state-by-state comparisons, the governors of all 50 states agreed to work toward implementing this method to tabulate statistics for their public high schools (NGA 2005).

On-Time Graduation Rates from 2006 to 2010

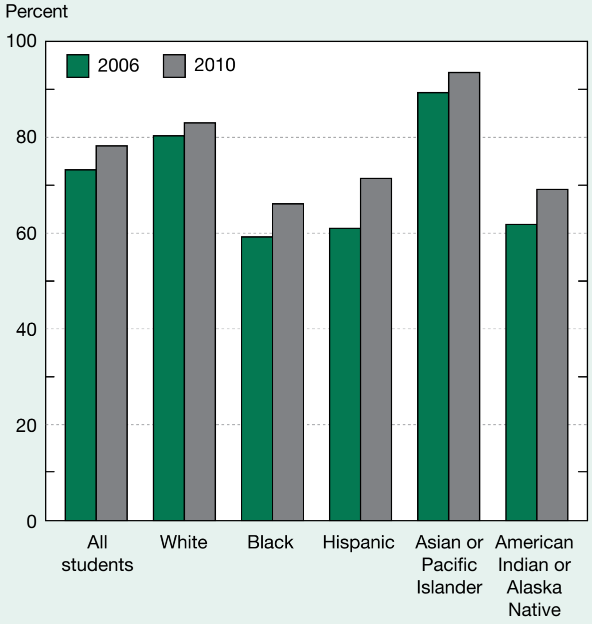
The U.S. on-time graduation rate among public high school students has increased steadily since 2006 (appendix table 1-20). In 2010, 78% of public high school students graduated on time with a regular diploma, up from 73% in 2006 (figure 1-18). Asian or Pacific Islander students (94%) graduated on time at a higher rate than did white students (83%) who, in turn, had a higher on-time graduation rate than did black, Hispanic, and American Indian or Alaska Native students (66%–71%). Between 2006 and 2010, however, on-time graduation rates improved more among black (from 59% to 66%), Hispanic (from 61% to 71%), and American Indian or Alaska Native (from 62% to 69%) students than among white (from 80% to 83%) and Asian or Pacific Islander (from 89% to 93%) students, therefore narrowing the gaps between black, Hispanic, and American Indian or Alaska Native students and their white and Asian or Pacific Islander counterparts.

Sex differences in on-time graduation rates persisted over time (appendix table 1-20). In each year between 2006 and 2009,[37] the percentage of male students who graduated from high school within 4 years was lower than that of female students. In 2009, for example, graduation rates for male students lagged behind those for female students by 8 percentage points (73% versus 81%).

High School Graduation Rates in the United States and Other OECD Nations

Each year, OECD estimates upper secondary graduation rates for its member countries and selected nonmember countries by dividing the number of graduates in a country by the number of people at the typical graduation age (OECD 2012).[38] These estimates enable a broad comparison among nations and illuminate the U.S. standing internationally. U.S. graduation rates are below those of many OECD countries. Of the 26 OECD nations for which graduation rate data were available in 2010, the United States ranked 22nd, with an average graduation rate of 77% compared with the OECD average of 84% (appendix table 1-21). The top-ranked countries include Japan, Greece, Korea, Ireland, Slovenia, Finland, Israel, and the United Kingdom, each of which had high school graduation rates above 90%.[39]

Figure 1-18
On-time graduation rates of U.S. public high school students, by race and ethnicity: 2006 and 2010



NOTES: On-time high school graduation rate is the percentage of entering ninth graders who graduated 4 years later. Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin.

SOURCES: Stillwell R, Sable J, *Public School Graduates and Dropouts from the Common Core of Data: School Year 2009–10: First Look (Provisional Data)*, National Center for Education Statistics (NCES), NCES 2013-309 (2013); Common Core Data Table Library, http://nces.ed.gov/ccd/tables/AFGR.asp, accessed February 2013. See appendix table 1-20.

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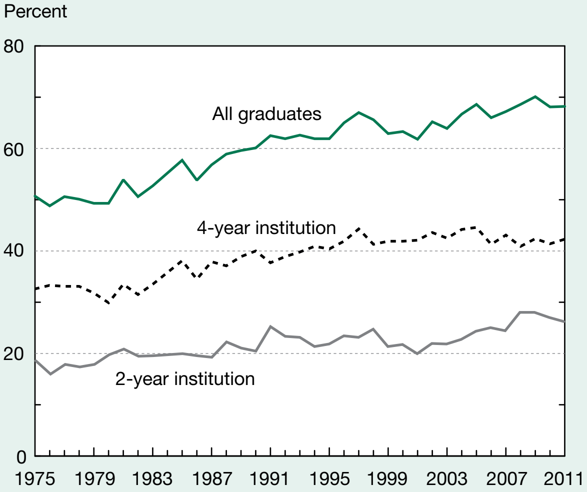
The relative standing of U.S. high school graduation rates has not improved during recent years. Among the 21 OECD countries for which graduation rate data were available in 2006, 2008, and 2010,[40] the United States ranked 16th in both 2006 and 2008 and 17th in 2010 (OECD 2008, 2010, 2012).

Enrollment in Postsecondary Education

Upon completing high school, students make critical choices about the next stage of their lives. Today, a majority of U.S. high school students expect to attend college at some point, and many do so immediately after high school graduation. In 2010, 93% of high school seniors expected to attend a postsecondary institution, with 60% having definite plans to graduate from a 4-year college program and 24% having definite plans to attend graduate or professional school after college (Aud et al. 2012). In 2011, 68% of students enrolled in a postsecondary institution immediately after they graduated from high school (i.e., by the October following high school completion), with 27% enrolling in 2-year colleges and 41% enrolling in 4-year institutions (figure 1-19).

The immediate college enrollment rate increased from 51% in 1975 to 68% in 2011, though the upward trend appeared to level off from 2009 to 2011 (figure 1-19). Overall, immediate college enrollment rose more for women (from

Figure 1-19
Immediate college enrollment rates among high school graduates, by institution type: 1975–2011



NOTES: Includes students ages 16–24 completing high school in survey year. Immediate college enrollment rates are defined as rates of high school graduates enrolled in college in October after completing high school. Before 1992, high school graduates referred to those who had completed 12 years of schooling. As of 1992, high school graduates are those who have received a high school diploma or equivalency certificate.

SOURCE: Aud S, Wilkinson-Flicker S, Kristapovich P, Rathbun A, Wang X, Zhang J, *The Condition of Education 2013*, NCES 2013-037 (2013). See appendix table 1-22.

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49% to 72%) than for men (from 53% to 65%); thus, the enrollment pattern has shifted over time to higher enrollment rates for women than for men (appendix table 1-22).

Large gaps persisted among students of different socioeconomic backgrounds. In each year between 1975 and 2011, the immediate college enrollment rates were lower among students from low-income families than among students from middle- and high-income families (appendix table 1-22). In 2011, the immediate college enrollment rate of students from low-income families was about 29 percentage points lower than the rate of those from high-income families (53% versus 82%). Enrollment rates also varied with parental education, with students whose parents had only a high school education (54%) or some college (67%) trailing behind those whose parents had a bachelor's or advanced degree (83%). Gaps existed among racial and ethnic groups as well. In each year between 1995 and 2011, for example, the enrollment rate of Hispanic students was lower than the rate for white students (e.g., 63% versus 69% in 2011). The immediate college enrollment rate of black students was also lower than the rate for white students in every year from 1995 to 2009 (e.g., 62% versus 71% in 2009).[41]

Postsecondary Enrollment in an International Context

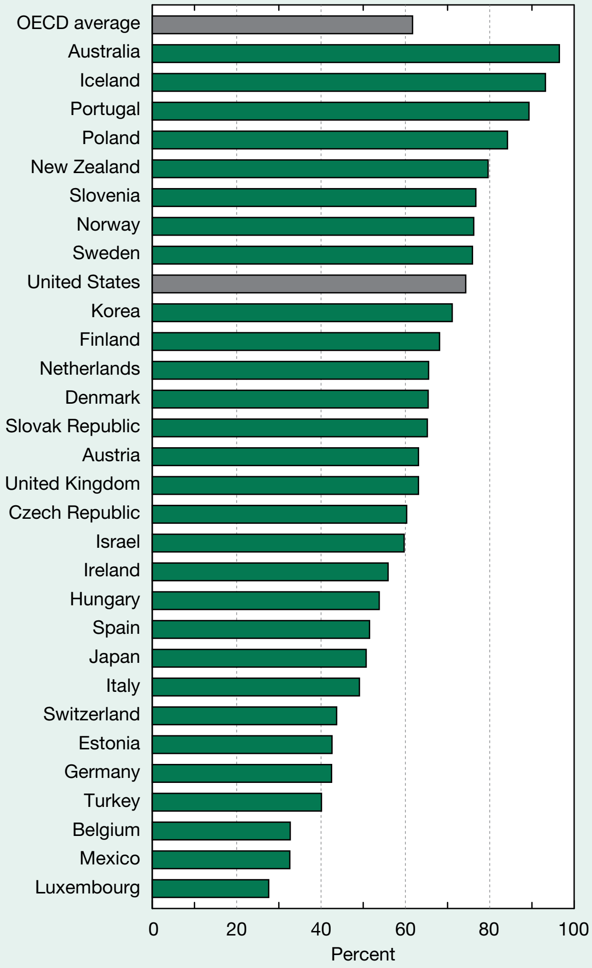
Participation in education beyond secondary schooling has been rising in many countries (Altbach, Reisberg, and Rumbley 2009; OECD 2012). One measure of such participation is the OECD-developed first-time entry rate into a university-level education program (referred to as a "tertiary-type A" program by OECD[42]). This measure, though not perfect,[43] provides a broad comparison of postsecondary enrollment rates in the United States and those in other OECD countries.

According to OECD data, the percentage of U.S. young adults enrolling in university-level education for the first time was 74% in 2010, above the OECD average of 62% (figure 1-20). The United States ranked 9th out of the 30 countries with available data. Women enroll in college at higher rates than men in most OECD countries, including the United States (appendix table 1-23). In the United States, women enrolled at a rate of 82% (compared with the OECD average of 69%), and men enrolled at a rate of 67% (compared with the OECD average of 55%).

Preparation for College

Despite the increasing numbers of U.S. students entering college, many are unprepared for college-level work and need remedial help to address their skill deficiencies (Kurlaender and Howell 2012). Nationally, half of first-time postsecondary students took some type of remedial course after they entered college, and 42% took one or more remedial math courses (table 1-15).[44] The overall remediation rates were much higher at 2-year institutions than at 4-year institutions (65% versus 37%) and at minimally selective 4-year institutions than at highly selective 4-year institutions (53% versus 22%). This variation largely reflects the kinds of students admitted to different types of institutions: 4-year colleges, particularly highly selective ones, tend to admit students with greater academic preparation than more accessible 2-year colleges, and this pattern, in turn, affects the number of students needing remedial education at these institutions (Berkner and Choy 2008).

Figure 1-20
First-time entry rates into university-level education, by OECD country: 2010



OECD = Organisation for Economic Co-operation and Development.

NOTES: Portugal's rate was overestimated because it included students who enrolled in the first year of any postsecondary program instead of a university-level education program. Countries/jurisdictions are ordered by 2010 first-time entry rate. Tied countries/jurisdictions with identical rounded estimates are listed alphabetically.

SOURCE: OECD, *Education at a Glance: OECD Indicators 2012* (2012). See appendix table 1-23.

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Table 1-15
Beginning 2003–04 postsecondary students who took remedial courses during their enrollment, by type of first institution: 2003–09
(Percent)

Type of first institution	One or more remedial courses in any field	One or more remedial mathematics courses
All beginning postsecondary students	50.4	42.2
4-year institution[a]	37.2	29.2
Highly selective	22.4	15.0
Moderately selective	37.1	29.4
Minimally selective or open admission	53.4	44.7
2-year institution	65.4	57.1

[a] A small proportion of students who first attended private, for-profit 4-year institutions were excluded from the estimates that are based on institution selectivity because information on the selectivity of these institutions was not available.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of 2003–04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09), National Center for Education Statistics.

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Conclusion

Raising student achievement, reducing performance gaps, and improving the international ranking of U.S. students on achievement tests from the middle to the top are high priorities for education reform across the United States. How well does this country perform in these areas? The indicators in this chapter present a mixed picture of the progress of elementary and secondary mathematics and science education in the United States. NAEP mathematics assessment results show that average mathematics scores for fourth and eighth graders have increased substantially since 1990, but this improvement has slowed down or halted for many groups in recent years. In science, eighth graders made small gains from 2009 to 2011. Overall, a large majority of U.S. fourth and eighth graders did not demonstrate proficiency in the knowledge and skills taught at their grade level. In particular, students from disadvantaged backgrounds lagged behind their more advantaged peers, with these disparities starting as early as kindergarten. International assessments have also produced mixed results. Although U.S. students have performed above the international average on the TIMSS mathematics and science tests, they have not been among the very top-achieving groups in the world.

Efforts to improve student achievement include raising high school graduation requirements, strengthening the rigor of curriculum standards, increasing advanced coursetaking, and promoting early participation in gatekeeper courses such as algebra 1. These efforts have brought some positive changes: increasing numbers of states adopted a common set of rigorous academic standards designed to ensure that students graduate from high school prepared for college and careers; rising proportions of students earned advanced mathematics and science credits before high school completion; large majorities of ninth graders took algebra 1 during or before their freshman year; and the number of students taking mathematics and science AP exams doubled in the recent decade. There is still room for improvement, however: the overall percentage of students taking mathematics and science AP tests remains very small; a sizeable number of students do not take any math or science in their freshman year; and wide gaps among students from different social and economic backgrounds persist.

Efforts to improve student achievement also focus on ensuring that all students have access to highly qualified teachers, although there has not yet been a consensus on what constitutes a "highly qualified" teacher. The majority of K–12 mathematics and science teachers held a teaching certificate and had taught their subjects for 3 or more years. Indicators of in-field teaching and undergraduate coursework suggest that high school mathematics and science teachers were generally better prepared for their teaching subjects than middle and elementary school teachers. Fully certified, well-prepared, and experienced teachers were not evenly distributed across schools or classes. Overall, schools or classes with lower concentrations of non-Asian minority and low-income students and higher concentrations of high-achieving students were more likely to have fully certified and better-prepared mathematics and science teachers. Working conditions were also not evenly distributed across schools: high-poverty schools were more likely to suffer from various problems that inhibit effective teaching (e.g., low student interest, high absenteeism, inadequate teacher preparation, and lack of materials and supplies).

The majority of middle and high school mathematics and science teachers participated in subject-focused professional development activities, but elementary science teachers were far less likely to do so. Many teachers reported that their professional development activities were of short duration, lasting in total from less than 6 hours to 35 hours during the past 3 years. About a quarter of secondary mathematics and science teachers left teaching within 3 years of entering the profession; this attrition rate was more than double the rate for other secondary-level teachers.

Recent federal and state policies encourage greater use of technology throughout the education system as a way to improve students' learning experience. The use of instructional technology in K–12 classrooms has been growing at a rapid pace. Many school districts have invested in technology such as computers and mobile devices. The number of students participating in online learning courses is also rising, jumping from 220,000 in 2003 to an estimated 1.8 million in 2010. Rigorous research on the effects of instructional technology and online learning has just begun, showing some modest positive effects on student mathematics learning, but far more research is needed to determine which technologies are effective and under what conditions.

Ensuring that students graduate from high school and are ready for college or the labor market is an important goal of high school education in the United States. Since 2006, the U.S. on-time high school graduation rates have improved steadily. In 2010, the vast majority of public high school students graduated with a regular diploma 4 years after entering ninth grade. Significant racial and ethnic and sex differences persisted, however, with white, Asian or Pacific Islander, and female students having higher graduation rates than their counterparts. In the broad international context, the United States ranked 22nd in graduation rates among 26 OECD countries with available data in 2010, and its relative standing has not improved in recent years.

The vast majority of high school seniors expect to attend college after completing high school, and many do so directly after high school graduation. Immediate college enrollment rates have increased for all students as well as for many demographic groups since 1975, although this upward trend leveled off somewhat from 2009 to 2011. Wide gaps have persisted, with black students, Hispanic students, low-income students, and students whose parents have less education enrolling in college at lower rates than their peers. Large proportions of college entrants, particularly those beginning at 2-year or minimally selective 4-year institutions, took remedial courses to address their skill deficiencies in mathematics and other areas.

Notes

1. The terms *achievement* and *performance* are used interchangeably in this section when discussing scores on mathematics and science assessments.

2. The No Child Left Behind Act of 2001 has been due for congressional reauthorization since 2007. President Obama announced in September 2011 that his administration would grant waivers from NCLB requirements to states in exchange for state-developed reform plans to prepare all students for college and career, focus aid on the neediest students, and support effective teaching and leadership. As of October 2012, 44 states had requested waivers from NCLB and 33 states (plus the District of Columbia) had been approved to implement their state-tailored reform agendas. The 33 approved states include Arizona, Arkansas, Colorado, Connecticut, Delaware, Florida, Georgia, Indiana, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Jersey, New Mexico, New York, North Carolina, Nevada, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Virginia, Washington, and Wisconsin. The 11 states with outstanding requests for waivers include Alabama, Alaska, California, Hawaii, Idaho, Illinois, Iowa, Maine, New Hampshire, North Dakota, and West Virginia. The 6 states that have not yet requested a waiver include Montana, Nebraska, Pennsylvania, Texas, Vermont (request withdrawn), and Wyoming (http://www.ed.gov/news/press-releases/seven-more-states-puerto-rico-and-bureau-indian-education-request-nclb-flexibili).

3. Whenever a difference is cited in this chapter, it was tested using Student's t-test statistic to minimize the chances of concluding that the difference exists based on the sample when no true difference exists in the population from which the sample was drawn. These tests were done with a significance level of 0.1, which means that a reported difference would occur by chance no more than once in 10 samples when there was no actual difference between the population means.

4. No new assessment data on high school students were available at the time this chapter was prepared. The 2012 volume of *Science and Engineering Indicators* (NSB 2012) contains recent trend data on mathematics and science performance of students in grade 12.

5. Asians and Pacific Islanders are combined into one category in some indicators for which the data were not collected separately for the two groups.

6. Mathematics assessments were administered in fall 2010 and spring 2011. These assessments were designed to measure students' conceptual knowledge, procedural knowledge, and problem-solving skills and included questions on number sense, properties, and operations; measurement; geometry and spatial sense; data analysis, statistics, and probability; and pre-algebra skills (Mulligan, Hastedt, and McCarroll 2012). Although the assessments included largely items related to students' knowledge at the kindergarten level, easier and more difficult items were included to measure the achievement of students performing below or above grade level. Some students who spoke a language other than English or Spanish at home did not participate in mathematics assessments because of low English proficiency. Because the ECLS-K:2011 is a longitudinal study, the assessments were developed to measure the growth in performance of children from kindergarten entry through fifth grade.

7. These two NAEP assessment programs differ in many respects, including samples of students and assessment times, instruments, and contents. See http://nces.ed.gov/nationsreportcard/about/ltt_main_diff.asp.

8. The 2010 volume reviewed long-term trends in mathematics from 1973 to 2008, and the 2004 volume examined trends in science from 1969 to 1999. The long-term trend assessments in mathematics were administered again in 2012 and are not yet available; no long-term trend assessments in science have been conducted since 1999.

9. Students in the below-basic category have scores that are lower than the minimum score for the basic level. Students in the basic category have scores that are at or above the minimum score for the basic level but lower than the minimum score for the proficient level. Students in the proficient category have scores that are at or above

the minimum score for the proficient level but lower than the minimum score for the advanced level. Students in the advanced category have scores that are at or above the minimum score for the advanced level.

10. See NAEP's mathematics and science achievement levels defined by grade at http://nces.ed.gov/nationsreportcard/mathematics/achieveall.asp and http://nces.ed.gov/nationsreportcard/science/achieveall.asp.

11. Estimates for long-term trends could not be performed for American Indian or Alaska Native students because of unavailable data in the 1990s.

12. Percentiles are scores below which the scores of a specified percentage of the population fall. For example, among fourth graders in 2011, the 10th percentile score for mathematics was 203. This means that 10% of fourth graders had mathematics scores at or below 203, and 90% scored above 203. The scores at various percentiles indicate students' performance levels.

13. Students' eligibility for free/reduced-price lunch is often used as a proxy measure of family poverty. In this chapter, students who are eligible for free/reduced-price lunch are considered to come from low-income families.

14. For fourth and twelfth graders' science assessment results in 2009, see *Science and Engineering Indicators 2012* (NSB 2012:1-13). For results from administration years prior to 2009, see *Science and Engineering Indicators 2008* (NSB 2008:1-13–1-14).

15. The substantive implication of this small increase will be clearer when more assessment data are available for analysis in the future.

16. Differences in performance between public and private school students reflect in part different types of students enrolled in public and private schools and differences in the availability of resources, admissions policies, level of parental involvement, and school conditions.

17. For detailed comparisons between PISA and TIMSS, see *Science and Engineering Indicators 2010* (NSB 2010:1–16).

18. For more information about the PISA results, see *Science and Engineering Indicators 2012* (NSB 2012:1-14–1-16).

19. The scores are reported on a scale from 0 to 1,000, with the TIMSS scale average set at 500 and the standard deviation set at 100.

20. The TIMSS results presented in this report exclude individual U.S. states, Canadian provinces, and Dubai and Abu Dhabi in the United Arab Emirates. These states/provinces participated in 2011 TIMSS as "benchmarking participants" in order to assess the comparative international standing of their students' achievement and to view their curriculum and instruction in an international context.

21. Taipei is the capital city of Taiwan.

22. The TIMSS scale for each subject and grade originally was established to have a mean of 500 as the average of all of the countries and jurisdictions that participated in TIMSS 1995. TIMSS assessments since then have scaled the achievement data so that scores are comparable from assessment to assessment. Thus, for example, a score of 500 in fourth grade mathematics in 2011 is equivalent to a score of 500 in fourth grade mathematics in 1995, 1999, 2003, or 2007.

23. The transcript studies reported in 2012 have not been updated since then.

24. A recent NCES study of algebra and geometry curricula in the nation's high schools found substantial variation in rigor and curriculum coverage among these courses (Brown et al. 2013). For more information, see http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2013451.

25. NCES established the Secondary Longitudinal Studies Program (SLSP) to study the educational, vocational, and personal development of young people beginning with their high school years and following them over time into adult roles and responsibilities. Thus far, the SLSP consists of five major studies: the National Longitudinal Study of the High School Class of 1972 (NLS:72); High School and Beyond (HS&B); the National Education Longitudinal Study of 1988 (NELS:88); the Education Longitudinal Study of 2002 (ELS:2002); and the High School Longitudinal Study of 2009 (HSLS:09). More information about each of these studies is available at http://nces.ed.gov/surveys/slsp.

26. The first follow-up collection of HSLS:09 was conducted in spring 2012 when most sample members were in the eleventh grade. Data from this collection were not available at the time of publication. Future follow-ups will include collection and coding of high school transcripts in 2013 and a second follow-up in 2016 when most sample members will be 3 years beyond high school graduation. Additional follow-ups are currently planned to at least age 26.

27. It is important to note that the data from HSLS indicate the percentage of students who enrolled in algebra in ninth grade but not the percentage who passed the course.

28. NAEP HSTS identifies three curriculum levels based on the types of courses students take: standard, midlevel, and rigorous. A rigorous mathematics curriculum includes 4 years of mathematics including up to at least pre-calculus (Nord et al. 2011).

29. Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal groups. Quintile 1 corresponds to the lowest one-fifth of the population and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined to form one category.

30. White students were equally likely to report enrollment in biology 1 or earth/environmental/physical science in ninth grade (36% each), whereas students in other racial and ethnic groups were more likely to report enrollment in biology 1: 35% of black students and 44% of Hispanic students reported enrollment in biology 1 compared with 27% and 24%, respectively, in earth/environmental/physical science. Asian students were the most likely to report enrollment in biology 1 (51%) and the least likely to report enrollment in environmental/physical science (17%). Research does not indicate why this coursetaking pattern is different for whites compared with other groups.

31. In previous editions of *Science and Engineering Indicators*, data from the NCES Schools and Staffing Survey (SASS) have been used to describe teachers and teaching. The 2011−12 SASS data were not available for analyses at the time this chapter was prepared, however.

32. The NSSME reports the percentage of mathematics teachers who have a degree in mathematics or mathematics education and the percentage of science teachers who have a degree in science (any subject), engineering, or science education. Teachers of mathematics with related degrees, such as computer science or physics are not included in the percentage of mathematics teachers with degrees in their field. The NSSME provides further level of detail for science teachers, indicating the percentage of teachers of each discrete science subject that have a degree in that particular area.

33. Effect sizes ranged from +0.1 to +0.2, indicating a difference of .1 to .2 standard deviations, generally considered small effect sizes.

34. Public school enrollment in K−12 in the United States in 2008 was approximately 49 million students (http://nces.ed.gov/fastfacts/display.asp?id=65).

35. See the U.S. Education Dashboard at http://dashboard.ed.gov/about.aspx.

36. The incoming freshman class size is estimated by summing the enrollment in eighth grade for 1 year, ninth grade for the next year, and tenth grade for the year after, and then dividing by 3. For example, the 2009–10 on-time graduation rate equals the total number of diploma recipients in 2009–10 divided by the average membership of the eighth grade class in 2005–06, the ninth grade class in 2006–07, and the tenth grade class in 2007–08 (Stillwell and Sable 2013).

37. Gender data were not available in 2010.

38. Upper secondary education as defined by OECD corresponds to high school education in the United States. In the calculation of the U.S. graduation rates, OECD included only students who earned a regular diploma and excluded those who completed a GED certificate program or other alternative forms of upper secondary education. OECD defines the typical age as the age of the students at the beginning of the school year; students will generally be 1 year older than the age indicated when they graduate at the end of the school year. According to OECD, the typical graduation age in the United States is 17 years old. The U.S. high school graduation rates calculated by OECD cannot be directly compared with U.S. on-time graduation rates because of the different population bases and calculation methods for the two measures.

39. Portugal's rate, though at the top, was not reliable and therefore is not listed here.

40. These countries are Czech Republic, Denmark, Finland, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Norway, Poland, Slovak Republic, Spain, Sweden, Turkey, the United Kingdom, and the United States.

41. The 2011 immediate college enrollment rates for whites and blacks were not measurably different (69% and 65%, respectively).

42. As defined by OECD, a "tertiary-type A" program provides education that is largely theoretical and is intended to provide sufficient qualifications for gaining entry into advanced research programs and professions with high-skill requirements. Entry into these programs normally requires successful completion of upper secondary education (e.g., high school); admission is competitive in most cases. Minimum cumulative duration at this level is 3 years of full-time enrollment.

43. International comparisons are often difficult because of differences between education systems, types of degrees awarded across countries, and definitions used in different countries. Some researchers have pinpointed various problems and limitations of international comparisons and warned readers to interpret data including those published by OECD with caution (Adelman 2008; Wellman 2007).

44. The data are from the U.S. Department of Education's 2003–04 Beginning Postsecondary Longitudinal Study (BPS:04/09). This national, longitudinal study examines students who first began their postsecondary education in the 2003–04 academic year and follows them for 6 years through 2009. Students are considered to have participated in remedial education if they took a remedial course at some point during these 6 years according to their postsecondary transcripts.

Glossary

Student Learning in Mathematics and Science

Eligibility for National School Lunch Program: Student eligibility for this program, which provides free or reduced-price lunches, is a commonly used indicator for family poverty. Eligibility information is part of the administrative data kept by schools and is based on parent-reported family income and family size.

Organisation for Economic Co-operation and Development (OECD): An international organization of 34 countries headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Estonia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected non-member countries.

Repeating cross-sectional studies: This type of research focuses on how a specific group of students performs in a particular year, and then looks at the performance of a similar group of students at a later point in time. An example would be comparing fourth graders in 1990 to fourth graders in 2011 in NAEP.

Scale score: Scale scores place students on a continuous achievement scale based on their overall performance on the assessment. Each assessment program develops its own scales.

Student Coursetaking in Mathematics and Science

Advanced Placement (AP): Courses that teach college-level material and skills to high school students who can earn college credits by demonstrating advanced proficiency on a final course exam. The curricula and exams for AP courses, available for a wide range of academic subjects, are developed by the College Board.

Teachers of Mathematics and Science

Elementary schools: Schools that have no grades higher than 8.

High schools: Schools that have at least one grade higher than 8 and no grade in K–6.

Middle schools: Schools that have any of grades 5–8 and no grade lower than 5 and no grade higher than 8.

Professional development: In-service training activities designed to help teachers improve their subject matter knowledge, acquire new teaching skills, and stay informed about changing policies and practices.

Instructional Technology and Digital Learning

Blended learning: Any time a student learns at least in part at a supervised, traditional school location away from home and at least in part through online delivery with some element of student control over time, place, path, and/or pace; often used synonymously with "hybrid learning."

Distance education: A mode of delivering education and instruction to students who are not physically present in a traditional setting such as a classroom. Also known as "distance learning," it provides access to learning when the source of information and the learners are separated by time and/or distance.

Online learning: Education in which instruction and content are delivered primarily over the Internet.

Transition to Higher Education

GED certificate: This award is received following successful completion of the General Educational Development (GED) test. The GED program, sponsored by the American Council on Education, enables individuals to demonstrate that they have acquired a level of learning comparable to that of high school graduates.

High school completer: An individual who has been awarded a high school diploma or an equivalent credential, including a GED certificate.

High school diploma: A formal document regulated by the state certifying the successful completion of a prescribed secondary school program of studies. In some states or communities, high school diplomas are differentiated by type, such as an academic diploma, a general diploma, or a vocational diploma.

Postsecondary education: The provision of a formal instructional program with a curriculum designed primarily for students who have completed the requirements for a high school diploma or its equivalent. These programs include those with an academic, vocational, or continuing professional education purpose and exclude vocational and adult basic education programs.

Remedial courses: Courses taught within postsecondary education that cover content below the college level.

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Chapter 2

Higher Education in Science and Engineering

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Highlights

Characteristics of the U.S. Higher Education System

Doctorate-granting institutions with very high research activity are the leading producers of S&E degrees at the bachelor's, master's, and doctoral levels, but other types of institutions are also important in the education of S&E graduates.

- ♦ In 2011, doctorate-granting institutions with very high research activity awarded 74% of doctoral degrees, 42% of master's degrees, and 38% of bachelor's degrees in S&E fields.
- ♦ Baccalaureate colleges are the source of relatively few S&E bachelor's degrees but are a prominent source of future S&E doctorate recipients.
- ♦ Master's colleges and universities awarded close to 30% of all S&E bachelor's degrees and 25% of all S&E master's degrees in 2011.
- ♦ Nearly one in five U.S. citizens or permanent residents who received a doctoral degree from 2007 to 2011 had earned some college credit from a community or 2-year college.

Higher education spending and revenue patterns and trends underwent substantial changes over the last two decades.

- ♦ Net student tuition more than doubled at public universities, whereas state and local appropriations fell by more than 25%.
- ♦ Although tuition remained lower at public very high research universities than at their private counterparts, average revenue from student tuition increased more rapidly at public institutions.
- ♦ In public very high research universities, revenues from federal appropriations, grants, and contracts per full-time equivalent (FTE) student nearly doubled between 1987 and 2010, and research expenditures grew by 79% in the same period. In private very high research universities, revenues from federal appropriations, grants, and contracts per FTE student grew by 61%, and research expenditures increased by 89%.
- ♦ Since 2007, expanding enrollment at community colleges, coupled with reductions in state and local appropriations, contributed to an 8% reduction in instructional spending per FTE student.

Over the past decade in the United States, tuition and fees for colleges and universities have grown faster than median household income.

- ♦ Undergraduate debt varies by type of institution and state. However, among recent graduates with S&E bachelor's degrees, the level of undergraduate debt does not vary by major.
- ♦ Levels of debt of doctorate recipients vary by field. In S&E fields, high levels of graduate debt were most common among doctorate recipients in social sciences, psychology, and medical or other health sciences.
- ♦ At the time of doctoral degree conferral, nearly half of 2011 S&E doctorate recipients had debt related to their undergraduate or graduate education.

Undergraduate Education, Enrollment, and Degrees

Undergraduate enrollment in U.S. higher education rose from 12.5 million to 18.3 million in the 15 years ending in 2011. The largest increases coincided with the two economic downturns, 2000–02 and 2008–10.

- ♦ Associate's colleges enroll the largest number of students, followed by master's colleges and universities and doctorate-granting institutions with very high research activity.
- ♦ Increased enrollment in higher education is projected to come mainly from minority groups, particularly Hispanics and Asians.

The number of S&E bachelor's degrees has risen steadily over the past 15 years, reaching a new peak of over half a million in 2011. The proportion of S&E bachelor's degrees has remained stable at about 32% during this period.

- ♦ All S&E fields experienced increases in the numbers of bachelor's degrees awarded in 2011, including computer sciences, which had declined sharply in the mid-2000s and had remained flat through 2009.
- ♦ Women have earned about 57% of all bachelor's degrees and half of all S&E bachelor's degrees since the late 1990s. Men earn the majority of bachelor's degrees in engineering, computer sciences, and physics. More women than men earn degrees in the biological, agricultural, and social sciences and in psychology.
- ♦ Between 2000 and 2011, the proportion of S&E bachelor's degrees awarded to women remained flat. During this period, it declined in computer sciences, mathematics, physics, engineering, and economics.

The racial and ethnic composition of those earning S&E bachelor's degrees is changing, reflecting both population changes and increases in college attendance by members of minority groups.

- ♦ For all racial and ethnic groups, the total number of bachelor's degrees earned, the number of S&E bachelor's degrees earned, and the number of bachelor's degrees in most S&E fields have increased since 2000.

The number of foreign undergraduate students in the United States increased substantially (18%) between fall 2011 and fall 2012.

- Most of the increase in undergraduate foreign enrollment was in non-S&E fields. Within S&E fields, the largest increases were in engineering and the social sciences.
- China, South Korea, and Saudi Arabia were the top countries sending undergraduates to the United States.

Graduate Education, Enrollment, and Degrees

Graduate enrollment in S&E increased from about 493,000 to more than 608,000 between 2000 and 2011.

- Graduate enrollment grew in most S&E fields, with particularly strong growth in engineering and in the biological and social sciences.
- Women continued to enroll at disproportionately low rates in engineering (23%), computer sciences (25%), physical sciences (33%), and economics (38%).
- In 2011, underrepresented minority students (blacks, Hispanics, and American Indians and Alaska Natives) made up 12% of students enrolled in graduate S&E programs, with Asians and Pacific Islanders representing 6% and whites 47%. Temporary residents accounted for most of the remainder of graduate S&E enrollment.

In 2011, the federal government was the primary source of financial support for 19% of full-time S&E graduate students. In recent years, this proportion has fluctuated between 18% and 20%.

- In 2009, the federal government funded 61% of S&E graduate students on traineeships, 51% of those with research assistantships, and 24% of those with fellowships.
- Graduate students in the biological sciences, the physical sciences, and engineering received relatively more federal financial support than those in computer sciences, mathematics, medical and other health sciences, psychology, and social sciences.

Between fall 2011 and fall 2012, the number of foreign graduate students increased by 3%, with all the increase occurring in non-S&E fields.

- Nearly 6 out of 10 foreign graduate students in the United States in fall 2012 were enrolled in S&E fields, compared with about 3 in 10 foreign undergraduates.
- The number of foreign graduate students enrolled in S&E fields between 2011 and 2012 was stable, with declines in the numbers of foreign students in computer sciences, biological sciences, and engineering offset by increases in mathematics, social sciences, and psychology.
- In fall 2012, about 60% of the foreign S&E graduate students in the United States came from China and India.

Master's degrees awarded in S&E fields increased from about 100,000 in 2000 to about 151,000 in 2011. In this period, the growth of S&E degrees at the master's level (57%) was higher than growth at the bachelor's (39%) and doctoral levels (38%).

- Increases occurred in most major S&E fields, with the largest in engineering, psychology, and political sciences and public administration.
- The number and percentage of master's degrees awarded to women in most major S&E fields have increased since 2000.
- The number of S&E master's degrees awarded increased for all racial and ethnic groups from 2000 to 2011. During this period, the proportion earned by blacks and Hispanics increased, that of Asians and Pacific Islanders and American Indians and Alaska Natives remained flat, and that of whites decreased.

In 2011, U.S. academic institutions awarded about 38,000 S&E doctorates.

- The number of S&E doctorates conferred annually by U.S. universities increased steeply from 2002 to 2007, then flattened and declined slightly in 2010, but increased again in 2011.
- Among fields that award large numbers of doctorates, the biggest increases in degrees awarded between 2000 and 2011 were in engineering (58%) and in the biological sciences (52%).

Students on temporary visas continue to earn high proportions of U.S. S&E doctorates, and these students dominated degrees in some fields. They also earned large shares of the master's degrees in S&E fields.

- In 2011, foreign students earned 56% of all engineering doctorates, 51% of all computer sciences doctorates, 44% of physics doctorates, and 60% of the economics doctorates. Their overall share of S&E degrees was about one-third.
- After steep growth from 2002 to 2008, the number of temporary residents earning S&E doctoral degrees declined through 2010, but it increased again in 2011.
- In 2011, temporary visa students earned 26% of S&E master's degrees, receiving 45% of those in computer sciences, 44% of those in economics, 42% of those in engineering, and 35% of those in physics.

International S&E Higher Education

In 2010, more than 5.5 million first university degrees were awarded in S&E worldwide. Students in China earned about 24%, those in the European Union (EU) earned about 17%, and those in the United States earned about 10% of these degrees.

- The number of S&E first university degrees awarded in China, Taiwan, Turkey, Germany, and Poland approximately doubled between 2000 and 2010. During this period, S&E first university degrees awarded in the United States and several other countries (e.g., Australia, Italy, the United Kingdom, Canada, and South Korea) increased between 23% and 56%, whereas those awarded in France, Japan, and Spain declined by 14%, 9%, and 4%, respectively.
- S&E degrees continue to account for about one-third of all bachelor's degrees awarded in the United States. In Japan, 6 out of 10 first degrees were awarded in S&E fields in 2010; in China, half.
- In the United States, about 5% of all bachelor's degrees awarded in 2010 were in engineering. This compares with about 18% throughout Asia and 31% in China specifically.

In 2010, the United States awarded the largest number of S&E doctoral degrees of any individual country, followed by China, Russia, Germany, and the United Kingdom.

- The numbers of S&E doctoral degrees awarded in China and the United States have risen substantially in recent years. S&E doctorates awarded in South Korea and in many European countries have risen more modestly. S&E doctorates awarded in Japan increased fairly steadily through 2006 but have declined since then.
- In 2007, China overtook the United States as the world leader in the number of doctoral degrees awarded in the natural sciences and engineering; in 2010, this number in China was stable.
- Women earned 41% of S&E doctoral degrees awarded in the United States in 2010, about the same as women's percentages in Australia, Canada, the EU, and Mexico and a higher proportion than in Malaysia, South Korea, and Taiwan.

International student mobility expanded over the past two decades, as countries are increasingly competing for foreign students.

- The United States remains the destination for the largest number of internationally mobile students worldwide (undergraduate and graduate), although its share decreased from 25% in 2000 to 19% in 2010. Among OECD countries, the U.S. share in natural sciences and engineering fields has declined during this period, but an increase in international students coming to the United States to study social and behavioral sciences has kept the overall S&E share stable.
- Some countries expanded recruitment of foreign students as their own populations of college-age students decreased.
- In addition to the United States, other countries that are among the top destinations for foreign students include the United Kingdom, Australia, Germany, and France.

Introduction

Chapter Overview

Higher education performs a number of societal functions, including developing human capital; building the knowledge base through research and knowledge development; and disseminating, using, and maintaining knowledge (Organisation for Economic Co-operation and Development [OECD] 2008). S&E higher education provides the advanced skills needed for a competitive workforce and, particularly in the case of graduate-level S&E education, the research capability necessary for innovation. This chapter focuses on the development of human capital through higher education.

Indicators presented in this chapter are discussed in the context of national and global developments, including changing demographics, increasing foreign student mobility, and global competition in higher education. The composition of the U.S. college-age population is becoming more diverse as the Asian and Hispanic shares of the population increase. During the latest economic downturn, public institutions of higher education faced unique pressures due to a combination of increasing enrollments and tight state budgets. Private institutions likewise experienced financial challenges stemming from declining incomes and the effects of stock market fluctuations on endowment growth. Technology has enabled very rapid growth in the delivery of online courses; the consequences of these changes remain to be seen.

Although the United States has historically been a world leader in providing broad access to higher education and in attracting foreign students, many other countries are providing expanded educational access to their own populations and attracting growing numbers of foreign students. Nevertheless, increases in foreign students contributed to most of the growth in overall S&E graduate enrollment in the United States in recent years. Following a decline in the number of foreign students coming to the United States after 11 September 2001, foreign student enrollment in S&E has recovered.

Chapter Organization

This chapter begins with an overview of the characteristics of U.S. higher education institutions providing instruction in S&E, followed by a discussion of characteristics of undergraduate and graduate education.[1] Trends are discussed by field and demographic group, with attention to the flow of foreign students into the United States by country. Various international higher education indicators are then presented, including comparative S&E degree production in several world regions and indicators that measure the growing dependence of industrialized countries on foreign S&E students.

The data in this chapter come from a variety of federal and nonfederal sources, primarily surveys conducted by the National Science Foundation's (NSF's) National Center for Science and Engineering Statistics (NCSES) and the National Center for Education Statistics (NCES) at the U.S. Department of Education. Data also come from international organizations, such as the OECD and the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute of Statistics, as well as individual countries. Most of the data in the chapter are from censuses of the population—for example, all students receiving degrees from U.S. academic institutions—and are not subject to sampling variability.

The U.S. Higher Education System

Higher education in S&E produces an educated S&E workforce and an informed citizenry. It has also been receiving increased attention as an important component of U.S. economic competitiveness. In his 24 February 2009 address to a joint session of Congress, President Barack Obama called for every American to commit to at least 1 year of education or career training after completing high school. A 2012 report by the President's Council of Advisors on Science and Technology (PCAST 2012) notes that economic forecasts point to a need to increase the proportion of college graduates going into the natural sciences and engineering over the next decade. This section discusses the characteristics of U.S. higher education institutions providing S&E education and the financing of higher education.

Institutions Providing S&E Education

The U.S. higher education system consists of a large number of diverse academic institutions that vary in their missions, learning environments, selectivity levels, religious affiliations, types of students served, types of degrees offered, and sectors (public, private nonprofit, or private for-profit) (Aud et al. 2010). There were approximately 4,700 postsecondary degree-granting institutions in the United States in the 2011–12 academic year. Of these, 63% offered bachelor's or higher degrees, 30% offered only associate's degrees, and 7% offered degrees that were at least 2-year but less than 4-year as the highest degree awarded.[2] More than half of the 4-year institutions are private nonprofits, 23% are public, and 25% are private for-profits. The majority of 2-year degree-granting institutions are public (56%) or private for-profit (39%) (table 2-1) (NCES 2012). In 2011, U.S. academic institutions awarded nearly 3.5 million associate's, bachelor's, master's, and doctoral degrees; 23% of the degrees were in S&E (appendix table 2-1).[3]

Doctorate-granting institutions with very high research activity, though few in number, are the leading producers of S&E degrees at the bachelor's, master's, and doctoral levels. In 2011, these research institutions awarded 74% of doctoral degrees, 42% of master's degrees, and 38% of bachelor's degrees in S&E fields (appendix table 2-1). (See sidebar, "Carnegie Classification of Academic Institutions.") Master's colleges and universities awarded another 29% of S&E bachelor's degrees and 25% of S&E master's degrees in 2011.

Baccalaureate colleges were the source of relatively few S&E bachelor's degrees (12%) (appendix table 2-1), but they produce a larger proportion of future S&E doctorate recipients (15%) (NSF/NCSES 2013b). When adjusted by the number of bachelor's degrees awarded in all fields, baccalaureate colleges as a group yield more future S&E doctorates per 100 bachelor's degrees awarded than all other types of institutions except research universities.

High Hispanic enrollment institutions (HHEs) and historically black colleges and universities (HBCUs) play an important role in training Hispanic and black U.S. citizens and permanent residents for doctoral-level study in S&E fields.[4] Among Hispanic U.S. citizen and permanent resident S&E doctorate recipients who received their doctorates between 2007 and 2011, 29% had obtained their baccalaureate credential at an HHE (table 2-2). Similarly, among black U.S. citizen and permanent resident doctorate recipients who received their doctorates in S&E fields during the same period, 26% had obtained their baccalaureate degree at an HBCU (table 2-3). HBCUs are the second most important contributor of black S&E doctorate recipients after non-HBCU institutions with very high research activity (NSF/NCSES 2013b).

Table 2-1
Degree-granting institutions, by control and level of institution: 2011–12

Institution level	All degree-granting institutions	Public	Private nonprofit	Private for-profit
Total	4,706	1,649	1,653	1,404
2-year	1,738	967	100	671
4-year	2,968	682	1,553	733

SOURCE: U.S Department of Education, National Center for Education Statistics, *Digest of Education Statistics*, 2011, table 279, based on data from Integrated Postsecondary Education Data System Fall 2011 Institutional Characteristics component.

Science and Engineering Indicators 2014

Carnegie Classification of Academic Institutions

The Carnegie Classification of Institutions of Higher Education is widely used in higher education research to characterize and control for differences in academic institutions.

The 2010 classification update retains the structure adopted in 2005. It includes 4,634 institutions, 483 of which were added after the 2005 update. More than three-quarters of the new institutions (77%) are from the private for-profit sector, 19% from the private nonprofit sector, and 4% from the public sector.

The Carnegie Classification categorizes academic institutions primarily on the basis of highest degree conferred, level of degree production, and research activity.* In this report, several Carnegie categories have been aggregated for statistical purposes. The characteristics of those aggregated groups are as follows:

- *Doctorate-granting universities* include institutions that award at least 20 doctoral degrees per year. They include three subgroups based on level of research activity: very high research activity (108 institutions), high research activity (99 institutions), and doctoral/research universities (90 institutions). Because doctorate-granting institutions with very high research activity are central to S&E education and research, data on these institutions are reported separately.
- *Master's colleges and universities* include the 724 institutions that award at least 50 master's degrees and fewer than 20 doctoral degrees per year.
- *Baccalaureate colleges* include the 810 institutions at which baccalaureate degrees represent at least 10% of all undergraduate degrees and that award fewer than 50 master's degrees or 20 doctoral degrees per year.
- *Associate's colleges* include the 1,920 institutions at which all degrees awarded are associate's degrees or at which bachelor's degrees account for less than 10% of all undergraduate degrees.
- *Special-focus institutions* are the 851 institutions at which at least 75% of degrees are concentrated in a single field or a set of related fields (e.g., medical schools and medical centers, schools of engineering, and schools of business and management).
- *Tribal colleges* are the 32 colleges and universities that are members of the American Indian Higher Education Consortium.

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*Research activity is based on two indexes (aggregate level of research and per capita research activity) derived from a principal components analysis of data on research and development expenditures, S&E research staff, and field of doctoral degree. See http://classifications.carnegiefoundation.org for more information on the classification system and on the methodology used in defining the categories.

Minority-serving academic institutions enroll a substantial fraction of minority undergraduates (NSF/NCSES 2013a).[5] In 2010, HBCUs awarded 19% of the 43,000 S&E bachelor's degrees earned by black U.S. citizens and permanent residents; HHEs awarded about 30% of the 46,000 S&E bachelor's degrees earned by Hispanic U.S. citizens and permanent residents. However, the percentages of blacks earning S&E bachelor's degrees from HBCUs and of Hispanics earning S&E bachelor's degrees from HHEs have declined since 2001. Tribal colleges, which mainly offer 2-year degrees, account for about 1% of S&E bachelor's degrees to American Indians; this proportion has been fairly stable over time.[6]

Community Colleges

Community colleges (also known as public 2-year colleges or associate's colleges) play a key role in increasing access to higher education for all citizens. These institutions serve diverse groups of students and offer a more affordable means of participating in postsecondary education. Community colleges are important in preparing students to enter the workforce with certificates or associate's

Table 2-2
U.S. citizen and permanent resident S&E doctorate recipients whose baccalaureate origin is a high Hispanic enrollment institution, by race and ethnicity: 2007–11

		Earned baccalaureate degree from a high Hispanic enrollment institution		
Race and ethnicity	All	Yes	No	Yes (%)
All races and ethnicities	101,216	3,773	97,443	3.7
American Indian or Alaska Native	376	21	355	5.6
Asian	10,258	178	10,080	1.7
Black or African American	4,958	181	4,777	3.7
Hispanic[a]	5,776	1,652	4,124	28.6
Native Hawaiian or Other Pacific Islander	218	15	203	6.9
White	75,973	1,601	74,372	2.1
More than one race	2,110	69	2,041	3.3
Unknown or unreported	1,547	56	1,491	3.6

[a] Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Survey of Earned Doctorates, 2007–11.

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Table 2-3
U.S. citizen and permanent resident S&E doctorate recipients whose baccalaureate origin is an HBCU, by race and ethnicity: 2007–11

		Earned baccalaureate degree from an HBCU		
Race and ethnicity	All	Yes	No	Yes (%)
All races and ethnicities	101,216	1,480	99,736	1.5
American Indian or Alaska Native	376	D	D	D
Asian	10,258	9	10,249	0.1
Black or African American	4,958	1,304	3,654	26.3
Hispanic[a]	5,776	21	5,755	0.4
Native Hawaiian or Other Pacific Islander	218	D	D	D
White	75,973	88	75,885	0.1
More than one race	2,110	40	2,070	1.9
Unknown or unreported	1,547	D	D	D

[a] Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

D = suppressed to avoid disclosure of confidential information.

HBCU = historically black college or university.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Survey of Earned Doctorates, 2007–11.

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degrees or to transition to 4-year colleges or universities. Community colleges tend to be closely connected with local businesses, community organizations, and government, so they can be more responsive to local workforce needs (NRC and NAE 2012).

In the 2011–12 academic year, there were nearly 1,000 community colleges in the United States, enrolling more than 7 million students, or about a third of all postsecondary students (NCES 2012). Six out of 10 community college students were enrolled part time. With the economic recession, enrollment in community colleges increased by about 800,000 students between 2007 and 2009 but slowed down in 2010 and declined slightly in 2011 as the labor market improved (Knapp, Kelly-Reid, and Ginder 2009, 2011).

Community colleges play a significant role in the education of individuals who go on to acquire advanced S&E credentials. Among U.S. citizen and permanent resident S&E doctorate holders who received their doctorates between 2007 and 2011, nearly 20% indicated that they had earned college credit from a community or 2-year college (table 2-4). According to data from the National Survey of Recent College Graduates (NSRCG), the proportion of recent bachelor's S&E graduates who reported ever attending a community college has increased since the late 1990s (table 2-5). Nearly half of 2008 and 2009 S&E graduates said that they had attended a community college (49% of the bachelor's recipients and 36% of the master's recipients). Graduates in physical sciences, engineering, and computer and mathematical sciences were less likely than those in the biological and social sciences to have attended a community college. Between 2003 and 2010, the proportion of S&E graduates who attended community colleges remained stable in all broad fields (figure 2-1).

In 2010, female S&E bachelor's and master's degree recipients were more likely to have attended a community college than their male counterparts (table 2-6). Attendance was higher among U.S. citizens and permanent visa holders than among temporary visa holders. Attendance was

Table 2-4

U.S. citizen and permanent resident S&E doctorate recipients who reported earning college credit from a community or 2-year college, by race and ethnicity: 2007–11

		Earned college credit from a community or 2-year college		
Race and ethnicity	All	Yes	No	Yes (%)
All races and ethnicities	99,029	18,484	80,545	18.7
American Indian or Alaska Native	360	125	235	34.7
Asian	10,197	1,279	8,918	12.5
Black or African American	4,755	819	3,936	17.2
Hispanic[a]	5,517	1,236	4,281	22.4
Native Hawaiian or Other Pacific Islander	200	58	142	29.0
White	74,649	14,237	60,412	19.1
More than one race	2,076	461	1,615	22.2
Unknown or unreported	1,275	269	1,006	21.1

[a] Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2007–11.

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Table 2-5

Community college attendance among recent recipients of S&E bachelor's and master's degrees, by degree level and degree year: 1999–2010

	1999		2001		2003		2006		2008		2010	
Degree level	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
All recent graduates	900,400	41	918,400	44	958,400	45	1,634,200	45	1,138,400	46	1,136,700	46
Bachelor's	743,400	43	758,300	46	794,400	47	1,343,000	47	934,300	49	916,500	49
Master's	157,000	35	160,100	34	164,000	34	291,200	34	204,100	35	220,300	36

NOTES: Recent graduates are those who earned degrees in the 2 academic years preceding the survey year or, for the 2006 survey year, in the 3 preceding academic years. For 2006, recent graduates are those who earned degrees between 1 July 2002 and 30 June 2005. Data are rounded to the nearest 100. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the National Survey of Recent College Graduates, 1999, 2001, 2003, 2006, 2008, and 2010.

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lower for Asian S&E graduates than for whites, blacks, or Hispanics. The likelihood of attending a community college before receiving an S&E bachelor's or master's degree was related to parental education level. Nearly 6 out of 10 of the S&E graduates who reported that their fathers or mothers had less than a high school diploma attended a community college, compared with about one-third of those whose fathers or mothers had a professional or a doctoral degree.

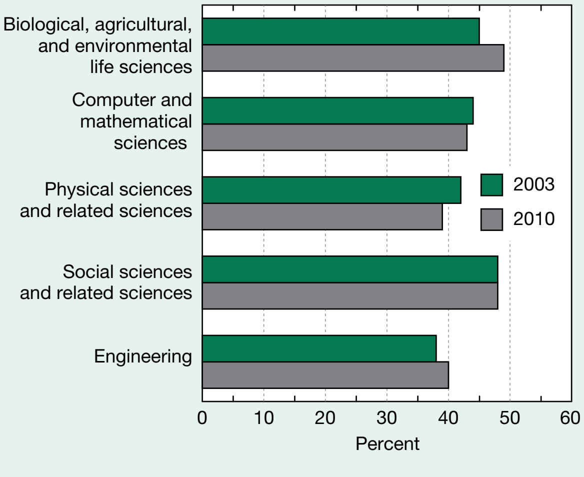
For-Profit Institutions

In 2011, about 3,400 higher education institutions in the United States operated on a for-profit basis. Nearly half of these institutions offer only less-than-2-year programs, and about 4 out of 10 are degree-granting institutions.[7] Two-year, for-profit institutions enroll considerably fewer students than community colleges. Over the last 12 years, however, the number of for-profit institutions has grown rapidly, and the number of degrees they award has more than tripled (NCES 2012; appendix table 2-2). A large part of that increase is accounted for by the growth of the University of Phoenix.

In 2011, for-profit academic institutions awarded between 2% and 6% of S&E degrees at the bachelor's, master's, and doctoral levels, as well as 33% of S&E degrees at the associate's level (appendix tables 2-1 and 2-2). Computer sciences accounted for 73% of the associate's degrees and 51% of the bachelor's degrees awarded by for-profit institutions in S&E fields in 2011 (appendix table 2-3). For-profit institutions awarded fewer S&E master's and doctoral degrees than associate's and bachelor's. At the master's level, S&E degrees were mainly in psychology, social sciences, and computer sciences; at the doctoral level, they were almost exclusively in psychology and social sciences. In 2011, degrees in psychology represented nearly half of the master's and three-quarters of the doctoral degrees awarded by for-profit institutions in S&E fields. Degrees in social science accounted for one-quarter of the master's and a similar proportion of the doctoral degrees awarded in S&E fields.

Figure 2-1

Community college attendance among recent recipients of S&E degrees, by field of most recent degree: 2003 and 2010



NOTE: Recent graduates are those who earned degrees in the 2 academic years preceding the survey year.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Survey of Recent College Graduates, 2003 and 2010.

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Table 2-6

Community college attendance among recent recipients of S&E degrees, by sex, race, ethnicity, and citizenship status: 2010

Characteristic	Number	Percent
All graduates	1,136,700	46
Sex		
Female	564,600	49
Male	572,100	43
Race, ethnicity		
American Indian or Alaska Native	1,900	39
Asian	155,300	39
Black or African American	72,000	46
Hispanic[a]	120,600	51
Native Hawaiian or Other Pacific Islander	4,900	64
White	746,400	46
More than one race	35,700	52
Citizenship status		
U.S. citizen	1,033,400	48
Permanent visa	27,200	42
Temporary visa	76,100	15
Father's education		
Less than high school	65,200	59
High school diploma or equivalent	210,300	52
Some college, vocational, or trade school	221,500	50
Bachelor's	292,100	45
Master's	175,500	43
Professional degree	86,300	31
Doctorate	64,600	34
Not applicable	21,100	47
Mother's education		
Less than high school	63,600	58
High school diploma or equivalent	226,600	53
Some college, vocational, or trade school	284,400	49
Bachelor's	313,400	41
Master's	175,200	42
Professional degree	34,700	36
Doctorate	27,900	33
Not applicable	10,900	37

[a] Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

NOTES: Recent graduates are those who earned degrees between 1 July 2007 and 30 June 2009. Data are rounded to the nearest 100.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the National Survey of Recent College Graduates, 2010.

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Online and Distance Education

Online education and distance education enable institutions of higher education to reach a wider audience by expanding access for students in remote geographic locations and providing greater flexibility for students who face time constraints, physical impairments, responsibility to care for dependents, and similar challenges. Online education is a relatively new phenomenon, and online enrollment has grown substantially in recent years. In 2011–12, about 62% of 2- and 4-year Title IV institutions (i.e., institutions that participate in federal financial aid programs) offered some distance education opportunities to their students (table 2-7) (Ginder and Sykes 2013).[8] The vast majority of public institutions offered some distance education to their students, as did more than half of the private nonprofit and about 71% of the private for-profit 4-year institutions. In the United States, 30 Title IV institutions were exclusively distance education institutions; most of these institutions were private for-profits, and more than 90% of the degrees awarded were in non-S&E fields (Ginder and Sykes 2013).

More recently, changes in the online education landscape have accelerated with the appearance of massive open online courses (MOOCs). MOOCs can provide broad access to higher education. Through their online platforms, they also have the potential to collect massive amounts of information that can be used to conduct experimental research on how people learn and to identify online practices that improve learning (U.S. Department of Education 2013).

MOOCs originated when a Stanford professor, Sebastian Thrun, and the director of research at Google, Peter Norvig, opened admission to their course on artificial intelligence in fall 2011. Until then, enrollment was typically 200 students. When free online access was offered, 160,000 students from 190 countries registered for the class, and about 23,000 completed it. Previous efforts by academic institutions, such as the Open Learning Initiative at Carnegie Mellon University and OpenCourseWare at the Massachusetts Institute of Technology, had included online courses for public access; however, the Stanford class also allowed students to take quizzes, submit homework, and attend virtual office hours. In the wake of the popular response to this class, other selective universities have collaborated in joint ventures (e.g., Udacity, Coursera, edX) to offer free versions of their courses online, reaching large populations of students around the world. These companies are growing rapidly, adding new courses and students, and increasing the number of university partners in the United States and abroad (Lewin 2013). In fall 2012, edX and Udacity gave students the option of paying a small fee to take a proctored final exam that will validate their learning (Parry 2012). In February 2013, the American Council on Education approved five Coursera courses for college credit (Kolowich 2013). It is not clear whether colleges will generally be willing to grant credit for those courses.

Changing modes of online education are prompting questions about how the use of this technology will affect the higher education sector. In particular, it is not yet clear how many students can sustain commitment to learning in the absence of more personal contact and to what extent the growing access to higher education facilitated by MOOCs will translate into learning and, in the long run, to higher levels of educational achievement.

Trends in Higher Education Expenditures and Revenues

Higher education spending and revenue patterns changed substantially over the last two decades, in trends that intensified during the economic downturn of the late 2000s. Although all types of higher education institutions faced competing demands in a stringent budget environment, each type faced unique challenges. Increases in the number

Table 2-7
Title IV Institutions, by distance education status, control, and level of institution: 2011–12

Institutional control and level	All	No distance education	Some distance education	Exclusively distance education
All 2- and 4-year institutions	5,288	1,966	3,292	30
Public	1,755	138	1,616	1
2-year	1,072	74	998	0
4-year	683	64	618	1
Private nonprofit	1,751	823	921	7
2-year	185	149	36	0
4-year	1,566	674	885	7
Private for-profit	1,782	1,005	755	22
2-year	1,048	811	235	2
4-year	734	194	520	20

NOTES: Title IV institutions are those with a written agreement with the Secretary of Education that allows the institution to participate in any of the Title IV federal student financial assistance programs. Data are for institutions surveyed during 2011–12.

SOURCES: U.S. Department of Education, National Center for Education Statistics (NCES), Integrated Postsecondary Education Data System, Fall 2011, Institutional Characteristics Component; NCES, 2013. *Characteristics of Exclusively Distance Education Institutions, by State: 2011–12*. NCES 2013-172. Washington DC. http://nces.ed.gov/pubs2013/2013172.pdf. Accessed 17 September 2013.

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of students seeking an affordable college education compounded the challenges created by tight budgets. This section shows trends in inflation-adjusted average spending and revenue per full-time equivalent (FTE) student from 1987 to 2010, based on data from the Delta Cost Project.[9]

Very High Research Universities—Public and Private Institutions

Net tuition and federal appropriations, grants, and contracts are the largest sources of revenues centrally involved with education for both public and private very high research institutions (appendix table 2-4).[10] For public institutions, state and local appropriations are also critical, supplying a similar amount of revenue as either of the other two sources (nearly $10,000 per FTE in 2010); in contrast, they are a small source of revenue for their private counterparts (about $400 per FTE in 2010). Much more important for private institutions are private and affiliated gifts, investment returns, and endowment income, which are usually the largest source of revenue.[11]

State and local appropriations for public very high research universities have declined since 1987, with a particularly steep drop between 2007 and 2010 (figure 2-2). This decline coincided with a compensating increase in net tuition. In 1987, average state appropriations per FTE at public very high research institutions were more than three times the amount of net tuition ($13,600 versus $4,000). By 2010, however, appropriations had dropped to $9,800 per FTE, whereas net tuition had increased from $4,000 to $9,600 per FTE (appendix table 2-4). This change represents a shift in tuition burden from state and local governments to individual students and their families. Starting at a higher level, net tuition at private very high research universities also increased during this period. But the increase, from $16,000 to $23,000, was proportionally much smaller.

Revenue from federal appropriations, grants, and contracts, the source used for most research expenditures, is highest at the most research-intensive universities (appendix table 2-4). Between 1987 and 2010, these funds increased at both the public and the private very high research institutions. At the public very high research institutions, these funds per FTE almost doubled, reaching the same level as the state and local appropriations (about $10,000). At private very high research institutions, they increased somewhat less, by more than 60% in this 24-year period.

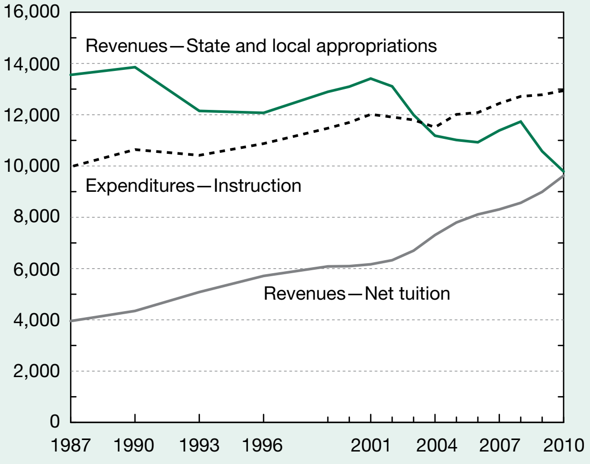
Research and instruction are the two largest core education expenditures at both public and private very high research universities. Between 1987 and 2010, research expenditures increased substantially at both types of institutions—by 89% at the private universities and by 79% at their public counterparts (figure 2-3; appendix table 2-5).[12]

Instructional spending per FTE followed a pattern similar to that of research expenditures. It was much higher at private very high research institutions than at their public counterparts, and it also increased at a higher rate. In the late 1980s and early 1990s, instructional spending at private very high research universities was slightly more than double that of the public ones. By the mid-2000s, it was more than triple (figure 2-4).

Most other expenditures also increased at both types of very high research institutions; however, at the public ones, spending on plant operation and maintenance declined from 2007 to 2010, with a sharp drop in 2010 (appendix table 2-5).

Figure 2-2
Selected average revenues and expenditures at public very high research universities: 1987–2010

2010 dollars



NOTE: Data are per full-time equivalent student.

SOURCE: IPEDS Analytics: Delta Cost Project Database, 1987–2010, special tabulations (2013).

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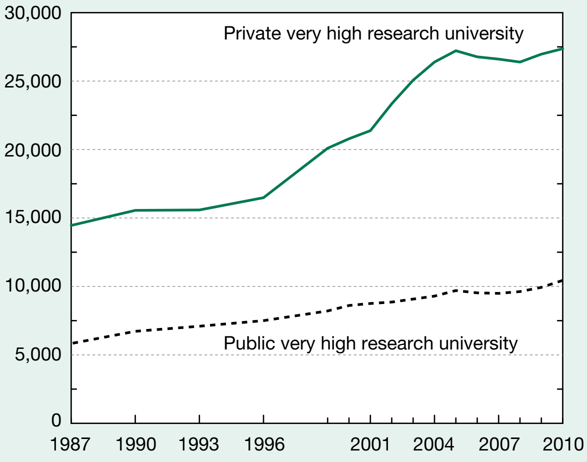
Figure 2-3
Average expenditures per FTE on research at public and private very high research universities: 1987–2010

2010 dollars



FTE = full-time equivalent student.

SOURCE: IPEDS Analytics: Delta Cost Project Database, 1987–2010, special tabulations (2013).

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Four-Year and Other Graduate Public Institutions

From 1987 to 2010, state and local appropriations and net student tuition were the largest sources of revenues centrally involved with education at other public institutions offering 4-year and graduate degrees (appendix table 2-4).[13] At these institutions, total revenues from these two sources were lower than those at public very high research universities and higher than those at community colleges. Overall, the percentage drop in revenue per FTE from state and local appropriations was similar to that experienced at the public very high research institutions. In 2010, net student tuition replaced state and local appropriations as the largest source of revenue in the public 4-year institutions. Average state appropriations per FTE in 1987 ($8,400) were three times higher than the corresponding amount of tuition revenue ($2,800). By 2010, average revenues from net student tuition, at $6,600 per FTE, exceeded average revenues from state appropriations per FTE by more than $500 (figure 2-5).

Spending on instruction at these institutions has been at least three times as high as almost all the other standard expense categories. It increased from an average of $5,800 per FTE in 1987 to $6,800 per FTE in 2010 (appendix table 2-5). Other expenditures represented much smaller shares of total spending; most of these expenditures increased. Spending on plant operation and maintenance fell by 4% over the 24-year period, with a large decline from 2007 to 2010 (18%).

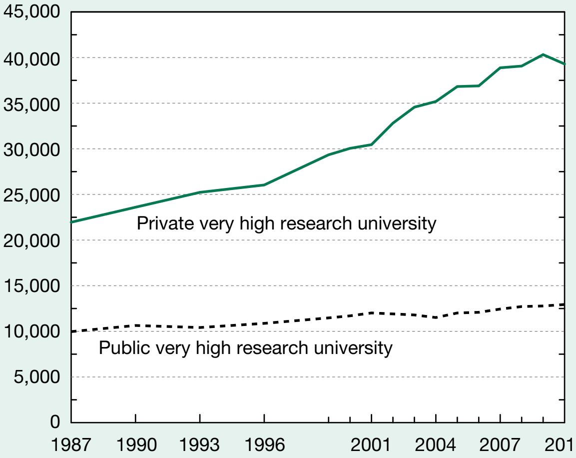
Community Colleges

Both revenues and expenditures are much lower for community colleges than for other public institutions of higher education.[14] As in these other institutions, the main sources of revenue at community colleges are state and local appropriations and net student tuition (appendix table 2-4). In 2010, average revenues from state and local appropriations at community colleges were about $5,600 per FTE, compared with $9,800 at public very high research institutions; average revenues from net tuition were $3,300 per FTE, compared with $9,600 at public very high research institutions.

Between 1987 and 2010, revenues from state and local appropriations at community colleges decreased from an average of $6,800 per FTE to $5,600 per FTE, with a steep drop from 2007 to 2010 (figure 2-6). During this 24-year period, as state support declined, revenues from net tuition more than doubled. In 1987, revenues from state and local appropriations represented 64% of total revenues at community colleges, and tuition accounted for 15%. By 2010, state and local appropriations had dropped to 46% of total revenues, whereas the proportion of revenues from tuition nearly doubled, to 27%.

At community colleges, instruction is by far the largest expenditure (appendix table 2-5). In 1987, spending on instruction was $4,700 per FTE, about 43% of total expenditures. In 2010, average instructional spending per FTE ($4,800) was nearly identical to the 1987 level. Overall, these expenditures had increased somewhat through 2008 but dropped by 10% between 2008 and 2010 (figure 2-6). Expenditures on student services, institutional and academic

Figure 2-4
Average expenditures per FTE on instruction at public and private very high research universities: 1987–2010
2010 dollars



FTE = full-time equivalent student.

SOURCE: IPEDS Analytics: Delta Cost Project Database, 1987–2010, special tabulations (2013).

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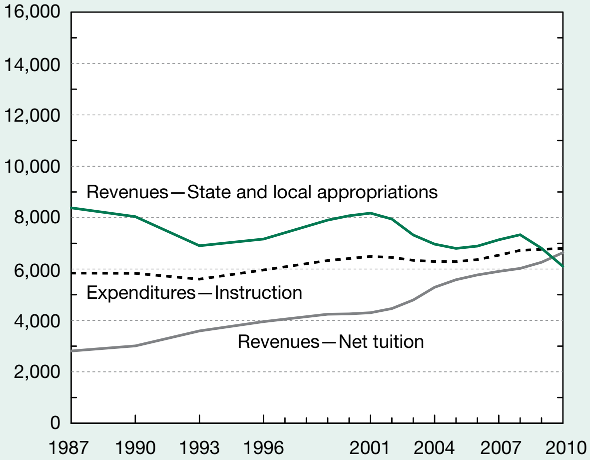
Figure 2-5
Selected average revenues and expenditures at public 4-year and other postsecondary institutions: 1987–2010
2010 dollars



NOTES: Average expenditures and revenues are per full-time equivalent. Four-year and other postsecondary institutions include doctorate-granting universities/high research activity, doctoral/research universities, master's colleges/universities, and baccalaureate colleges, according to the 2005 Carnegie Classification of Institutions.

SOURCE: IPEDS Analytics: Delta Cost Project Database, 1987–2010, special tabulations (2013).

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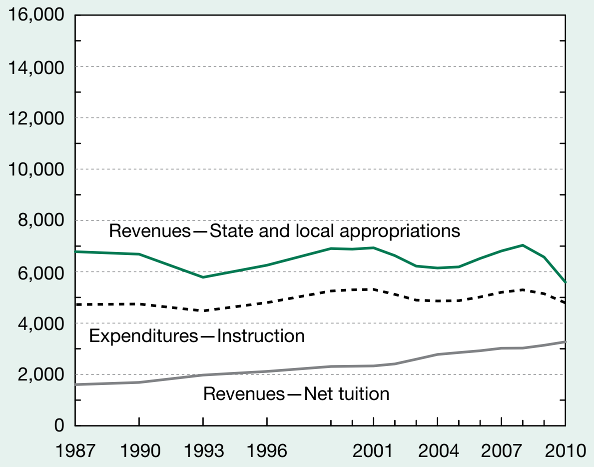
support, and plant operation and maintenance also declined between 2007 and 2010.

Public Institutions Comparison

Between 1987 and 2010, revenues from state and local appropriations and net tuition, the main two revenue sources at public institutions, grew less at community colleges than at the other two types of public institutions. In community colleges, these two revenue sources combined increased by 6% during this period, lower than the comparable increases at the public 4-year and other graduate institutions (14%) and the very high research institutions (11%). However, trends in these individual revenue sources were substantially different. States and localities cut funding for all three categories of institutions, but the reduction was smaller in the community colleges (18%) than in the very high research public institutions (28%) and the 4-year and other graduate public institutions (27%). Unlike the community colleges, though, the other two types of public institutions were able to increase revenues from net tuition. FTE net tuition revenues increased by 143% at the public very high research universities and by 136% at the 4-year and other graduate public institutions, compared with 104% at community colleges (appendix table 2-4).

Expenditures for instruction followed a different pattern. They rose most rapidly at the very high research institutions (30%), where there was pressure to keep faculty salaries (a major component of instructional expenses) competitive with those of their private counterparts, which spent more on instruction to begin with and were increasing these expenses at an even more rapid rate (79%) (appendix table 2-5). At community colleges, FTE instructional expenses were essentially the same at the end of the period as they were at the beginning;[15] in 4-year and other graduate institutions, they fell somewhere in between. Overall, during this period, community colleges had more limited resources and less flexibility to draw on alternate revenue sources to support their instructional expenses, which were growing because of large increases in enrollment (see section "Undergraduate Enrollment in the United States").

Figure 2-6
Selected average revenues and expenditures at community colleges: 1987–2010



NOTES: Revenues and expenditures are per full-time equivalent. Community colleges are public associate's colleges in the 2005 Carnegie Classification of Institutions.

SOURCE: IPEDS Analytics: Delta Cost Project Database, 1987–2010, special tabulations (2013).

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In recent years, universities have been under pressure to improve the way they monitor and manage their performance and are attempting to contain costs without compromising quality or accessibility. In May 2012, the National Research Council released a report titled "Improving Measurement of Productivity in Higher Education" (NRC 2012a), which examined key issues regarding the measurement of productivity (for a summary of the panel's conclusions and recommendations, see sidebar, "Improving Measurement of Productivity in Higher Education").

Financing Higher Education

Cost of Higher Education

Affordability and access to U.S. higher education institutions are continuing concerns (NCPPHE 2008; NRC 2012a). Estimated average net tuition and fees (i.e., the published prices minus grant aid and tax benefits) paid by full-time undergraduate students in public 4-year colleges declined from 2007–08 to 2009–10 and in their private counterparts from 2007–08 to 2010–11 because of unusually large increases in grant aid and tax credits. However, since then, net tuition and fees have increased at both public and private nonprofit institutions. At public 2-year colleges, net tuition and fees followed a similar pattern, but since 2008–09, the average student enrolled full time has received enough funding through federal tax benefits and grant aid from all sources to cover other expenses, in addition to tuition and fees (–$1,220 net tuition in 2012–13) (table 2-8) (College Board 2012a).[16]

For at least the past 10 years, tuition and fees for colleges and universities in the United States have grown rapidly (see section "Trends in Higher Education Expenditures and Revenues"), whereas real median household income declined 8.9% between 1999 and 2011 (DeNavas-Walt, Proctor, and Smith 2012). Some evidence suggests that increases in net tuition and fees, however, have fallen disproportionately on households at higher levels in the income distribution, where financial aid is less readily available (College Board 2012a).[17]

Undergraduate Financial Support Patterns and Debt

Financial Support for Undergraduate Education. With rising tuition, students increasingly rely on financial aid (particularly loans) to finance their education. Financial aid for undergraduate students comes mainly in the form of grants, student loans, and work-study. A financial aid package may contain one or more of these kinds of support. In the 2011–12 academic year, federal loans constituted 38% of the $185 billion in student aid that undergraduate students received, followed by federal grants (26%), institutional grants (18%), state grants (5%), private employer grants (4%), and federal work-study programs (1%) (College Board 2012b). According to the latest data available from the NCES National Postsecondary Student Aid Study, a higher proportion of undergraduates in private for-profit institutions (96%) and in private nonprofit 4-year institutions (85%) than those in public 4-year (71%) or public 2-year (48%) institutions received some type of financial aid (Wei et al. 2009).

Undergraduate Debt. Among recent graduates with S&E bachelor's degrees, the level of undergraduate debt does not vary much by undergraduate major (NSF/NCSES 2010); however, levels of debt vary by type of institution and state. Levels of undergraduate debt for students from public colleges and universities are almost as high as those for students from private colleges and universities. Nearly 6

Improving Measurement of Productivity in Higher Education

An expert panel convened by the National Research Council produced a report on measuring productivity in higher education (NRC 2012a). The panel defined productivity as a ratio of outputs (degrees completed, credit hours passed, or other indicators of successful completion) to inputs (labor and nonlabor factors of production).

The panel identified the many complexities characteristic of higher education processes that complicate the measurement of productivity in this sector. Among them are the following:

- The need to disentangle the joint production of outputs (e.g., educated citizens, research findings, athletic events, hospital services) and inputs (e.g., labor, public service)
- The high variability in the quality and characteristics of inputs (e.g., teachers and students) and outputs (e.g., degrees)
- The difficulty of making meaningful comparisons across institutions, given that the diversity of its institutions is in itself one of the system's main strengths
- The need to account for the differences in students' preparedness for college and to measure the academic value added in terms of student achievement of learning outcomes and competencies

The panel made several recommendations to develop the data infrastructure necessary to measure productivity and to improve data collection across the federal statistical system, in particular by the National Center for Education Statistics (NCES) and the Bureau of Labor Statistics (BLS). The panel noted that, at the moment, the graduation rates produced by the NCES Integrated Postsecondary Education Data System (IPEDS) survey restrict the denominator to first-time, full-time students, so graduation rates are not meaningful productivity indicators for institutions that enroll more part-time students or in instances in which students transfer to a different institution. More accurate productivity measurement will require the development of comprehensive longitudinal student databases to be able to calculate more precise graduation rates, follow students through their college years and into their careers, and compile detailed reports on which colleges produce the most successful graduates. To do that, the panel recommended that the BLS facilitate multistate links of unemployment insurance records and education data. That step will enable research on issues such as return on investment from postsecondary training or placement rates in different occupations. Given the importance of higher education, the panel also advocated efforts to include colleges and universities in the U.S. Economic Census, as was the case in 1977.

Table 2-8

Net tuition and fees for full-time undergraduate students by institutional control: 2007–08 through 2012–13

(2012 U.S. dollars)

Institutional control	2007–08	2008–09	2009–10	2010–11	2011–12	2012–13[a]
Public 2-year	10	-450	-890	-1,460	-1,350	-1,220
Public 4-year	2,470	2,340	1,950	2,120	2,620	2,910
Private, nonprofit 4-year	13,870	13,440	12,650	12,540	12,600	13,380

[a] Estimated value.

NOTES: Prices have been rounded to the nearest $10. Net tuition and fees equal published tuition and fees minus total grant aid and tax benefits.

SOURCE: The College Board, *Annual Survey of Colleges, Trends in College Pricing* (2012).

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out of 10 students who earned bachelor's degrees in 2010–11 from the public 4-year colleges where they began their studies graduated with debt, and their average total debt was $23,800. Among students who earned their bachelor's from the private 4-year institutions where they began their studies, two-thirds graduated with debt, and their average total debt was $29,900. Students who attend private for-profit institutions are more likely to borrow, and to borrow larger amounts, than those who attend public and private nonprofit institutions (College Board 2012b).

Levels of debt varied widely by state. Average debt for 2011 graduates of public 4-year colleges and universities ranged from $16,317 in Utah to $32,385 in New Hampshire. Average debt for graduates of private nonprofit colleges and universities ranged from $18,614 in Utah to $34,017 in Connecticut (Reid and Cochrane 2012). Cost of living may account for some of the differences by state.

Graduate Financial Support Patterns and Debt

Financial Support for S&E Graduate Education. More than one-third of all S&E graduate students are primarily self-supporting; that is, they rely primarily on loans, their own funds, or family funds for financial support. The other approximately two-thirds receive primary financial support from a variety of sources, including the federal government, university sources, employers, nonprofit organizations, and foreign governments.

Support mechanisms include research assistantships (RAs), teaching assistantships (TAs), fellowships, and traineeships. Sources of funding include federal agency support, nonfederal support, and self-support. Nonfederal support includes state funds, particularly in the large public university systems; these funds are affected by the condition of overall state budgets. Most graduate students, especially those who pursue doctoral degrees, are supported by more than one source or mechanism during their time in graduate school, and some receive support from several different sources and mechanisms in any given academic year.

Other than self-support, over time RAs have been the most prevalent primary mechanism of financial support for full-time S&E graduate students (appendix table 2-6). In 2011, 27% of full-time S&E graduate students were supported primarily by RAs, 18% primarily through TAs, and 12% primarily by fellowships or traineeships (table 2-9).

Primary mechanisms of support differ widely by S&E field of study (figure 2-7; appendix table 2-7). For example, in fall 2011, full-time students in physical sciences were financially supported mainly through RAs (40%) and TAs (38%). RAs also were important in agricultural sciences (51%); earth, atmospheric, and ocean sciences (39%); biological sciences (38%); and engineering (38%, and in particular in materials and chemical engineering). In mathematics, nearly half (49%) of full-time students were supported primarily through TAs and another quarter were self-supported. Full-time students in computer sciences and the social and behavioral sciences were mainly self-supporting (49% and 48%, respectively) or received TAs (14% and 20%, respectively). Students in medical and other health sciences were mainly self-supporting (59%).

The federal government plays a substantial role in supporting S&E graduate students in some fields but a smaller role in others. Federal financial support for graduate education reaches a larger proportion of students in the biological sciences; the physical sciences; the earth, atmospheric, and ocean sciences; and engineering. Lower proportions of students in computer sciences, mathematics, medical and other health sciences, psychology, and social sciences receive federal support (figure 2-8). Appendix table 2-8 provides detailed information by field and mechanism.

Table 2-9
Full-time S&E graduate students, by source and mechanism of primary support: 2011

Source	All	Research assistantship	Fellowship	Traineeship	Teaching assistantship	Other	Self-support[a]
All sources (number)	444,991	121,010	40,583	12,557	80,719	29,799	160,323
Federal	84,816	61,799	9,766	7,600	1,091	4,560	NA
Nonfederal	199,852	59,211	30,817	4,957	79,628	25,239	NA
All sources (%)	100.0	27.2	9.1	2.8	18.2	6.7	36.1
Federal	100.0	72.9	11.5	9.0	1.3	5.4	NA
Nonfederal	100.0	29.6	15.4	2.5	39.8	12.6	NA

NA = not available; self-support is not included in federal or nonfederal counts.

[a] Includes any loans (including federal) and support from personal or family financial contributions.

NOTES: S&E includes health fields (i.e., medical sciences and other health sciences). These fields are reported separately in data from the National Science Foundation's Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS). S&E excludes fields that are collected by the GSS (architecture, communication, and family and consumer sciences/human sciences) that are not included in other tables in this report from other data sources. Percentages may not add to 100% because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Graduate Students and Postdoctorates in Science and Engineering, 2011.

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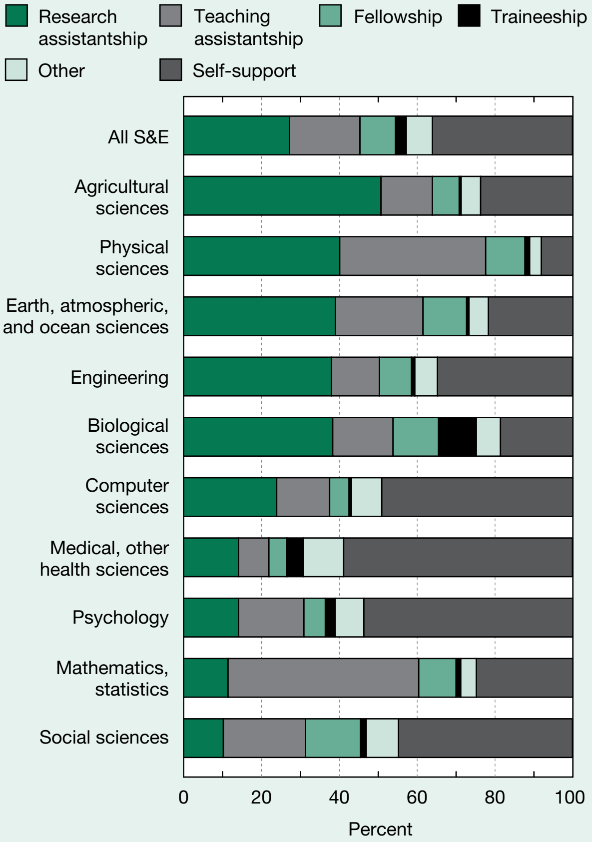
The federal government was the primary source of financial support for 19% of full-time S&E graduate students in 2011, whereas 45% were supported by nonfederal sources (institutional, state or local government, other U.S. sources, or other non-U.S. sources) and 36% were self-supported (appendix table 2-6). The number of full-time S&E graduate students supported by the federal government increased between 1998 and 2004 but has been fairly stable since then, whereas the number of students supported by nonfederal sources or through self-support has gradually increased between 1997 and 2011 (figure 2-9).

For some mechanisms of support, the federal role is fairly large. In 2011, the federal government funded 61% of S&E graduate students who were on traineeships, 51% of those with RAs, and 24% of those with fellowships (appendix table 2-8).

Figure 2-7

Full-time S&E graduate students, by field and mechanism of primary support: 2011



NOTE: Self-support includes any loans (including federal) and support from personal or family financial contributions.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Graduate Students and Postdoctorates in Science and Engineering, 2011.

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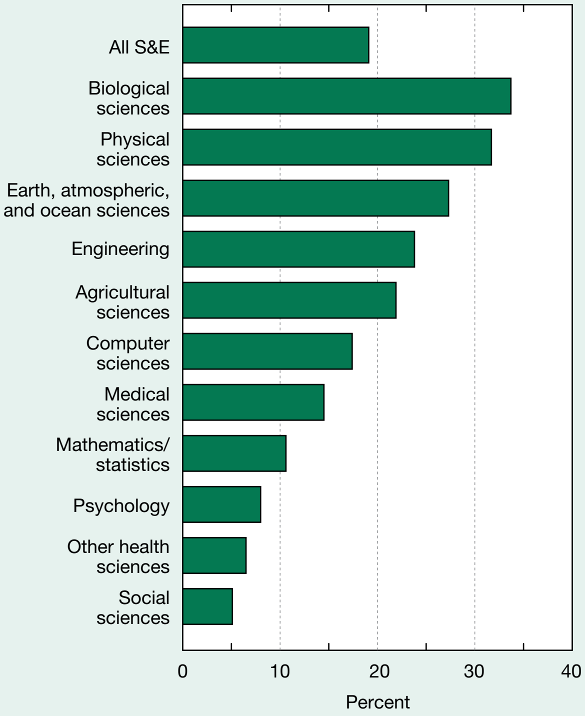
Most federal financial support for graduate education is in the form of RAs funded through grants to universities for academic research. RAs are the primary mechanism of support for 73% of federally supported full-time S&E graduate students. Fellowships and traineeships are the means of funding for 21% of the federally funded full-time S&E graduate students. For students supported through nonfederal sources in 2011, TAs were the most prominent mechanism (40%), followed by RAs (30%) (table 2-9; appendix table 2-6).

The National Institutes of Health (NIH) and NSF support most of the full-time S&E graduate students whose primary support comes from the federal government, followed by the U.S. Department of Defense (DOD) (appendix table 2-9). In 2011, NIH supported about 26,000 students, NSF about 24,000, and DOD about 9,000. Trends in federal agency support of graduate students show considerable increases from 1997 to 2011 in the proportion of students funded by NSF, from 21% to 29% (appendix table 2-9). NSF supported nearly 60% of students in computer sciences or mathematics whose primary support comes from the federal government; 50% of those in earth, atmospheric, and ocean sciences; 39% of those in the physical sciences; and 34% of those in engineering overall (about 43% of those in chemical and electrical engineering) (appendix table 2-10). The proportion

Figure 2-8

Full-time S&E graduate students with primary support from federal government, by field: 2011



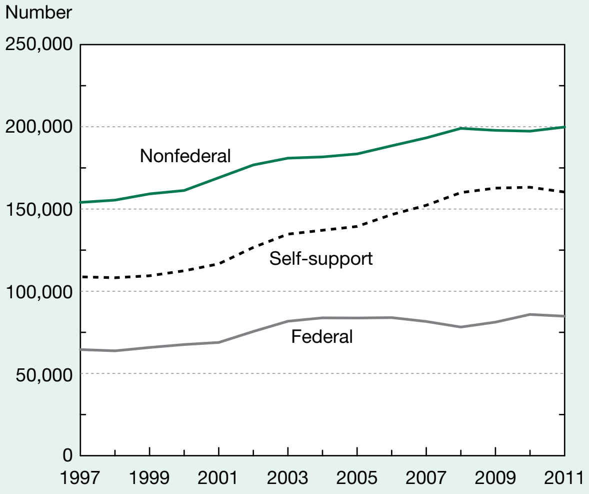
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Graduate Students and Postdoctorates in Science and Engineering, 2011.

Science and Engineering Indicators 2014

of students funded by NIH increased from 28% to 33% between 1997 and 2008 but since then has decreased to 30%. In 2011, NIH funded about 71% of such students in the biological sciences, 53% of those in the medical sciences, and 43% of those in psychology. The proportion of graduate students supported by DOD decreased slightly between 1997 and 2011. In 2011, DOD supported almost half of the S&E graduate students in aerospace engineering, about one-third of those in industrial and electrical engineering, and close to one-quarter of those in mechanical engineering and in computer sciences.

For doctoral degree students, notable differences exist in primary support mechanisms by type of doctorate-granting institution (table 2-10). In 2011, RAs were the primary support mechanism for S&E doctorate recipients from research universities (i.e., doctorate-granting institutions with very high research activity, which receive the most federal funding, as well as those with high research activity). For those from medical schools, which are heavily funded by NIH, fellowships or traineeships accounted for the main source of support. Students at less research-intensive universities relied mostly on personal funds. These differences by type of institution hold for all S&E fields (NSF/NCSES 2000; NSB 2010).

Figure 2-9
Full-time S&E graduate students, by source of primary support: 1997–2011



NOTES: Self support includes any loans (including federal) and support from personal or family financial contributions. In 2007, the survey was redesigned to improve reporting. In this figure, "2007" shows data as collected in 2007. Because of methodological changes, counts should be used with caution for trend analysis. See http://www.nsf.gov/statistics/nsf10307/ for more detail. S&E excludes fields that were collected in this survey starting in 2007 (architecture, communication, and consumer sciences/human sciences) that are not included in other tables in this report.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Graduate Students and Postdoctorates in Science and Engineering, 2011.

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Notable differences also exist in primary support mechanisms for doctoral degree students by sex, race or ethnicity, and citizenship (appendix table 2-11). In 2011, among U.S. citizens and permanent residents, men were more likely than women to be supported by RAs (31% compared with 22%). Women were more likely than men to be supported by fellowships or traineeships (29% compared with 24%) and to support themselves from personal sources (18% compared with 12%). Also, among U.S. citizens and permanent residents, whites and Asians were more likely than other racial or ethnic groups to receive primary support from RAs (28% and 32%, respectively), whereas underrepresented minorities depended more on fellowships or traineeships (35%). The primary source of support for doctoral degree students with temporary visas was an RA (50%).

To some extent, the sex, citizenship, and racial and ethnic differences in types of support mechanisms are related to differences in field of study. White and Asian men, as well as foreign doctoral degree students, are more likely than white and Asian women and underrepresented minority doctoral degree students of both sexes to receive doctorates in engineering and physical sciences, fields largely supported by RAs. Women and underrepresented minorities are more likely than other groups to receive doctorates in social sciences and psychology, fields in which self-support is prevalent. However, differences in type of support by sex, race or ethnicity, or citizenship remain, even after accounting for doctoral field (NSF/NCSES 2000, NSB 2010).

Graduate Debt. At the time of doctoral degree conferral, 45% of S&E doctorate recipients have debt related to their undergraduate or graduate education. In 2011, 28% of S&E doctorate recipients reported having undergraduate debt, and 32% reported having graduate debt. For some, debt levels were high, especially for graduate debt: 5% reported more than $40,000 of undergraduate debt, and 7% reported more than $70,000 of graduate debt (appendix table 2-12).

Levels of debt vary widely by doctoral field. A higher percentage of doctorate recipients in non-S&E fields (49%) than those in S&E fields (32%) reported graduate debt. In 2011, within S&E, high levels of graduate debt were most common among doctorate recipients in social sciences, psychology, and medical and other health sciences. The proportion of doctorate recipients in these fields who reported graduate debt has increased since 2001. Psychology doctorate recipients were most likely to report having graduate debt and also high levels of debt.[18] In 2011, 24% of psychology doctoral degree recipients reported graduate debt of more than $70,000 (appendix table 2-12). Doctorate recipients in mathematics and computer sciences were the least likely to report graduate debt. Since 2001, the proportion of doctorate recipients reporting graduate debt higher than $30,000 has increased in all broad fields except engineering and mathematics (appendix table 2-13).

Men and women differed little in level of undergraduate debt, but women were more likely to have accumulated more graduate debt. U.S. citizens and permanent residents accumulated more debt than temporary visa holders. Blacks, Hispanics, and American Indian and Alaska Natives had higher levels of graduate debt than whites, even accounting for differences in field of doctorate (NSF/NCSES 2012).

Undergraduate Education, Enrollment, and Degrees in the United States

Undergraduate education in S&E courses prepares students majoring in S&E for the workforce. It also prepares nonmajors to become knowledgeable citizens with a basic understanding of science and mathematics concepts. This section includes indicators related to enrollment by type of institution, field, and demographic characteristics; intentions to major in S&E fields; and recent trends in the number of earned S&E degrees.

Undergraduate Enrollment in the United States

Overall Undergraduate Enrollment

Over the last 15 years, enrollment in U.S. institutions of higher education at all levels rose from 14.5 million students in fall 1996 to 21.3 million in fall 2011, with two main periods of high growth—between 2000 and 2002 and between 2007 and 2010, the two most recent recessionary periods. Undergraduate enrollment typically represents about 86% of all postsecondary enrollment (appendix table 2-14).

In 2011, for the first time since 1996, undergraduate enrollment declined slightly. As in previous years, the types of institutions enrolling the largest numbers of students at the undergraduate level were associate's colleges (8.2 million, 45% of all students enrolled), master's colleges/universities (3.8 million, 21%), and doctorate-granting universities with very high research activity (2.0 million, 11%). Between 1996 and 2011, undergraduate enrollment nearly doubled at doctoral/research universities and increased by 56% at associate's colleges, 47% at master's colleges, and 39% at baccalaureate colleges (appendix table 2-14). (See sidebar, "Carnegie Classification of Academic Institutions," for definitions of the types of academic institutions.)

According to the latest Census Bureau projections, the number of college-age individuals (ages 20–24) is expected to decline from 22.6 million in 2015 to 21.6 million in 2025 but increase in the longer term (to 25.3 million by 2060) (appendix table 2-15). The short-term decline in this segment of the population is mostly due to a drop in the number of whites who are not Hispanic, which is projected overall to continue to fall through 2060, and a decline in the population of blacks who are not Hispanic between 2015 and 2035. The populations of 20–24-year-old Hispanics and of Asians who are not Hispanic are expected to increase continuously between 2015 and 2060. The proportion of Hispanics in this age group is expected to grow from 22% in 2015 to 36% in 2060, and the proportion of Asians in this age group is expected to increase from 5% to 7%. Increased enrollment in higher education is projected to come mainly from minority groups, particularly Hispanics.[19]

Undergraduate Enrollment in S&E

Freshmen's Intentions to Major in S&E. Since 1971, the annual The American Freshman: National Norms survey, administered by the Higher Education Research Institute at

Table 2-10

Primary support mechanisms for S&E doctorate recipients, by 2010 Carnegie classification of doctorate-granting institution: 2011

Mechanism	All institutions	Research universities (very high research activity)	Research universities (high research activity)	Doctoral/ research universities	Medical schools and medical centers	Other/not classified
Doctorate recipients (*n*)	36,654	27,641	5,773	1,219	1,197	824
All mechanisms	100.0	100.0	100.0	100.0	100.0	100.0
Fellowship or traineeship	20.9	22.6	13.2	11.7	35.2	12.5
Grant	6.4	6.8	3.2	2.5	18.0	3.2
Teaching assistantship	16.1	16.3	21.2	7.7	1.3	7.3
Research assistantship	32.7	35.8	28.6	7.9	20.2	14.1
Other assistantship	0.5	0.4	1.1	1.1	D	D
Personal	9.6	6.3	17.3	34.8	9.4	30.0
Other	3.3	2.8	4.4	7.1	D	D
Unknown	10.4	8.9	11.1	27.2	12.2	28.5

D = suppressed to avoid disclosure of confidential information.

NOTES: Personal support mechanisms include personal savings, other personal earnings, other family earnings or savings, and loans. Traineeships include internships and residencies. Other support mechanisms include employer reimbursement or assistance, foreign support, and other sources. Percentages may not add to 100% because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012), of the 2011 Survey of Earned Doctorates.

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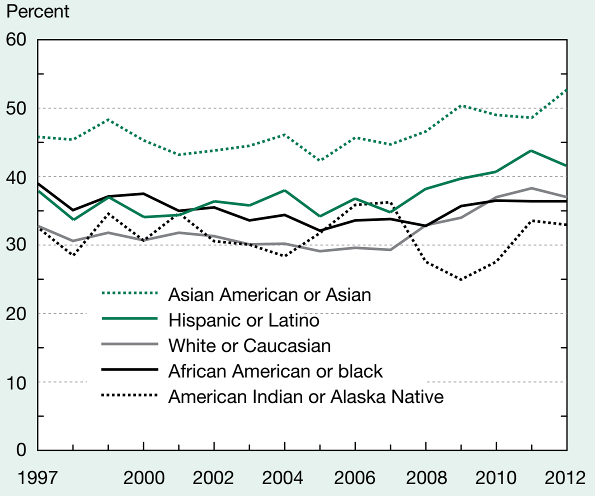
the University of California–Los Angeles, has asked freshmen at a large number of universities and colleges about their intended majors.[20] The data have proven to be a broadly accurate picture of trends in degree fields several years later.[21] Data show that up until 2007, about one-third of all freshmen planned to study S&E; this proportion gradually rose to 39% by 2012. Increases in the proportion of freshmen planning to major in biological and agricultural sciences account for most of this growth. In 2012, about 13% of freshmen intended to major in the biological and agricultural sciences and about 10% each in the social and behavioral sciences and engineering. About 3% each intended to major in physical sciences and mathematics, statistics, or computer sciences (appendix table 2-16).

In 2012, more than half of Asian American or Asian freshmen reported that they intended to major in S&E; proportions were lower for Hispanic or Latino freshmen (42%) and lower still for white (37%), black (36%), and American Indian or Alaska Native (33%) freshmen (figure 2-10). The proportions planning to major in S&E were higher for men than for women in every racial and ethnic group (appendix table 2-16). For most racial and ethnic groups, about 10% planned to major in social and behavioral sciences; about 8%–10% in engineering; about 12% in biological and agricultural sciences; 3% in mathematics, statistics, or computer sciences; and 2% in physical sciences. Higher proportions of Asian American or Asian freshmen than of those from other racial and ethnic groups planned to major in engineering; biological and agricultural sciences; and mathematics, statistics, or computer sciences. Higher proportions of blacks and Hispanics or Latinos intended to major in the social and behavioral sciences. The percentage of all freshmen intending to major in mathematics, statistics, or computer sciences has dropped since the late 1990s, whereas the percentages of students intending to major in biological and agricultural sciences, engineering, and the social and behavioral sciences have increased.

Generally, the percentages of students earning bachelor's degrees in specific S&E fields are similar to the percentages planning to major in those fields, with the exception of engineering and social and behavioral sciences (see "S&E Bachelor's Degrees" section and appendix tables 2-17 and 2-23 for trends in bachelor's degrees; see section on "Persistence and Retention in Undergraduate Education [S&E versus Non-S&E Fields]" in NSB 2012 for a discussion of longitudinal data on undergraduate attrition in S&E). For both sexes and all racial and ethnic groups, the percentage of students earning bachelor's degrees in engineering is smaller than the percentage planning to major in it (figures 2-11 and 2-12). The percentage earning bachelor's degrees in social and behavioral sciences in 2011 (16%) (appendix table 2-17) is larger than the percentage that planned to major in those fields as freshmen 6 years earlier (10%) (appendix table 2-16). For women, blacks, and Hispanics—unlike for men, whites, and Asians—the proportion earning bachelor's degrees in the natural sciences is smaller than the proportion who begin college planning to major in these fields (figures 2-13 and 2-14).

Figure 2-10
Freshmen intending S&E major, by race and ethnicity: 1997–2012



NOTE: In 2001, Native Hawaiian or Pacific Islander was added as a category under Asian American or Asian.

SOURCE: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2013).

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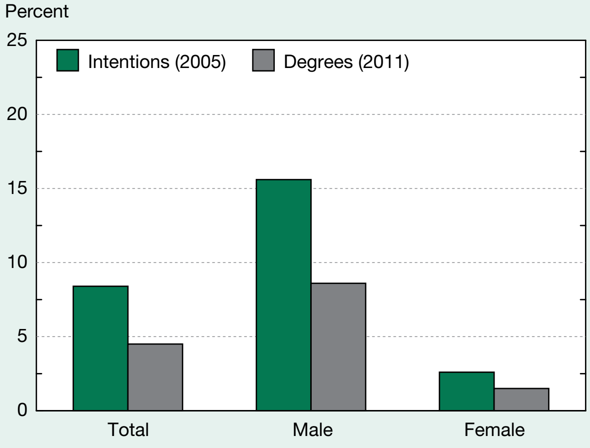
Figure 2-11
Engineering: Freshmen intentions and degrees, by sex



NOTES: Degrees do not reflect the same student cohort.

SOURCES: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2013); National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2011; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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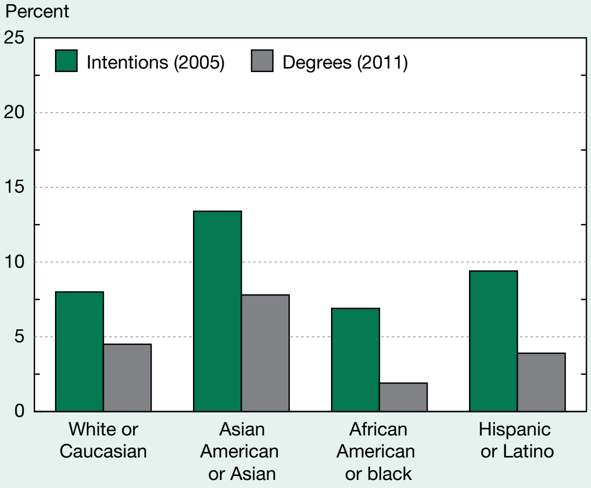
Figure 2-12
Engineering: Freshmen intentions and degrees, by race and ethnicity



NOTES: Degrees do not reflect the same student cohort. Asian American or Asian includes Native Hawaiian or Pacific Islander.

SOURCES: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2013); National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2011; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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Figure 2-13
Natural sciences: Freshmen intentions and degrees, by sex

NOTE: Degrees do not reflect the same student cohort.

SOURCES: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2013); National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2011; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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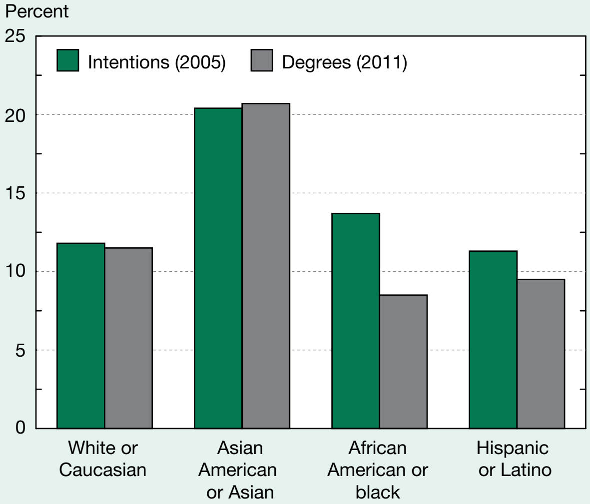
According to the 2012 PCAST report on science, technology, engineering, and mathematics (STEM) education (PCAST 2012), to retain the U.S. historical preeminence in S&E, the United States will need to increase the proportion of students who receive undergraduate degrees in STEM (or the natural sciences and engineering) fields considerably over current rates. Persistent historic patterns suggest that generating such an increase may be challenging because the following have been true for at least 15 years:

- The proportion of freshmen intending to major in the different S&E fields changed little for most fields, except for biological and agricultural sciences, and even declined for mathematics, statistics, and computer sciences (appendix table 2-16).
- The proportion of bachelor's degrees in the natural sciences and engineering combined has remained 15%–17% (appendix table 2-17 and NSB 2010).[22]
- The patterns of net undergraduate migration into S&E majors and attrition out of them have been stable (see section on "Persistence and Retention in Undergraduate Education [S&E versus Non-S&E Fields]" in NSB 2008 and NSB 2012).

One strategy to increase retention of students in STEM fields, however, is to improve student learning by improving the quality of undergraduate education in S&E. The 2012

Figure 2-14
Natural sciences: Freshmen intentions and degrees, by race and ethnicity



NOTES: Degrees do not reflect the same student cohort. Asian American or Asian includes Native Hawaiian or Pacific Islander.

SOURCES: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2013); National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2011; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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National Academies report, "Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering" (NRC 2012b), examines available research on current teaching practices that have been shown to be more effective than the traditional lecture (see sidebar, "Discipline-Based Education Research").

The demographic profile of students planning to major in S&E has become more diverse over time. The proportion of white students declined from about three-quarters in 1998 to about two-thirds in 2012. On the other hand, in the same period, the proportion of Asian American or Asian students doubled to 16%, and the proportion of Hispanic students nearly tripled, also to 16%, in 2012. American Indian or Alaska Native and black students accounted for roughly 2% and 11%, respectively, of freshmen intending to major in S&E in both 1998 and 2012 (appendix table 2-18).

Discipline-Based Education Research

The purpose of discipline-based education research (DBER) is to improve teaching and learning in S&E by bringing together general findings and perspectives from the science of learning and expert knowledge of specific S&E disciplines. DBER seeks to understand how people learn the concepts, practices, and thinking of S&E fields. It focuses on a group of related research fields (physics, chemistry, engineering, biology, the geosciences, and astronomy).

In 2012, at the request of the National Science Foundation, the National Research Council (NRC) examined the status, contributions, and future directions of DBER in undergraduate education. It found that across the different disciplines, students have incorrect understandings of basic concepts, in particular those involving time or space scales that are very large or very small. The NRC also concluded that students find important aspects of the fields that seem easy or obvious to experts to be challenging and to pose barriers to further learning, especially when instructors are unaware of the challenges for the novice.

DBER has shown that actively involving undergraduate students in the learning process improves understanding more than listening to a traditional lecture. Effective instruction strategies can promote conceptual change. Such strategies include, for example, making lectures more interactive, having students work in groups, and incorporating authentic activities and open-ended problems into teaching (e.g., learning in laboratories or learning in a field setting). Students can be taught more expert-like problem-solving skills and strategies to improve their understanding of concepts by instructional practices that provide steps and prompts to guide them, use multiple ways to represent those concepts, and help them to make their own thinking visible.

Foreign Undergraduate Enrollment.[23] In recent years, foreign undergraduate enrollment has been on the rise. In the 2011–12 academic year, the number of foreign students enrolled in bachelor's degree programs in U.S. academic institutions rose 11% from the previous year, to approximately 245,000 (IIE 2012). This rise continues a 5-year trend following the decline seen after 9/11. The number of foreign undergraduates enrolled in 2011–12 was 18% above the peak in 2001–02. New enrollments of foreign undergraduates in 2011–12 increased by 8% over the previous year. The countries that accounted for the largest numbers of foreign undergraduates enrolled in a U.S. institution in 2011–12 were China (75,000), South Korea (38,000), Saudi Arabia (14,000), India (13,000), Canada (13,000), and Vietnam (11,000). The numbers of Chinese and Saudi Arabian undergraduates each increased by 31% over the previous year. The numbers of South Korean undergraduates increased by 1%, whereas the numbers of Indian undergraduates decreased by 7%. In 2011–12, among all foreign students (undergraduate and graduate), the number of those studying mathematics and computer sciences increased 11% over the preceding year, and the number of those studying engineering, physical and life sciences, and social sciences also grew, each by 4% (IIE 2012).

More recent data from the Student and Exchange Visitor Information System (SEVIS) at the Department of Homeland Security show a substantial increase in foreign undergraduate enrollment in the United States between November 2011 and November 2012 (table 2-11; appendix table 2-19).[24] Most of the increase in foreign enrollment was in non-S&E fields, but within S&E the largest increases were in engineering and the social sciences. The top 10 countries sending foreign undergraduates in fall 2012 were similar to those in the preceding year (figure 2-15; appendix table 2-19). One-third of all foreign students in undergraduate programs at U.S. institutions are enrolled in S&E fields; in 2012, the proportion of undergraduate students enrolled in S&E fields was 50% or higher among students from Malaysia, Kuwait, India, and Nigeria.[25] Between 2008 and 2011, undergraduate foreign enrollment in S&E increased each year by about 6%–10%, with the growth rate more than doubling in 2012 (21%). At the undergraduate level, growth in non-S&E fields was between 1% and 3% each year between 2008 and 2011 but climbed to 16% in 2012 (table 2-11). About 50% of the growth in foreign undergraduate enrollment in the last year, both in S&E and non-S&E fields, is accounted for by the increase in the number of students from China.

Engineering Enrollment. For the most part, students do not declare majors until their sophomore year. Because of this, undergraduate enrollment data for domestic students are not available by field. However, engineering is an exception. Engineering programs generally require students to declare a major or an intent to major in the first year of college, so engineering enrollment data can serve as an early indicator of both future undergraduate engineering degrees and student interest in engineering careers. The Engineering Workforce Commission administers an annual fall survey that tracks enrollment in undergraduate and graduate engineering programs (EWC 2012).

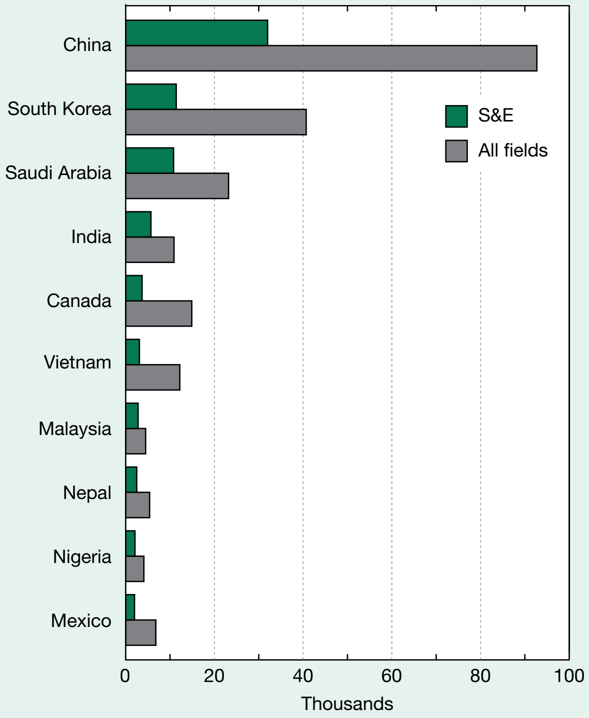
Undergraduate engineering enrollment was flat in the late 1990s, increased from 2000 to 2003, declined slightly through 2006, and has risen steadily since then to a peak of 511,000 in 2011 (figure 2-16; appendix table 2-20). The number of undergraduate engineering students increased by 26% between 2006 and 2011. Full-time freshman enrollment followed a similar pattern, reaching 122,000 in 2011—the highest since 1982. These trends correspond with declines in the college-age population through the mid-1990s, particularly the drop in white 20–24-year-olds, who account for the majority of engineering students (NSF/NCSES 2013a).

Enrollment by Disability Status. According to the most recent available estimates, 11% of undergraduate students reported a disability in 2008. Nearly half of them were enrolled in 2-year institutions, 41% in 4-year institutions, 3% in less-than-2-year institutions, and 8% in more than one institution. About one in five undergraduates with a disability was in an S&E field (NSF/NCSES 2013a).

Undergraduate Degree Awards

The number of undergraduate degrees awarded by U.S. academic institutions has been increasing over the past two decades in both S&E and non-S&E fields. These trends are expected to continue at least through 2021 (Hussar and Bailey 2013).

Figure 2-15
Foreign undergraduate student enrollment in U.S. universities, by top 10 places of origin and field: November 2012



NOTES: Data include active foreign national students on F-1 visas and exclude those on optional practical training. Undergraduate enrollment includes associate's and bachelor's degrees.

SOURCE: Bureau of Citizenship and Immigration Services, Student and Exchange Visitor Information System database, special tabulations (2013).

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Table 2-11
Foreign students enrolled in U.S. higher education institutions, by broad field and academic level: 2008–12

Field and level	2008	2009	2010	2011	2012
All fields					
All levels	526,570	525,680	537,650	574,360	635,650
Undergraduate	266,320	272,980	284,770	297,950	351,030
Graduate	260,260	252,710	252,890	276,400	284,620
S&E fields					
All levels	229,010	229,230	235,990	260,280	280,020
Undergraduate	76,780	81,110	87,590	96,400	116,640
Graduate	152,230	148,120	148,400	163,880	163,390
Non-S&E fields					
All levels	297,560	296,460	301,670	314,080	355,630
Undergraduate	189,530	191,870	197,180	201,560	234,390
Graduate	108,030	104,590	104,490	112,520	121,240

NOTES: Data include active foreign national students on F-1 visas and exclude those on optional practical training. Undergraduate level includes associate's and bachelor's degrees; graduate level includes master's and doctoral degrees. Numbers are rounded to the nearest 10. Detail may not add to total because of rounding.

SOURCE: U.S. Department of Homeland Security, U.S. Immigration and Customs Enforcement, Student and Exchange Visitor Information System database, special tabulations (2013).

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S&E Associate's Degrees

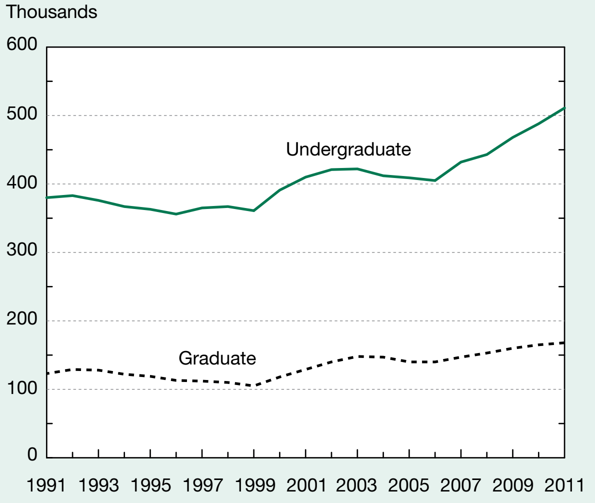
Community colleges often are an important and relatively inexpensive gateway for students entering higher education. Associate's degrees, largely offered by 2-year programs at community colleges, are the terminal degree for some, but others continue their education at 4-year colleges or universities and subsequently earn higher degrees.[26] Many who transfer to baccalaureate-granting institutions do not earn associate's degrees before transferring. Combined, associate's degrees in S&E and in engineering technologies accounted for about 12% of all associate's degrees in 2011 (appendix table 2-21).

S&E associate's degrees from all types of academic institutions have been rising continuously since 2007, after a steep decline between 2003 and 2007. The overall trend mirrors the pattern of computer sciences, which also peaked in 2003, declined through 2007, and increased through 2011. Associate's degrees earned in engineering technologies (not included in S&E degree totals because of their applied focus) declined from about 40,000 in 2000 to about 30,000 in 2006, but they have been rising since then to about 38,000 in 2011 (appendix table 2-21).[27]

In 2011, women earned 62% of all associate's degrees, up from 60% in 2000, and 43% of S&E associate's degrees, down from 48% in 2000. Most of the decline is attributable to a decrease in women's share of computer sciences degrees, which dropped from 42% in 2000 to 23% in 2011 (appendix table 2-21).

Students from underrepresented minority groups (blacks, Hispanics, and American Indians and Alaska Natives) earn a higher proportion of associate's degrees than of bachelor's or more advanced degrees, both in S&E fields and in all fields.[28] (See the "S&E Bachelor's Degrees by Race and Ethnicity" and "Doctoral Degrees by Race and Ethnicity" sections.) In 2011, underrepresented minorities earned 27% of S&E associate's degrees—more than one-third of all associate's degrees in social and behavioral sciences and more than one-quarter of all associate's degrees in biological sciences, physical sciences, and mathematics (appendix table 2-22). Since 2000, the number of S&E associate's degrees earned by these students grew faster than the overall national increase.

Figure 2-16
U.S. engineering enrollment, by level: 1991–2011



NOTE: Enrollment data include full- and part-time students.

SOURCE: American Association of Engineering Societies, Engineering Workforce Commission, Engineering & Technology Enrollments (various years).

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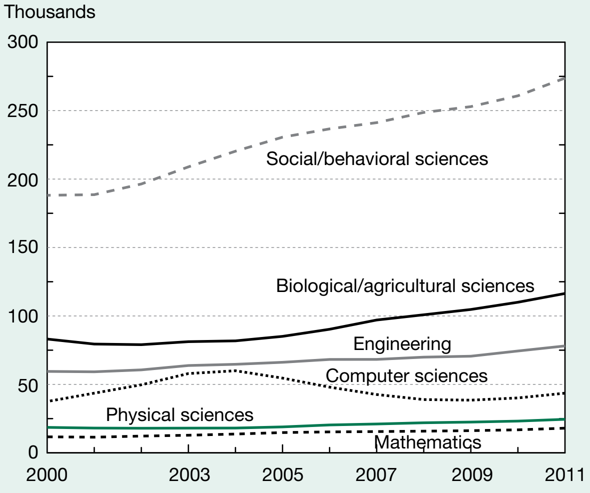
S&E Bachelor's Degrees

The baccalaureate is the most prevalent S&E degree, accounting for nearly 70% of all S&E degrees awarded. S&E bachelor's degrees have consistently accounted for roughly one-third of all bachelor's degrees for at least the past 10 years. The number of S&E bachelor's degrees awarded rose steadily from about 400,000 in 2000 to more than 550,000 in 2011 (appendix table 2-17).[29]

In the last decade, the number of bachelor's degrees awarded increased fairly consistently, although to different extents, in all S&E fields. The exception was computer sciences, where the number increased sharply from 2000 to 2004, dropped as sharply through 2009, but increased again in 2010 and 2011 (figure 2-17; appendix table 2-17).

S&E Bachelor's Degrees by Sex. Since 1982, women have outnumbered men in undergraduate education. They have earned relatively constant fractions of all bachelor's and S&E bachelor's degrees for several years. Since the

Figure 2-17
S&E bachelor's degrees, by field: 2000–11



NOTE: Physical sciences include earth, atmospheric, and ocean sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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late 1990s, women have earned about 57% of all bachelor's degrees and about half of all S&E bachelor's degrees. Among U.S. citizens and permanent residents, women also earn about half of all S&E bachelor's degrees (NSF/NCSES 2013a).

Within S&E, men and women tend to study different fields; these tendencies are also observed at the master's and doctoral levels, as will be seen below and in the workforce data in chapter 3. In 2011, men earned the vast majority of bachelor's degrees awarded in engineering, computer sciences, and physics. Women earned half or more of the bachelor's degrees in psychology, biological sciences, agricultural sciences, and all the broad fields within social sciences except for economics (appendix table 2-17).

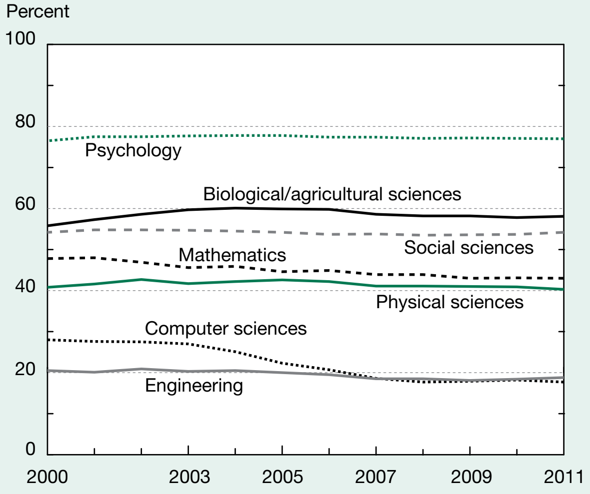
Since 2000, changes have not followed a consistent pattern. The share of bachelor's degrees awarded to women declined in computer sciences (by 10%), mathematics (by 5%), physics (by 2%), and engineering (by 2%) (figure 2-18; appendix table 2-17). Fields in which the proportion of bachelor's degrees awarded to women grew during this period include atmospheric sciences (by 9%), agricultural sciences (by 6%), astronomy (by 3%), chemistry (by 2%), anthropology (by 3%), and political science and public administration (by 1%) (appendix table 2-17).

The number of bachelor's degrees awarded to men and women in S&E and in all fields increased in similar proportions between 2000 and 2011.[30]

S&E Bachelor's Degrees by Race and Ethnicity. The racial and ethnic composition of the cohort of S&E bachelor's degree recipients has changed over time, reflecting both population changes and increasing rates of college attendance by members of minority groups.[31] Between 2000 and 2011, the share of S&E degrees awarded to white students among U.S. citizens and permanent residents declined from 71% to 63%, although the number of S&E bachelor's degrees earned by white students increased during that time (figure 2-19; appendix table 2-23). The share awarded to Hispanic students increased from 7% to 10% and to Asians and Pacific Islanders from 9% to 10%. The shares to black and American Indian or Alaska Native students have remained flat since 2000, at 9% and 1%, respectively. The number of S&E bachelor's degrees earned by students of unknown race or ethnicity nearly tripled in this period, to about 42,000.

Despite considerable progress over the past two decades for underrepresented minority groups earning bachelor's degrees in any field, the gap in educational attainment between young minorities and whites continues to be wide. In 2011, the percentage of the population ages 25–29 with bachelor's or higher degrees was 20% for blacks, 13% for Hispanics, and 39% for whites. These figures changed from the 1980 shares of 12%, 8%, and 25%, respectively (Aud et al. 2012). Differences in completion of bachelor's degrees in S&E by

Figure 2-18
Women's share of S&E bachelor's degrees, by field: 2000–11



NOTE: Physical sciences include earth, atmospheric, and ocean sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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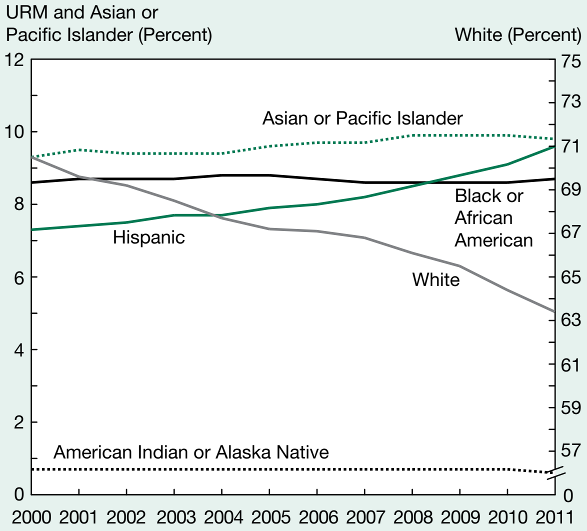
Figure 2-19
Share of S&E bachelor's degrees among U.S. citizens and permanent residents, by race and ethnicity: 2000–11



URM = underrepresented minorities (black, Hispanic, and American Indian or Alaska Native).

NOTES: Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin. Percentages do not sum to 100 because data do not include individuals who did not report their race and ethnicity.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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race or ethnicity reflect differences in high school completion rates, college enrollment rates, and college persistence and attainment rates. In general, blacks, Hispanics, and American Indians and Alaska Natives are less likely than whites and Asians or Pacific Islanders to graduate from high school, to enroll in college, and to graduate from college. (For information on immediate post-high school college enrollment rates, see the "Transition to Higher Education" section in chapter 1.) Among those who do enroll in or graduate from college, blacks, Hispanics, and American Indians and Alaska Natives are about as likely as whites to choose S&E fields; Asians or Pacific Islanders are more likely than members of other racial and ethnic groups to choose these fields. For Asians and Pacific Islanders, almost half of all bachelor's degrees received are in S&E, compared with close to one-third of all bachelor's degrees earned by each of the other racial and ethnic groups. However, the proportion of Asians and Pacific Islanders earning degrees in the social sciences is similar to that of other racial and ethnic groups (appendix table 2-23).

The contrast in field distribution among whites, blacks, Hispanics, and American Indians and Alaska Natives on the one hand and Asians and Pacific Islanders on the other is apparent within S&E fields as well. White, black, Hispanic, and American Indian and Alaska Native S&E baccalaureate recipients share a similar distribution across broad S&E fields. In 2011, between 9% and 11% of all baccalaureate recipients in each of these racial and ethnic groups earned their degrees in the natural sciences, 2%–4% in engineering, and 15%–18% in the social and behavioral sciences. Asian and Pacific Islander baccalaureate recipients earned 21% of their bachelor's degrees in natural sciences and 8% in engineering (appendix table 2-23).

Since 2000, the total number of bachelor's degrees and the number of S&E bachelor's degrees rose for all racial and ethnic groups. The number of bachelor's degrees in all broad S&E fields except computer sciences also rose for most racial and ethnic groups (appendix table 2-23). In all racial and ethnic groups, the number of degrees in computer sciences followed the pattern for the general population: it increased considerably through 2003–04 and then sharply declined through 2008–09. In the last 2 or 3 years, the numbers started to increase, and in the case of Hispanics, the number of earned bachelor's degrees in computer sciences in 2011 was close to the peak reached in 2004.

Bachelor's Degrees by Citizenship. Students on temporary visas in the United States have consistently earned a small share (3%–4%) of S&E degrees at the bachelor's level. In 2011, these students earned a larger share of bachelor's degrees awarded in economics and in chemical, electrical, and industrial engineering (about 10%). The number of S&E bachelor's degrees awarded to students on temporary visas increased from about 15,000 in 2000 to about 19,000 in 2004, then declined to 17,000 by 2008, but it increased through 2011, peaking at almost 21,000 (appendix table 2-23).

Graduate Education, Enrollment, and Degrees in the United States

Graduate education in S&E contributes to global competitiveness, producing the highly skilled workers of the future and the research needed for a knowledge-based economy. This section includes indicators related to graduate enrollment; recent trends in the number of earned degrees in S&E fields; and participation by women, minorities, and foreign students in graduate education in U.S. academic institutions.

Graduate Enrollment by Field

S&E graduate enrollment in the United States increased between 2000 and 2011 to more than 600,000 (appendix table 2-24).[32] Graduate enrollment grew considerably in most S&E fields, particularly in engineering and in the biological and the social sciences (where most of the growth is accounted for by the increase of graduate enrollment in political science and public administration). Graduate enrollment in computer sciences grew rapidly in the early 2000s, then decreased through 2006, but it has generally increased since then.

Graduate enrollment in engineering grew between 2000 and 2011. Although the rate of growth slowed somewhat in 2011, the number of full-time engineering students reached a new peak in that year (appendix table 2-25).

The number of full-time students enrolled for the first time in S&E graduate departments is an indicator of developing trends. Despite some drops in first-time, full-time enrollment in engineering and computer sciences in the early to mid-2000s, this indicator has increased fairly steadily in most broad S&E fields, particularly between 2008 and 2011. In 2011, the number of first-time, full-time S&E graduate students reached a new peak in most S&E fields (appendix table 2-26).

First-time, full-time graduate enrollment, particularly in engineering and to some extent in computer sciences, often follows trends in employment opportunities. When employment opportunities are plentiful, recent graduates often forgo graduate school, but when employment opportunities are scarce, further training in graduate school may be perceived as a better option. Figure 2-20 shows trends in unemployment rates and trends in first-time, full-time graduate enrollment in engineering and computer sciences. Enrollment in S&E fields that offer fewer employment opportunities at the bachelor's level (e.g., biological sciences) does not follow this trend. According to data from the NSRCG, the proportion of recent S&E bachelor's recipients who were taking classes or enrolled full-time in a degree program after obtaining their degree increased to about 30% among those who graduated in 2008 and 2009, up from about 25% among those who graduated earlier in the decade.[33]

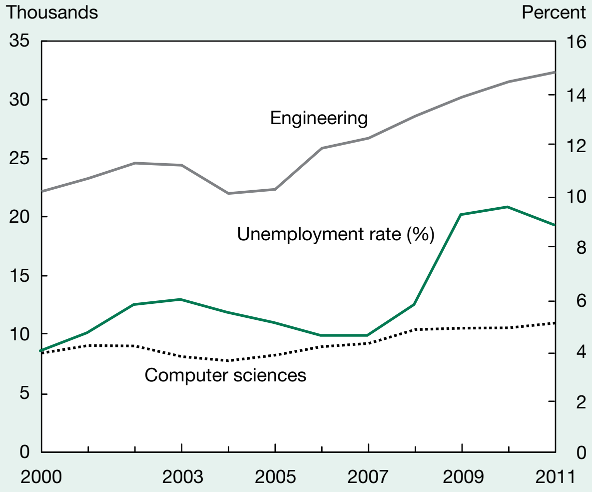
Graduate Enrollment by Sex

In 2011, 46% of the S&E graduate students enrolled in the United States were women (appendix table 2-24). The proportions of women graduate students enrolled in S&E differed considerably by field, with the lowest proportions in engineering, computer sciences, and physical sciences. Women constituted the majority of graduate students in psychology, medical and other health sciences, biological sciences, and social sciences, and they were half or close to half of graduate students in agricultural sciences and earth, atmospheric, and ocean sciences. Among the social sciences, economics has an unusually low proportion of women. Except for computer sciences and physical sciences, in most of these broad fields, the proportion of women enrolled increased between 2000 and 2005–07, but it has remained fairly stable since then. The proportion of women enrolled in graduate programs in computer sciences peaked in 2000 and has decreased since then. In the physical sciences, the proportion of women increased gradually in the last two decades, from 25% in 1991 to 33% in 2011 (for earlier data, see NSB 2008).

Graduate Enrollment of Underrepresented Groups

In 2011, among U.S. citizens and permanent residents, underrepresented minority students (blacks, Hispanics, and American Indians and Alaska Natives) accounted for 17% of students enrolled in graduate S&E programs (appendix table 2-27). The proportion of underrepresented minorities was highest in psychology and the social sciences (23%), medical and other health sciences (19%), and computer sciences (15%); it was lowest in the earth, atmospheric, and ocean sciences (9%) and the physical sciences (10%). Between 2000 and 2011, the proportion of underrepresented minorities enrolled has increased in all broad S&E fields, in particular in psychology and computer sciences.

Figure 2-20
First-time, full-time graduate enrollment in engineering and computer sciences and unemployment rate of all workers: 2000–11



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Graduate Students and Postdoctorates in Science and Engineering, 2011. Unemployment rates are from the Bureau of Labor Statistics, Current Population Survey, table 1, employment status of the civilian noninstitutional population, 1942 to date, http://www.bls.gov/cps/cpsaat01.htm, accessed 4 February 2013.

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In 2011, whites accounted for about 65% of S&E graduate enrollment among U.S. citizens and permanent residents. They constituted a larger proportion of graduate students enrolled in agricultural sciences and in earth, atmospheric, and ocean sciences (about 80%) and a smaller proportion of those enrolled in computer sciences and social sciences (about 60%). The proportions of whites in other fields fell in between. Over time, however, the proportion of whites among graduates enrolled in S&E has declined in all broad S&E fields except for computer sciences, where the proportion of whites increased slightly, from 58% in 2000 to 60% in 2011.

Asians and Pacific Islanders accounted for 9% of S&E graduate enrollment among U.S. citizens and permanent residents in 2011, with larger proportions in computer sciences (14%), engineering (13%), the biological and medical sciences (about 12% and 11%, respectively) and a lower proportion in the agricultural sciences (3%); earth, atmospheric, and ocean sciences (4%); psychology (5%); and the social sciences (6%). Between 2000 and 2011, the proportion of Asians and Pacific Islanders enrolled increased slightly in most broad fields, but it declined in computer sciences (from 21% in 2000 to 14% in 2011).

About 20% of graduate students reporting a disability were enrolled in S&E fields. Nearly two-thirds of those in S&E fields were men; nearly 90% were 24 years old or older (NSF/NCSES 2013a).

Foreign Graduate Enrollment

In 2011, nearly 174,000 foreign students on temporary visas were enrolled in S&E graduate programs (appendix table 2-27). The concentration of foreign enrollment was highest in computer sciences, engineering, physical sciences, mathematics/statistics, chemistry, and economics.[34]

Following a post-9/11 decline, the numbers of first-time, full-time foreign graduates enrolled increased more or less consistently in most broad fields through 2011 (appendix table 2-26). Declines and subsequent increases were concentrated in engineering and computer sciences, the fields heavily favored by foreign students. However, between 2000 and 2011, foreign students' share of first-time, full-time S&E graduate enrollment dropped in other broad fields, particularly in the physical sciences (from 43% to 40%) and the social sciences (from 29% to 24%).

According to data collected by the Institute of International Education (IIE), the overall number of foreign graduate students in all fields increased by 1% from academic year 2010–11 to 2011–12 (IIE 2012). The number of new foreign graduate students increased by 3%. India, China, South Korea, Taiwan, and Canada were the top originating locations for foreign graduate students, similar to the leading foreign sources for undergraduate enrollment.

More recent data from SEVIS show an overall 3% increase in foreign graduate students from November 2011 to November 2012 in all fields (appendix table 2-28, table 2-11).[35] In 2012, nearly 60% of all foreign students in graduate programs at U.S. institutions were enrolled in S&E fields. Between fall 2011 and fall 2012, the number of foreign graduate students enrolled in S&E fields was stable, with declines in the numbers of foreign students in computer sciences (5%), biological sciences (4%), and engineering (2%) offset by increases in mathematics (11%), social sciences (7%), and psychology (4%). China and India continued to account for about 61% of the foreign S&E graduates in the United States in November 2012; however, between fall 2011 and fall 2012, the number of S&E foreign students from China increased, whereas the number of foreign students from India declined. South Korea, Taiwan, and Canada also sent large numbers of S&E graduate students, although these economies sent larger numbers of graduate students in non-S&E fields, primarily business and the humanities.

S&E Master's Degrees

In some fields, such as engineering and geosciences, a master's degree can be a terminal degree that fully prepares students for an established career track. In other fields, master's degrees primarily mark a step toward doctoral degrees. Master's degrees awarded in S&E fields increased from about 96,000 in 2000 to about 151,000 in 2011, with growth concentrated in two periods, 2002–04 and 2007–11 (appendix table 2-29).[36] Increases occurred in all major science fields. Master's degrees awarded in engineering and computer sciences declined between 2004 and 2007, but they have since increased. The number of master's degrees awarded in engineering in 2011 was the highest in the last 12 years; in the case of computer sciences, the number of master's degrees awarded in 2011 was near its peak in 2004 (figure 2-21). During this 12-year period, growth was particularly high in engineering, psychology, and political science and public administration (appendix table 2-29). Both students and institutions are concerned that success rates in completing master's degrees are too low (see sidebar, "Master's Completion and Attrition in S&E").

In 2012, the Commission on Pathways through Graduate School and into Careers, a 14-member commission composed of industry leaders and university executives, led a research effort to understand the different career paths students may take and to modernize graduate education by emphasizing skills that align more closely with workforce needs (Wendler et al. 2012).[37] Professional science master's degree programs, which stress interdisciplinary training, are part of this relatively new direction in graduate education (for details, see sidebar, "Professional Science Master's Degrees").

Master's Degrees by Sex

The number of S&E master's degrees earned by both men and women rose between 2000 and 2011 (figure 2-22). In 2000, women earned 43% of all S&E master's degrees; by 2011, they earned 45% (appendix table 2-29). Among U.S. citizens and permanent residents, women earned nearly half of all S&E master's degrees; among temporary residents, women earned about one-third of all S&E master's degrees (NSF/NCSES 2013a).

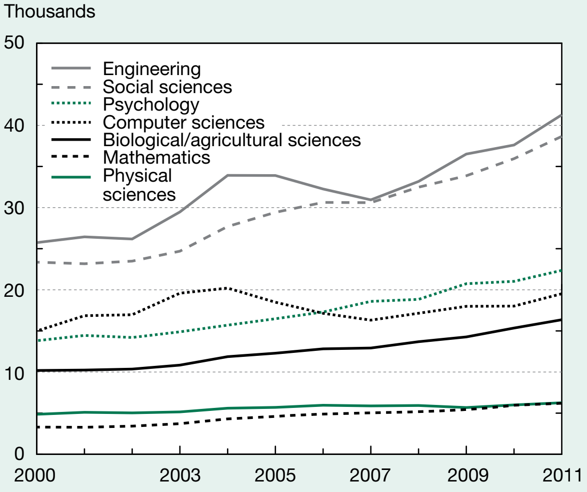
Women's share of S&E master's degrees varies by field. As with bachelor's degrees, in 2011, women earned a majority of master's degrees in psychology, biological sciences, agricultural sciences, and most social sciences except economics, but low proportions of master's degrees in engineering, computer sciences, and physics. Women's share of master's degrees in engineering in 2011, however, was slightly higher than their share in 2000 (appendix table 2-29). The number of master's degrees awarded to women in most major S&E fields increased fairly consistently throughout the last decade. In computer sciences, the numbers increased through 2004, then declined sharply through 2007, but they have increased consistently since then.

Master's Degrees by Race and Ethnicity

The number of S&E master's degrees awarded to U.S. citizens and permanent residents increased for all racial and ethnic groups between 2000 and 2011 (figure 2-23; appendix table 2-30).[38]

The proportion of master's degrees in S&E fields earned by U.S. citizens and permanent residents from underrepresented racial and ethnic minorities increased slightly between

Figure 2-21
S&E master's degrees, by field: 2000–11



NOTE: Physical sciences include earth, atmospheric, and ocean sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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2000 and 2011. The trends are not very different from those found in the data on bachelor's degree awards among racial and ethnic groups. Blacks accounted for 10% of S&E master's degree recipients in 2011, up from 8% in 2000; Hispanics accounted for 8%, up from 5%; and American Indians and Alaska Natives accounted for 0.5%, similar to the proportion in 2000. The proportion of Asian and Pacific Islander S&E recipients also remained flat in this period.

Master's Completion and Attrition in S&E

Trends in master's education have attracted considerable attention in recent years, but little is known about the extent to which master's students succeed in completing their programs. A study by the Council of Graduate Schools (CGS 2013) collected data on master's completion and attrition trends in master's programs from the 2003–04 to the 2006–07 academic years from five academic institutions in five broad S&E fields (biological and agricultural sciences, engineering, mathematics and computer sciences, physical and earth sciences, social and behavioral sciences) and in business. Although the data from this study are not nationally representative and cannot be generalized to S&E graduate programs as a whole, they come from a range of fields and institutions and are suggestive of factors affecting master's degree completion.

In surveys, graduating S&E master's students said that the most important factor contributing to the successful completion of a master's program was their motivation and determination, followed by nonfinancial family support, being a full-time student, quality of teaching, and supportive faculty.

S&E master's students who left their programs reported that the most important factors preventing them from earning a master's degree were interference from employment, program structure, lack of adequate financial support, and lack of support from faculty. Among students who reported having concerns about their ability to complete their master's in S&E, the most frequently reported challenge was finding the time to manage school, work, and family commitments.

In the institutions studied, 41% of the S&E master's students completed their program within 2 years, 60% within 3 years, and 66% within 4 years. Completion rates within 4 years varied little by S&E field, but rates within 2 years were lowest for students in physical and earth sciences. Women, Asians and Pacific Islanders, temporary residents, and younger cohorts of students completed their master's degrees at higher rates.

About 10% of students in S&E fields left their programs within 6 months, 17% within 1 year, and 23% within 2 years. The median time to degree for students in S&E fields was 23 months, and the median time to attrition was 8 months.

The percentage of S&E master's degrees earned by white students fell from 70% in 2000 to 61% in 2011, whereas the percentage of degrees earned by blacks, Hispanics, and temporary residents increased. The proportion of S&E master's degrees recipients of other or unknown race doubled between 2000 and 2011, to 12% (appendix table 2-30).

Professional Science Master's Degrees

Professional science master's (PSM) degrees provide advanced training in an S&E field beyond the bachelor's degree level while also developing administrative and business skills that are valued by employers, including leadership, project management, teamwork, and communication. Starting from a handful of PSM programs in 1997, there are now almost 300 such programs in more than 100 institutions in 32 states and the District of Columbia, as well as some international programs in Canada, Australia, and the United Kingdom.

Total enrollment in PSM programs in the United States reached nearly 5,800 students in 2012, about one-third of whom were first-time enrollees (Allum, Gonzales, and Remington 2013). More than half of the enrollees were men (55%) and, among U.S. citizens and permanent residents, one-quarter were underrepresented minorities. The majority of the students were enrolled in one of four fields of study: computational sciences (21%), biotechnology (16%), environmental sciences and natural resources (14%), and mathematics and statistics (14%).

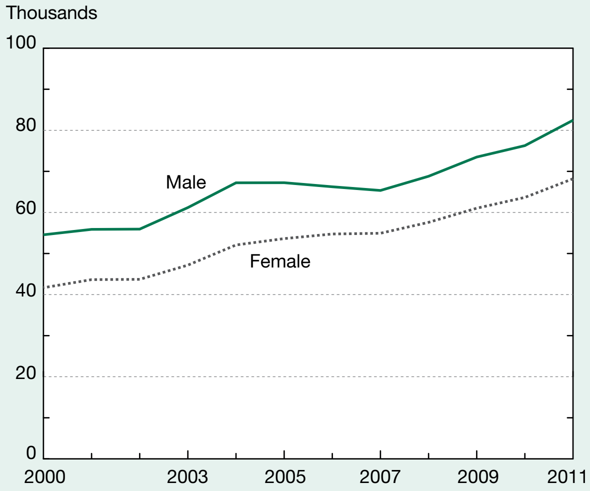
Nearly 1,800 PSM degrees were awarded in 2012. More than one in five of them were in biotechnology, and a similar proportion was in computer or information sciences. Men earned the majority of the PSM degrees awarded in chemistry, geosciences and geographic information systems, bioinformatics and computational biology, and mathematics and statistics. Women earned the majority of the degrees granted in medical-related sciences and environmental sciences and natural resources.

PSM programs have not yet been subject to a systematic, formal evaluation. However, according to the Outcomes for PSM Alumni: 2010/11 survey conducted by the Council of Graduate Schools (Bell and Allum 2011), more than 8 in 10 PSM program graduates were working in the summer of 2011, the vast majority of them in jobs closely related to their fields of study. More than half of those working full-time reported salaries of $50,000 or higher. Similar findings are reported by individual PSM programs that track student outcomes (Carpenter 2012).

Master's Degrees by Citizenship

Foreign students make up a much higher proportion of S&E master's degree recipients than of bachelor's or associate's degree recipients. In 2011, foreign students earned more than one-quarter of S&E master's degrees. Their degrees were heavily concentrated in computer sciences, economics, and engineering, where they received more than 4 out of 10 of all master's degrees awarded in 2011 (appendix table 2-30). Within engineering, students on temporary visas earned more than half of the master's degrees in electrical and chemical engineering.

Figure 2-22
S&E master's degrees, by sex of recipient: 2000–11



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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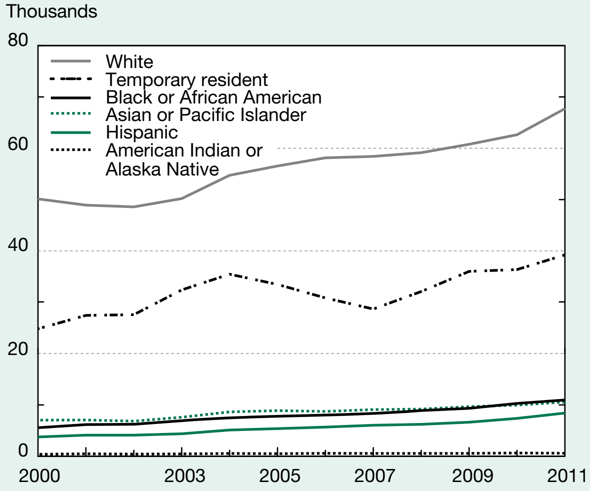
Figure 2-23
S&E master's degrees, by race, ethnicity, and citizenship of recipient: 2000–11



NOTES: Data on race and ethnicity include U.S. citizens and permanent residents. Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific islander, black or African American, and white refer to individuals who are not of Hispanic origin.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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The number of S&E master's degrees awarded to students on temporary visas reached its highest point in a decade in 2011 (39,000), after a sharp decline between 2004 and 2007. Most of the drop during this period was accounted for by decreasing numbers of temporary residents in the computer sciences and engineering fields, but in both fields numbers rebounded in both fields by about one-third in the following years.

S&E Doctoral Degrees

Doctoral education in the United States generates new knowledge important for the society as a whole and for U.S. competitiveness in a global knowledge-based economy. It prepares a new generation of researchers in academia, industry, and government, as well as a highly skilled workforce for other sectors of the economy.

The number of S&E doctorates (excluding those in other health sciences) conferred annually by U.S. universities increased steadily between 2002 and 2008, then decreased in 2009 and 2010.[39] The number rose by nearly 5% in 2011, to more than 38,000 (appendix table 2-31).[40] The growth in the number of S&E doctorates between 2000 and 2012 occurred among U.S. citizens and permanent residents as well as temporary residents. The largest increases were in engineering and the biological sciences (figure 2-24).

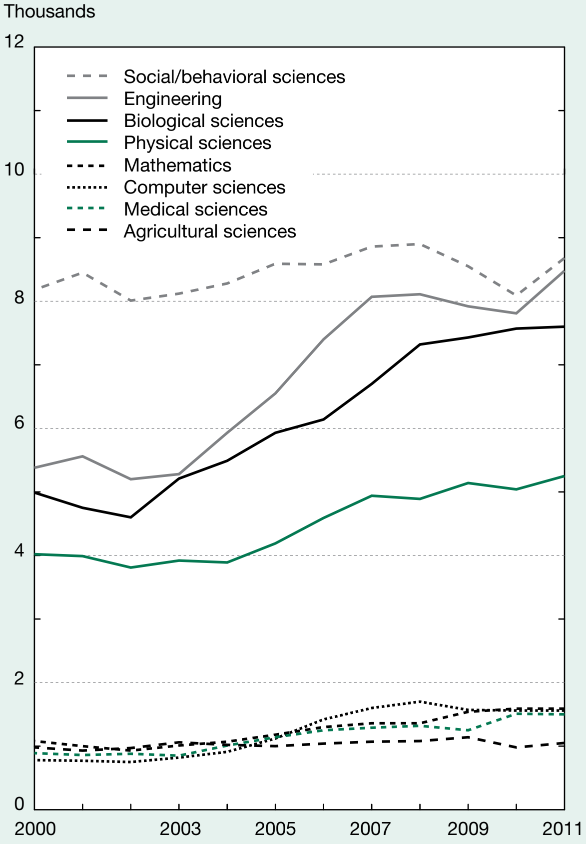
Time to Doctoral Degree Completion

The time required to earn a doctoral degree and the success rates of those entering doctoral programs are concerns for those pursuing a degree, the universities awarding the degree, and the agencies and organizations funding graduate study. Longer times to degree mean lost earnings and a higher risk of attrition. Time to degree (as measured by time from graduate school entry to doctorate receipt) increased through the mid-1990s but has since decreased in all S&E fields from 7.7 to 7.0 years (appendix table 2-32). The physical sciences and mathematics had the shortest time to degree, whereas the social sciences and medical and other health sciences had the longest.

Between 1997 and 2011, time to degree for doctorate recipients decreased in each of the Carnegie types of academic institutions awarding doctoral degrees (see sidebar, "Carnegie Classification of Academic Institutions"). Time to degree was shortest at research universities with very high research activity (6.9 years in 2011, down from 7.2 years in 1997). Doctorate recipients at medical schools also finished quickly (6.7 years in 2011). Time to degree was longer at universities that were less strongly oriented toward research (table 2-12).

The median time to degree varies somewhat by demographics, but these variations tend to reflect differences among broad fields of study. In 2011, across all doctorate recipients, women have a longer time to degree than men (7.9 versus 7.4 years, respectively) (NSF/NCSES 2012). However, these differences were very small or nonexistent when men and women were compared within broad fields.[41] Time to degree for men and women was similar in most broad S&E fields except for engineering, where it was slightly shorter for women (6.5 versus 6.9 for men). Within broad S&E fields, time to degree was longer for temporary visa holders than for U.S. citizens and permanent residents, and, in most broad fields, it was shorter for whites than for any other racial or ethnic group. In the life sciences, time to degree of Hispanic doctorate recipients was as short as that of whites (6.7).

Figure 2-24
S&E doctoral degrees earned in U.S. universities, by field: 2000–11



NOTES: Physical sciences include earth, atmospheric, and ocean sciences. Data differ from doctoral degree data in other tables and figures in this report that are based on the National Science Foundation Survey of Earned Doctorates and that refer to research doctorates only. Greatest differences are in psychology and medical sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov.

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Doctoral Degrees by Sex

Among U.S. citizens and permanent residents, the proportion of S&E doctoral degrees (excluding those in other health sciences; see endnote 39) earned by women grew from 43% in 2000 to 47% in 2011 (appendix table 2-31). During this decade, women made gains in most major fields, but considerable disparities continued in certain fields. In 2011, women earned half or more of doctorates in non-S&E fields, in most social and behavioral sciences except for economics, in the biological sciences, and in medical and other health sciences. They earned fewer than one-third of the doctorates awarded in physical sciences, mathematics and computer sciences, and engineering (appendix table 2-31). Although the percentages of degrees earned by women in physical sciences and engineering are low, they are higher than they were in 2000.

The number of S&E doctoral degrees earned by women grew faster than that earned by men. The number of U.S. citizen and permanent resident women earning doctorates in S&E increased from nearly 8,000 in 2000 to nearly 11,000 in 2011, while the number earned by men increased from about 10,000 to nearly 12,000 in the same time interval (appendix table 2-31). The increase in the number of S&E doctorates earned by women occurred in most major S&E fields. For example, the number of engineering doctorates earned by U.S. citizen and permanent resident women increased from approximately 500 in 2000 to 900 in 2011, biological sciences doctorates from 1,700 to 2,900, and physical sciences doctorates from 600 to nearly 900. A decrease in the number of doctorates earned by U.S. citizen and permanent resident men in the early years of the decade occurred in non-S&E fields and in many S&E fields. However, since 2005, the number of doctorates earned by men has increased in all major S&E fields except for agricultural sciences, and psychology.

Doctoral Degrees by Disability Status

In 2011, 3% of doctorate recipients reported having a disability. Compared with persons without disabilities, those with disabilities were less likely to earn doctorates in engineering fields (9% versus 17%) and more likely to earn doctorates in the social and behavioral sciences (21% versus 17%). Nearly one-third of the S&E doctorate recipients with disabilities reported a learning disability, 17% reported being blind or visually impaired, 13% reported a physical or orthopedic disability, 12% indicated being deaf or hard of hearing, 4% reported a vocal or speech disability, and 21% cited other or unspecified disabilities (NSF/NCSES 2013a).

Doctoral Degrees by Race and Ethnicity

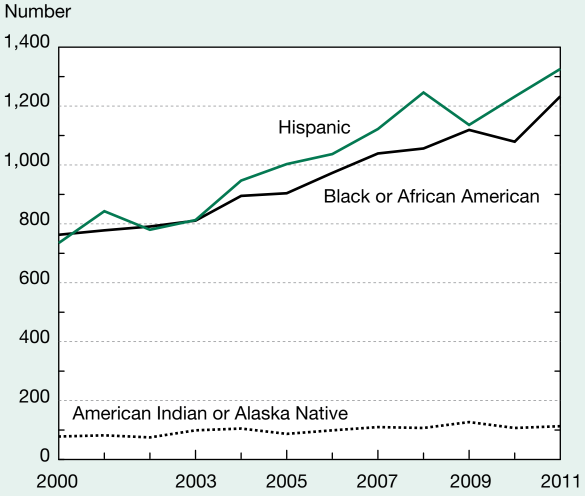
The number and proportion of doctoral degrees in S&E fields earned by underrepresented minorities increased between 2000 and 2011. In 2011, blacks earned 1,233 S&E doctorates, Hispanics earned 1,326, and American Indians and Alaska Natives earned 113—accounting for 8% of S&E

doctoral degrees (excluding doctorates in other health sciences; see endnote 39) earned that year, up from 6% in 2000 (appendix table 2-33).[42] Their share of the S&E doctorates earned by U.S. citizens and permanent residents rose from 9% to 12% in the same period. Gains by all groups contributed to this rise, although the number of S&E degrees earned by blacks and Hispanics rose considerably more than the number earned by American Indians and Alaska Natives (figure 2-25). Asian and Pacific Islander U.S. citizens and permanent residents earned 6% of all S&E doctorates in 2011, similar to 2000.

Although the number of S&E doctorates earned by white U.S. citizens and permanent residents increased between 2000 and 2011 (figure 2-26), the number of S&E doctorates awarded to minorities and temporary residents increased at a faster pace. As a result, the proportion of S&E doctoral degrees earned by white U.S. citizens and permanent residents decreased from 53% in 2000 to 43% in 2011 (appendix table 2-33).

Figure 2-25

S&E doctoral degrees earned by U.S. citizen and permanent resident underrepresented minorities, by race and ethnicity: 2000–11



NOTES: Data differ from doctoral degree data in other tables and figures in this report that are based on the National Science Foundation Survey of Earned Doctorates and that refer to research doctorates only. Greatest differences are in psychology and medical/other health sciences. S&E excludes other health sciences. Hispanic may be any race. American Indian or Alaska Native and black or African American refer to individuals who are not of Hispanic origin.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov. See appendix table 2-33.

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Table 2-12

Median number of years from entering graduate school to receipt of S&E doctorate, by 2010 Carnegie classification of doctorate-granting institution: 1997–2011

Year	All institutions	Research universities (very high research activity)	Research universities (high research activity)	Doctoral/ research universities	Medical schools and medical centers	Other/not classified
1997	7.7	7.2	8.2	9.7	7.7	8.2
1998	7.3	7.2	8.2	9.2	6.9	7.7
1999	7.2	7.2	7.9	9.0	6.7	7.7
2000	7.5	7.2	8.2	9.2	7.2	7.9
2001	7.2	7.2	8.2	9.7	6.9	7.7
2002	7.5	7.2	8.2	9.9	6.9	7.9
2003	7.6	7.2	8.2	9.7	6.9	8.7
2004	7.2	7.0	8.0	9.3	6.9	7.7
2005	7.3	7.2	7.9	9.3	7.0	7.9
2006	7.2	7.0	7.9	9.0	6.9	7.7
2007	7.0	6.9	7.7	8.9	6.9	7.7
2008	7.0	6.9	7.7	8.9	6.7	7.6
2009	7.0	6.9	7.7	9.2	6.8	7.7
2010	7.0	6.9	7.7	8.9	6.7	7.4
2011	7.0	6.9	7.7	8.7	6.7	7.7

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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Foreign S&E Doctorate Recipients

Temporary residents earned nearly 13,000 S&E doctorates in 2011, up from about 8,000 in 2000. Foreign students on temporary visas earned a larger proportion of doctoral degrees than master’s, bachelor’s, or associate’s degrees (appendix tables 2-33, 2-30, 2-23, and 2-22, respectively). The temporary residents’ share of S&E doctorates rose from 31% in 2000 to 36% in 2011. In some fields, these students earned even larger shares of doctoral degrees. In 2011, they earned half or more of doctoral degrees awarded in engineering, computer sciences, and economics. They earned considerably lower proportions of doctoral degrees in other S&E fields—for example, 27% in biological sciences, 26%

in medical sciences, 7% in psychology, and between 11% and 38% in most social sciences (except economics) (appendix table 2-33).

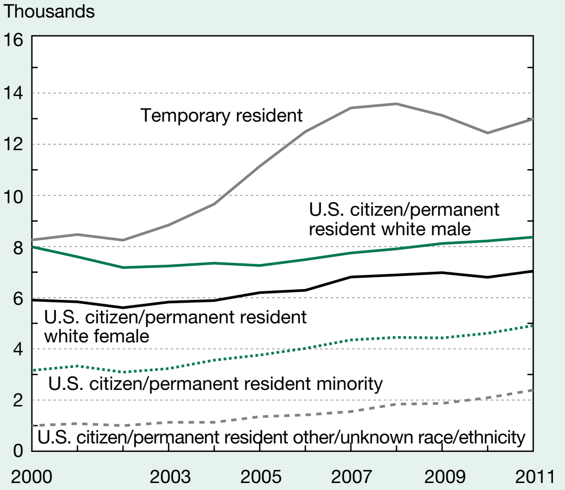
Countries and Economies of Origin

The top 10 countries and economies of origin of foreign S&E doctorate recipients (both permanent and temporary residents) together accounted for 68% of all foreign recipients of U.S. S&E doctoral degrees from 1991 to 2011 (table 2-13). Six out of those top 10 locations are in Asia.

Asia. From 1991 to 2011, students from four Asian countries and economies (China, India, South Korea, and Taiwan, in descending order) earned more than half of U.S. S&E doctoral degrees awarded to foreign students (131,000 of 236,000)—more than three times more than students from Europe (41,000). China accounted for almost half of these (63,000), followed by India (28,000), South Korea (22,000), and Taiwan (17,000). Most of these degrees were awarded in engineering, biological sciences, and physical sciences (table 2-14). About one in five of the doctorates awarded to South Korean and Taiwanese recipients in this period was in a non-S&E field.

Figure 2-26

S&E doctoral degrees, by sex, race, ethnicity, and citizenship: 2000–11



NOTES: Minority includes American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and Hispanic. Data differ from doctoral degree data in other tables and figures in this report that are based on the National Science Foundation Survey of Earned Doctorates and that refer to research doctorates only. Greatest differences are in psychology and medical/other health sciences. S&E excludes other health sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov. See appendix tables 2-31 and 2-33.

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The number of S&E doctorates earned by students from China declined in the late 1990s, increased through 2007, and dropped 16% in the following 3 years, but it rose 4% in 2011 (figure 2-27). Over the 20-year period, however, despite these fluctuations, the number of S&E doctorates earned by Chinese nationals more than doubled. The number of S&E doctorates earned by students from India also declined in the late 1990s, but it has increased almost every year since 2002; over the last two decades it nearly tripled. South Korea followed a similar trend but with a less dramatic increase. The number of S&E doctoral degrees earned by South Korean students also dipped in the late 1990s and then rose in the mid-2000s. In contrast, Taiwan experienced a substantially different trajectory. In 1991, its students earned more U.S. S&E doctoral degrees than those from India or South Korea.[43] However, as universities in Taiwan increased their capacity for advanced S&E education in the 1990s, the number of students from Taiwan earning S&E doctorates from U.S. universities declined. Since 2004, however, the number of Taiwanese doctorate recipients in the United States has been slowly going up again.

Europe. European students earned far fewer U.S. S&E doctorates than Asian students between 1991 and 2011, and they tended to focus less on engineering than did their Asian counterparts (tables 2-14 and 2-15). European countries whose students earned the largest number of U.S. S&E doctorates from 1991 to 2011 were Germany, Russia, the United Kingdom, Greece, Italy, Romania, and France, in that order. Trends in doctorate recipients from individual Western European countries vary (figure 2-28). The number of Central and Eastern European students earning S&E doctorates at U.S. universities quintupled between 1991 and 2011, to 553. Although their numbers almost reached the Western Europe total between 2005 and 2007, they have declined

Table 2-13

Foreign recipients of U.S. S&E doctorates, by country/economy of origin: 1991–2011

Country/economy	Number	Percent
All foreign recipients	235,582	100.0
Top 10 total	160,082	68.0
China	63,341	26.9
India	27,787	11.8
South Korea	22,400	9.5
Taiwan	16,997	7.2
Canada	7,511	3.2
Turkey	6,138	2.6
Thailand	4,232	1.8
Germany	3,985	1.7
Japan	3,974	1.7
Mexico	3,717	1.6
All others	75,500	32.0

NOTE: Foreign doctorate recipients include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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since then (figure 2-29). A higher proportion of doctorate recipients from Russia, Romania, and Greece than from the United Kingdom, France, Italy, and Germany earned their doctorates in S&E. Russian and Romanian doctorate recipients were more likely than those from Western European countries to earn their doctorates in mathematics and physical sciences, and Greeks were more likely to earn doctoral degrees in engineering (table 2-15).

The Americas. Despite the proximity of Canada and Mexico to the United States, the shares of U.S. S&E doctoral degrees awarded to residents of these countries were small compared with those awarded to students from Asia and Europe. The number of U.S. doctoral S&E degrees earned by students from Canada increased from about 320 in 1991 to nearly 500 in 2009, but it has declined in the last 2 years. The overall number of doctoral degree recipients from

Figure 2-27

U.S. S&E doctoral degree recipients, by selected Asian country/economy of origin: 1991–2011

NOTE: Degree recipients include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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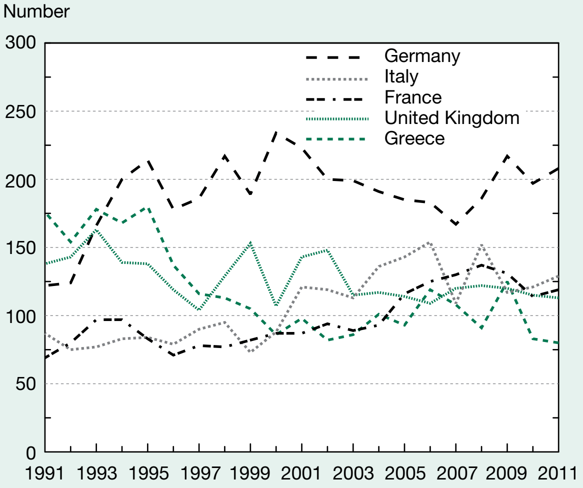
Figure 2-28

U.S. S&E doctoral degree recipients, by selected Western European country: 1991–2011



NOTE: Degree recipients include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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Table 2-14

Asian recipients of U.S. S&E doctorates, by field and country/economy of origin: 1991–2011

Field	Asia	China	India	South Korea	Taiwan
All fields	174,538	68,104	30,985	28,898	21,307
S&E	150,963	63,341	27,787	22,400	16,997
Engineering	54,831	20,823	12,144	8,779	7,294
Science	96,132	42,518	15,643	13,621	9,703
Agricultural sciences	5,296	1,804	727	831	630
Biological sciences	27,276	14,326	4,760	2,746	2,753
Computer sciences	8,400	3,312	2,346	1,017	855
Earth, atmospheric, and ocean sciences	3,063	1,737	324	377	286
Mathematics	7,356	4,068	782	1,017	639
Medical/other health sciences	5,226	1,342	1,232	654	936
Physical sciences	22,155	11,947	3,145	2,561	1,684
Psychology	2,213	485	320	462	350
Social sciences	15,147	3,497	2,007	3,956	1,570
Non-S&E	23,575	4,763	3,198	6,498	4,310

NOTES: Data include permanent and temporary residents. Asia includes Afghanistan, Armenia, Azerbaijan, Bangladesh, Bhutan, Brunei, Burma/Myanmar, Cambodia, China, Georgia, Hong Kong, India, Indonesia, Japan, Kazakhstan, Kyrgyzstan, Laos, Macau, Malaysia, Maldives, Mongolia, Nepal, Pakistan, Philippines, Singapore, South Korea, Spratly Islands, Sri Lanka, Taiwan, Tajikistan, Thailand, Turkmenistan, Uzbekistan, and Vietnam.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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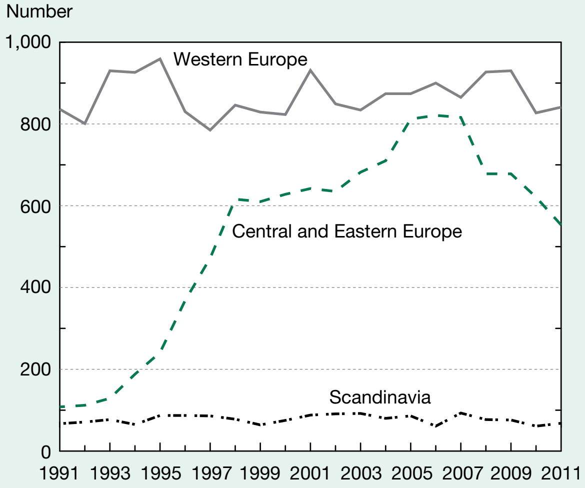
Figure 2-29
U.S. S&E doctoral degree recipients from Europe, by region: 1991–2011



NOTES: Degree recipients include permanent and temporary residents. Western Europe includes Andorra, Austria, Belgium, France, Germany, Greece, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Portugal, San Marino, Spain, Switzerland, and United Kingdom. Central and Eastern Europe includes Albania, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Kosovo, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, and Ukraine. Scandinavia includes Denmark, Finland, Iceland, Norway, and Sweden.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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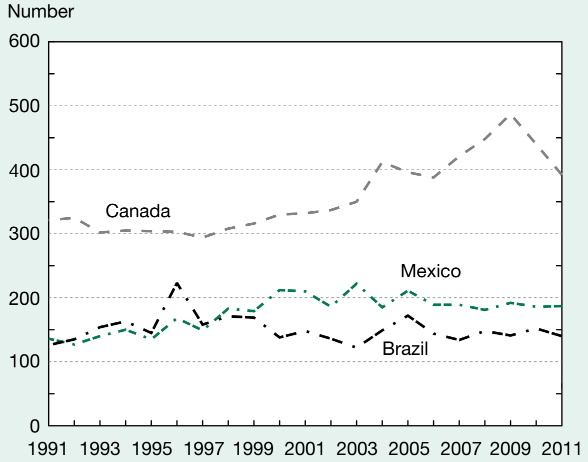
Mexico and Brazil peaked earlier (2003 and 1996, respectively) and declined in recent years (figure 2-30).

A higher proportion of Mexican and Brazilian students earned U.S. doctorates in S&E fields than the comparable proportion for Canadians (table 2-16). In particular, higher proportions of Mexican and Brazilian students than Canadian students received U.S. doctoral degrees in engineering and agricultural sciences.

Figure 2-30
U.S. S&E doctoral degree recipients from Canada, Mexico, and Brazil: 1991–2011



NOTE: Degree recipients include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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Table 2-15
European recipients of U.S. S&E doctorates, by field and region/country of origin: 1991–2011

Field	All European countries	Germany	Russia	United Kingdom	Greece	Italy	Romania	France
All fields	40,529	5,442	3,505	4,035	2,821	2,963	2,414	2,767
S&E	31,479	3,986	3,115	2,669	2,479	2,245	2,144	2,056
Engineering	6,142	610	464	281	888	465	346	646
Science	25,337	3,376	2,651	2,388	1,591	1,780	1,798	1,410
Agricultural sciences	827	113	27	68	61	60	23	62
Biological sciences	4,912	700	445	548	264	229	264	297
Computer sciences	1,803	238	141	66	249	93	263	78
Earth, atmospheric, and ocean sciences	1,154	189	113	153	40	90	43	91
Mathematics	3,015	300	407	178	168	217	398	83
Medical/other health sciences	752	105	16	128	62	33	21	36
Physical sciences	6,190	749	1,088	462	375	384	554	412
Psychology	1,174	228	54	216	56	66	37	37
Social sciences	5,510	754	360	569	316	608	195	314
Non-S&E	9,050	1,456	390	1,366	342	718	270	711

NOTE: Data include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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The Middle East. Between 1991 and 2011, Middle Eastern students earned far fewer U.S. S&E doctorates (about 20,000) than did students from Asia, Europe, or the Americas (tables 2-14, 2-15, and 2-16). Students from Turkey earned the largest number of U.S. S&E doctorates in this region, followed by those from Iran and Jordan. A larger proportion of doctorate recipients from Iran earned their doctorates in engineering (55%) than recipients from any other country above. More than one-third of doctorate recipients from Turkey and Jordan earned their doctorates in engineering, a proportion similar to that from Asian countries.

International S&E Higher Education

In the 1990s, many countries expanded their higher education systems and increased access to higher education. At the same time, flows of students worldwide increased. More recently, a number of countries have adopted policies to encourage the return of students who studied abroad, to attract foreign students, or both. As the world becomes more interconnected, students who enroll in tertiary (post-high school) institutions outside their own countries have opportunities to expand their knowledge of other societies and languages and improve their employability in globalized labor markets.

Higher Education Expenditures

Increasingly, governments around the world have come to regard movement toward a knowledge-based economy as key to economic progress. Realizing that this requires a well-trained workforce, they have invested in upgrading and expanding their higher education systems and broadening participation in them. In most instances, government spending underwrites these initiatives. Recent investments by several governments to send large numbers of their students to study abroad are a strategy for workforce and economic development. Examples include the Brazilian Scientific Mobility Program (also known as "Science without Borders"), launched officially in July 2011, whose goal is to enable 75,000 Brazilian students to study in foreign countries (Knobel 2012). Similarly, the government of Saudi Arabia has invested considerably in a scholarship program launched in 2005 that has supported study abroad for more than 100,000 Saudi students throughout the world, at an estimated cost of at least $5 billion since the program's inception (Knickmeyer 2012).

One indicator of the importance of higher education is the percentage of a nation's resources devoted to it, as measured by the ratio of expenditures on tertiary education to gross domestic product (GDP). Between 2005 and 2009, this indicator declined for the United States and Canada, even though

Table 2-16
North American, South American, and Middle Eastern recipients of U.S. S&E doctorates, by field and region/country of origin: 1991–2011

	North and South America[a]				Middle East[b]			
Field	All countries	Canada	Mexico	Brazil	All countries	Turkey	Iran	Jordan
All fields	28,759	11,329	4,458	3,904	19,660	7,257	3,290	2,012
S&E	21,634	7,511	3,717	3,168	16,169	6,138	3,079	1,737
Engineering	4,331	1,098	866	750	7,118	2,728	1,800	783
Science	17,303	6,413	2,851	2,418	9,051	3,410	1,279	954
Agricultural sciences	2,037	263	578	422	627	256	68	84
Biological sciences	4,114	1,614	593	543	1,603	511	300	173
Computer sciences	733	253	112	174	924	348	120	91
Earth/atmospheric/ocean sciences	780	254	140	133	264	109	29	14
Mathematics	1,058	342	204	164	741	299	138	83
Medical/other health sciences	1,030	556	98	172	563	55	66	148
Physical sciences	2,058	903	315	162	1,482	592	322	187
Psychology	1,270	897	84	80	442	123	38	8
Social sciences	4,223	1,331	727	568	2,405	1,117	198	166
Non-S&E	7,125	3,818	741	736	3,491	1,119	211	275

[a] North America includes Bermuda, Canada, and Mexico; South America includes Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela.

[b] Middle East includes Bahrain, Gaza Strip, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, West Bank, and Yemen.

NOTE: Data include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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of all OECD countries, these countries and South Korea spent the highest percentage of GDP on higher education. Between 1995 and 2005, U.S. expenditures on tertiary education as a percentage of GDP were about double the OECD average; by 2009, this proportion had decreased to about 60% above the OECD average. Between 2005 and 2009, expenditures on tertiary education as a percentage of GDP rose in most other OECD countries; they remained stable in the United Kingdom (appendix table 2-34). As a result of the global recession and fiscal crisis, some European governments have cut investments on higher education. The effects of these cuts are not yet evident in the most recent data.

Higher education funding data are not always comparable across different nations. They can vary between countries for reasons unrelated to actual expenditures, such as differences in measurement, prevalence of public versus private institutions,[44] types and levels of government funding included, and types and levels of education included.

Educational Attainment

Higher education in the United States expanded greatly after World War II. As a result, the U.S. population led the world in educational attainment for several decades. Because of this, the United States offered clear advantages for firms whose work would benefit from the availability of a highly educated workforce. In the 1990s, however, many countries in Europe and Asia began to expand their higher education systems. Some of them have now surpassed the United States in the attainment of degrees from tertiary-type A (see "Glossary") and advanced research programs in their younger cohorts. Over time, the expansion of higher education elsewhere has substantially diminished the U.S. educational advantage and its related economic advantages.

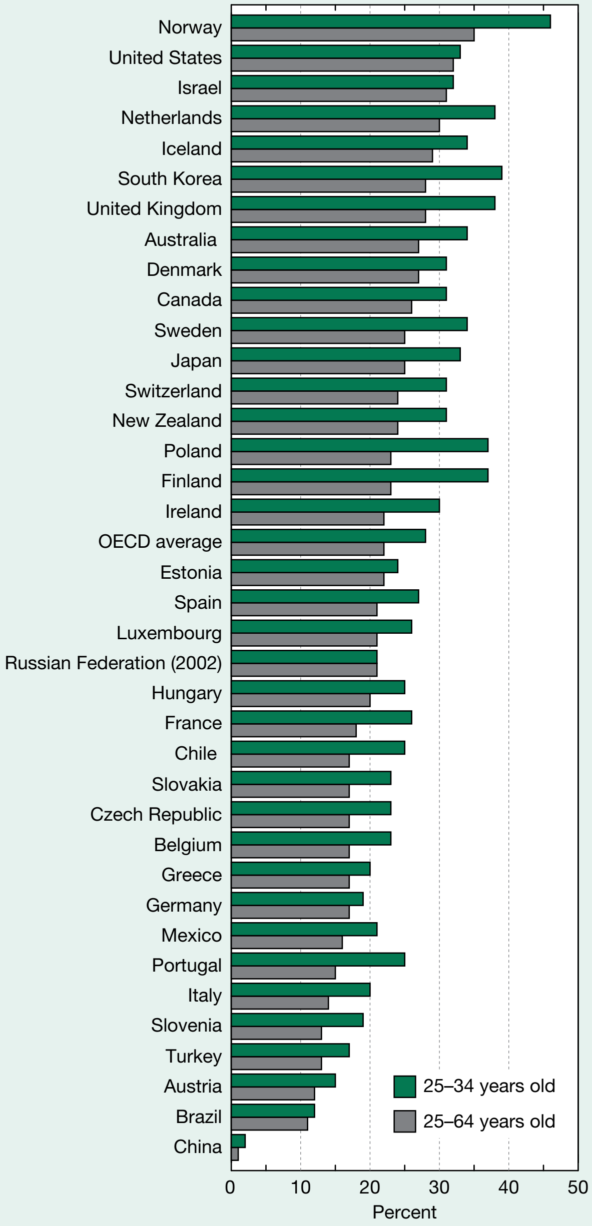
Although the United States continues to be among those countries with the highest percentage of the population ages 25–64 with a bachelor's degree or higher, several other countries have surpassed the United States in the percentage of the younger population (ages 25–34) with a bachelor's degree or higher (figure 2-31; appendix table 2-35).

China has lower tertiary education attainment than all OECD countries. China's tertiary attainment rates are also lower than those of Brazil and Russia, the two non-OECD, G20 countries for which data are available. As in most OECD countries, attainment among the younger population (ages 25–34) in China is higher than in the older population.[45]

First University Degrees in S&E Fields

Almost 17 million students worldwide earned first university degrees in 2010, with about 5.5 million of these in S&E fields (appendix table 2-36). These worldwide totals include only countries for which relatively recent data are available (primarily countries in Asia, Europe, and the Americas) and are therefore underestimates. Asian universities accounted for nearly 2.5 million of the world's S&E first university degrees in 2010, close to half of them in engineering. Students

Figure 2-31
Attainment of tertiary-type A and advanced research programs, by country and age group: 2010



OECD = Organisation for Economic Co-operation and Development.

NOTES: International Standard Classification of Education (ISCED) tertiary-type A programs, ISCED 5A, are largely theory-based and designed to provide sufficient qualifications for entry to advanced research programs and professions with high skill requirements such as medicine, dentistry, or architecture and have a minimum duration of 3 years' full-time equivalent, although they typically last 4 years or longer. In the United States, they correspond to bachelor's and master's degrees. Advanced research programs are tertiary programs leading directly to award of an advanced research qualification (e.g., doctorate).

SOURCE: OECD, *Education at a Glance 2012: OECD Indicators* (2012).

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across Europe (including Eastern Europe and Russia) earned more than 1.5 million first university S&E degrees (nearly 40% of them in engineering), and students in North America earned more than 700,000 such degrees in 2010 (22% in engineering).

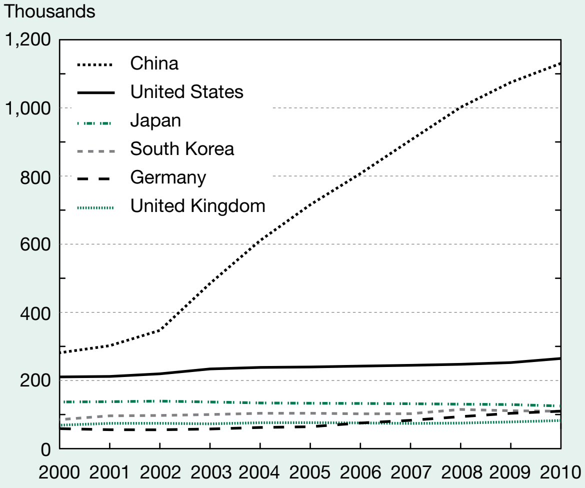
In several countries and economies around the world, the proportion of first university degrees in S&E fields was higher than in the United States. Half or more of all first university degrees in Japan and China were in S&E fields, compared with about one-third in the United States. National differences in engineering degrees largely account for overall differences in the proportion of S&E degrees, given that the disparity was especially large in engineering. However, differences in the taxonomies and quality of engineering programs and level of reporting detail across countries make comparisons problematic. For example, according to Wadhwa et al. (2007), in China in the mid-2000s, the term "engineer" had no standard definition and did not translate well into different dialects, so the reports sent to the Ministry of Education from different Chinese provinces did not count degrees consistently. In the late 1990s, the Chinese government implemented top-down policy changes to increase enrollment in engineering. However, the total number of technical schools and the corresponding teachers and staff declined, which meant that degree awards were achieved by increasing class sizes and student-to-teacher ratios.

China has traditionally awarded a large proportion of its first university degrees in engineering, although the percentage declined from 43% in 2000 to 31% in 2011 (appendix table 2-37). Other places with a high proportion of engineering degrees are Singapore, Iran, South Korea, and Taiwan (appendix table 2-36). In the United States, about 5% of all bachelor's degrees are in engineering. About 11% of all bachelor's degrees awarded in the United States and worldwide are in natural sciences (physical, biological, computer, and agricultural sciences, as well as mathematics).

The number of S&E first university degrees awarded in China, Taiwan, Turkey, Germany, and Poland more than doubled or nearly doubled between 2000 and 2010. During this period, S&E first university degrees awarded in the United States and several other countries (i.e., Australia, Italy, the United Kingdom, Canada, and South Korea) increased between 23% and 56%, whereas those awarded in France, Japan, and Spain declined by 14%, 9%, and 4%, respectively (appendix table 2-37).

Natural sciences and engineering degrees account for most of the increase in S&E first university degrees in China. The number of natural sciences and engineering first university degrees in China grew by more than 300% between 2000 and 2010 (figure 2-32). The number awarded in Germany grew by nearly 90%, and the number awarded in South Korea, the United States, and the United Kingdom increased between 20% and 29%; in Japan, it declined by 9%.

Figure 2-32
First university natural sciences and engineering degrees, by selected country: 2000–10



NOTE: Natural sciences include agricultural sciences; biological sciences; computer sciences; earth, atmospheric, and ocean sciences; and mathematics.

SOURCES: China—National Bureau of Statistics of China, China Statistical Yearbook, annual series (Beijing) various years; Germany and South Korea—Organisation for Economic Co-operation and Development, Education Online Database, http://stats.oecd.org/Index.aspx; Japan—Government of Japan, Ministry of Education, Culture, Sports,Science and Technology, Higher Education Bureau, Monbusho Survey of Education; United Kingdom—Higher Education Statistics Agency; and United States—National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov.

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In 1999, 29 European countries, through the Bologna Declaration, initiated a system of reforms in higher education throughout Europe. The goal of the Bologna Process was to harmonize certain aspects of higher education within participating countries so that degrees were comparable; credits were transferable; and students, teachers, and researchers could move freely from institution to institution across national borders. Ten years later, the European Higher Education Area was launched, and higher education reform in Europe was extended to 47 participating countries. In recent years, countries have made considerable changes: they have modified higher education structures by implementing three degree cycles (bachelor's, master's, and doctorate), developed quality assurance systems, and established mechanisms to facilitate mobility (EACEA 2012). In 2009, for the first time, the Bologna Process established a quantitative target for student mobility. By 2020, at least 20% of those graduating in the Area should have spent time studying abroad. For details on student mobility in Europe, see sidebar, "Mapping Mobility in European Higher Education."

S&E First University Degrees by Sex

Women earned half or more of first university degrees in S&E in many countries around the world in 2010, including the United States and a number of smaller countries. Most large countries in Europe are not far behind, with more than 40% of first university S&E degrees earned by women. In the Middle East, women earned nearly half or more of the S&E first university degrees in most countries in the region, except for Iraq, Turkey, Iran, and Jordan. In several Asian and African countries, women generally earn about one-third or fewer of the first university degrees awarded in S&E fields (appendix table 2-38).

In Canada, Japan, the United States, and many smaller countries, more than half of the S&E first university degrees earned by women were in the social and behavioral sciences. In South Korea and Singapore, nearly half of the S&E first university degrees earned by women were in engineering, a much higher proportion than in the United States or in any countries in Europe.

Mapping Mobility in European Higher Education

A 2011 study produced for the European Commission's Directorate-General for Education and Culture examines degree mobility and credit mobility into, out of, and between 32 European countries (the European Union [EU]-27, European Free Trade Association [EFTA]-4, and Turkey, also called the "Europe 32 [EU 32] area") (Teichler et al. 2011).

The report distinguishes between two types of student mobility. Degree or diploma mobility includes students who travel abroad to obtain a degree, whereas credit mobility refers to students who study abroad on a more temporary basis. Data for degree mobility come from United Nations Educational, Scientific and Cultural Organization, Organisation for Economic Co-operation and Development, and Eurostat data. For credit mobility, however, there is no comprehensive data set, so the study examines data on participation in ERASMUS, an EU study-abroad program that enables students at higher education institutions in Europe to study in another participating country for a period between 3 months and 1 year.* Although ERASMUS is one of the largest programs of its kind in this region, it supports only a portion of total credit mobility in Europe, so its figures are an underestimation.

Average degree mobility levels in the EU 32 region are high by global standards and increased considerably between 1998–99 and 2006–07. In 2006–07, 1.5 million foreign students, representing 51% of the global student market, were enrolled in a degree program in the EU 32. In addition, despite growing competition worldwide, EU 32 countries have increased their global share of foreign students since 1998–99. The strong growth in foreign enrollment was fueled primarily by students from non-EU 32 nations. These students accounted for 58% of all foreign students in 2006–07, compared with 38% of nationals from EU 32 countries (in the case of 4% of foreign students, the nationality was unknown).

Degree mobility levels differed considerably across countries. Almost two-thirds of all foreign students pursuing a degree in the EU 32 zone were enrolled in one of three countries: the United Kingdom, Germany, and France. In all other countries of the EU 32, regional mobility levels are considerably lower. The proportion of EU 32 students in a degree program in a foreign country grew by nearly 40% between 1998–99 and 2006–07, but growth was considerably lower than that of foreign nationals studying in the EU 32 zone.

Large differences exist between countries. At one extreme, in Cyprus, the majority of citizens are enrolled abroad (1,380 abroad for every 1,000 at home); at the other, in the United Kingdom, studying in a foreign country is rare (12 abroad for every 1,000 in the United Kingdom). The vast majority of students from the EU 32 who are pursuing a degree in another country choose a country in the same region.

With regard to credit mobility, according to ERASMUS statistics, the number of students embarking in a study-abroad program more than doubled in the 11-year period between 1998–99 and 2008–09, to nearly 200,000. Despite this growth, the number of students participating in ERASMUS represents a very small share (less than 1%) of EU 32 students.

Spain, Finland, Malta, Poland, Portugal, and Slovakia are more attractive as study-abroad destinations than for degree-type studies. Compared to the other EU 32 countries in 2006–07, these countries hosted more ERASMUS students than foreign degree students. Although the United Kingdom has a large number of college students, it has one of the lowest numbers of study-abroad students.

In the case of both degree and credit mobility, in 2008–09, 21 out of the 32 countries were either net exporters or net importers. Eastern European countries tended to be net exporters (with the exception of the Czech Republic and Hungary), and countries from Western and Northern Europe tended to be net importers. Ten countries were net importers of degree-seeking students but net exporters of study-abroad students. These countries include Germany, France, the Czech Republic, and Hungary.

Students in the social sciences, business, and law; engineering; and humanities and arts more often embarked on ERASMUS study-abroad programs than students in mathematics, computing, sciences, agriculture, and teacher training and education science.†

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* ERASMUS also provides opportunities for student placements in enterprises and for university staff teaching and training, and it also funds cooperation projects between higher education institutions across Europe.

† The data do not allow comparisons by degree level.

Global Comparison of S&E Doctoral Degrees

More than 200,000 S&E doctoral degrees were earned worldwide in 2010.[46] The United States awarded the largest number of S&E doctoral degrees of any country (about 33,000), followed by China (about 31,000), Russia (almost 16,000), Germany (about 12,000), and the United Kingdom (about 11,000) (appendix table 2-39). About 58,000 S&E doctoral degrees were earned in the European Union (EU; see "Glossary" for member countries).

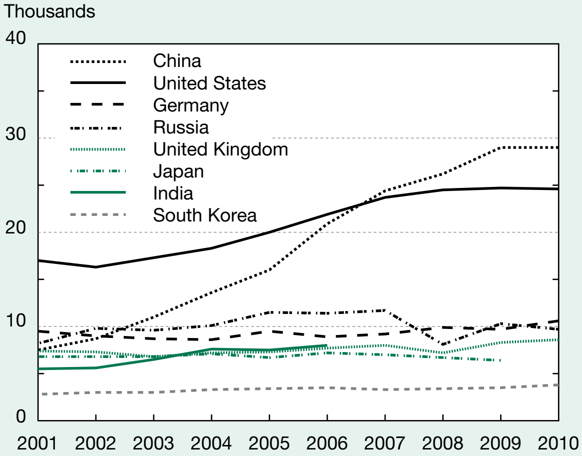
Women earned 41% of S&E doctoral degrees awarded in the United States in 2010, about the same percentage earned by women in Australia, Canada, the EU, and Mexico (appendix table 2-40). In the United States, women earned nearly half of the S&E doctoral degrees awarded to U.S. citizens and permanent residents in 2010 (appendix table 2-31). Women earned close to half of S&E doctoral degrees in Portugal and Italy but less than one-quarter of those in the Netherlands, South Korea, and Taiwan (appendix table 2-40).

The number of S&E doctoral degrees awarded in China rose steeply between 2000 and 2009 and leveled off in 2010. Although the rise was steeper in China, the trend was similar to the recent trend in doctoral production in the United States (appendix tables 2-41 and 2-42).

In 2007, China surpassed the United States as the world's largest producer of natural sciences and engineering doctoral degrees (figure 2-33). In the United States, as well as in France, Germany, Italy, Spain, Switzerland, and the United Kingdom, the largest numbers of S&E doctoral degrees were awarded in the physical and biological sciences (appendix table 2-41).

In Asia, China has been the largest producer of S&E doctoral degrees since 2000 (appendix table 2-42). As China's capacity for advanced S&E education increased, the number of S&E doctorates awarded rose from about 4,000 in 1996 to more than 31,000 in 2010, a substantially faster rate of growth than that of the number of doctorates earned by Chinese citizens in the United States during the same period (figure 2-34). In the mid-1990s the number of "homegrown" Chinese doctorate recipients and the number of doctorate recipients of Chinese origin with U.S. degrees were very similar, but since then the gap has grown considerably because of the large increase of doctorates awarded in China. In 2007, the Chinese Ministry of Education announced that China would begin to limit admissions to doctoral programs and would focus more on quality of graduates (Mooney 2007). The number of S&E doctorates awarded in India, South Korea, and Taiwan also increased from 1996 to 2010, but at a lower rate; in Japan the numbers rose consistently through 2006 but declined in the following years. In China, Japan, South Korea, and Taiwan, more than half of S&E doctorates were awarded in engineering. In India, close to three-quarters of the S&E doctorates were awarded in the physical and biological sciences (appendix table 2-42).

Figure 2-33
Natural sciences and engineering doctoral degrees, by selected country: 2001–10



NOTES: Natural sciences and engineering include biological, physical, earth, atmospheric, ocean, and agricultural sciences; computer sciences; mathematics; and engineering. Data for India are not available for 2007–10; data for Japan are not available for 2010.

SOURCES: China—National Bureau of Statistics of China; India—Department of Science and Technology; Japan—Government of Japan, Ministry of Education, Culture, Sports, Science and Technology, Higher Education Bureau, Monbusho Survey of Education; Russia—Institute for Statistical Studies and Economics of Knowledge/National Research University, Higher School of Economics; Germany and South Korea—Organisation for Economic Co-operation and Development, Education Online database, http://www.oecd.org/education/database/; United Kingdom—Higher Education Statistics Agency; and Organisation for Economic Co-operation and Development, Education Online database, http://stats.oecd. org/Index.aspx; United States—National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov.

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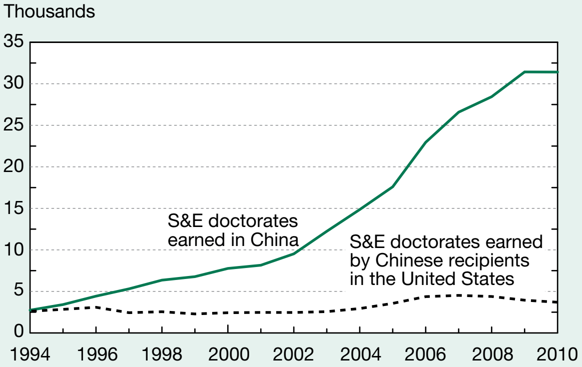
Figure 2-34
S&E doctoral degrees earned by Chinese students at home universities and U.S. universities: 1994–2010



NOTE: Degree recipients in the United States include permanent and temporary residents.

SOURCES: China—National Research Center for Science and Technology for Development and Education Statistics Yearbook of China (various years); United States—National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of the Survey of Earned Doctorates, 2011.

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Global Student Mobility

Students have become more internationally mobile in the past two decades, and countries are increasingly competing for them. According to data from UNESCO, the number of internationally mobile students nearly doubled between 2000 and 2010, to 3.6 million (UNESCO 2011).[47] In general, students migrate from developing countries to the more developed countries and from Europe and Asia to the United States. However, a few countries have emerged as regional hubs in their geographic regions—for example, Australia, China, and South Korea for East Asia and South Africa for sub-Saharan Africa (UNESCO 2009). In addition, several countries have set targets for increasing the numbers of international students they host; among these are Jordan (which plans to host 100,000 students by 2020), Singapore (150,000 by 2015), Japan (300,000 by 2025), and China (500,000 by 2020) (Bhandari and Belyavina 2012).

Some students migrate temporarily for education, whereas others remain abroad permanently after completing their studies. Some factors influencing the decision to seek a degree abroad include the policies of the countries of origin regarding sponsoring their citizens' study abroad, the tuition fee policies of the countries of destination, the financial support the countries of destination offer to international students, the cost of living and exchange rates that affect the cost of international education, and the perceived value of obtaining a foreign credential. The long-term return from international education also depends on how international degrees are recognized by the labor market in the country of origin (OECD 2010). For host countries, enrolling international students can help raise revenues from higher education and can also be part of a larger strategy to attract highly skilled workers, in particular as demographic changes in many developed countries cause their own populations of college-age students to decrease (OECD 2012) (appendix table 2-43).[48]

In recent years, many countries have expanded their provision of transnational education. One growing trend is the establishment of branch campuses: offshore programs established by higher education institutions in foreign countries. Branch campuses give students the opportunity to earn degrees from foreign universities without leaving their home countries. According to research by the Observatory on Borderless Higher Education, by the end of 2011, 200 degree-awarding international branch campuses were operating worldwide, and 37 new ones were planning to open in 2012 and 2013 (Lawton and Katsomitros 2012). Collaborative programs, such as international joint and dual-degree programs, are another trend in transnational education. In these programs, students study at two or more institutions; after successfully completing the requirements, they receive a separate diploma from each institution in dual-degree programs or a single diploma representing both institutions in joint degree programs (CGS 2010). The most common fields for dual degrees at the master's level are business, engineering, and the social sciences; at the doctoral level, engineering and physical sciences predominate (for additional details, see sidebar, "Transnational Higher Education," in NSB 2012).

More internationally mobile students (both undergraduate and graduate) go to the United States than to any other country (figure 2-35). Other top destinations for international students include the United Kingdom (11%), Australia (7%), France (7%), and Germany (6%). Together with the United States, these countries receive about half of all internationally mobile students worldwide.

Although the United States remains the destination for the largest number of internationally mobile students

Figure 2-35
Internationally mobile students enrolled in tertiary education, by selected country: 2010

NOTES: Data are based on the number of students who have crossed a national border and moved to another country with the objective of studying (i.e., mobile students). Data for Canada and the Russian Federation correspond to 2009. Data for the Netherlands and Germany exclude advanced research programs (e.g., doctorate). Data for Spain exclude advanced research programs and tertiary-type B programs (e.g., associate's).

SOURCE: UNESCO Institute for Statistics, special tabulations (2013).

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worldwide, its share in all fields has declined from 25% in 2000 to 19% in 2010 (UNESCO 2011). Between 2005 and 2010, the U.S. share in the natural sciences and engineering declined as well, but an increase in international students coming to the United States to study social and behavioral sciences kept the overall S&E share stable (table 2-17).

In the United States, international students are a small proportion (about 3%) of students enrolled in higher education (including both undergraduate and graduate levels); this proportion is higher at the graduate level. In other countries, the proportion of international students is much higher. Australia, with a much smaller higher education system than the United States, has a higher percentage (21%) of international students but a lower share (7%) of international students worldwide. Other countries with relatively high percentages of international higher education students in their higher education systems include the United Kingdom (16%), Austria (15%), Switzerland (15%), and New Zealand (14%).[49] In Switzerland and the United Kingdom, more than 4 out of 10 doctoral students are international students. A number of other countries, including New Zealand, Australia, the United States, Ireland, Sweden, and Canada, have relatively high percentages (more than 20%) of doctoral students who are internationally mobile (OECD 2012).

Since the late 1990s, the United Kingdom has been actively working to improve its position in international education, both by recruiting foreign students to study in the country and by expanding its provision of transnational education (British Council 2013; UK Council for International Student Affairs 2013). Between 1994 and 2010, foreign student enrollment in S&E fields in the United Kingdom increased, especially at the graduate level, with increasing flows of students from China and India (appendix table 2-44). The overall pattern of top countries is similar to that of the United States. In 2010, foreign students made up 48% of all graduate students studying S&E in the United Kingdom (an increase from 29% in the mid-1990s). Foreign students accounted for 60% of graduate students in mathematics and computer sciences, as well as in engineering. Students from China and India accounted for most of the increase, but the number of graduate students from Nigeria, Pakistan, the United States, France, Ireland, and Germany also increased considerably. At the undergraduate level, the overall percentage of foreign students in S&E did not increase as much during this period. As a result of recent stricter student visa regulations that apply to those from non-EU countries, in the last year, foreign enrollment declined at the graduate level, mainly due to a decline in the number of students from India and Pakistan. The declines were larger in mathematics and computer sciences and in engineering (appendix table 2-44).

Japan has increased its enrollment of foreign students in recent years (both in S&E and in all fields) and in 2008 announced plans to triple foreign enrollment in 12 years (McNeil 2008, 2010). Nonetheless, growth has slowed considerably in the last 2 years (appendix table 2-45; appendix table 2-41 in NSB 2012), perhaps caused in part by the March 2011 earthquake and tsunami (McNeil 2012). In 2012, slightly more than 70,000 foreign students were enrolled in S&E programs in Japanese universities, similar to 2010, and up from 57,000 in 2004. Unlike in the United Kingdom, foreign S&E student enrollment in Japan is concentrated at the undergraduate level, accounting for more than two-thirds of all foreign S&E students. Foreign nationals accounted for 3% of undergraduate and 17% of graduate

Table 2-17

Internationally mobile students in selected OECD countries and the United States: 2005 and 2010

			S&E					
	All fields		Total		Natural sciences and engineering		Social and behavioral sciences	
Host location	2005	2010	2005	2010	2005	2010	2005	2010
Worldwide	2,814,917	3,645,622	NA	NA	NA	NA	NA	NA
OECD countries[a]	2,128,579	2,574,710	800,052	995,295	598,416	746,718	201,635	248,577
United States	590,158	684,807	242,358	301,447	202,516	245,937	39,842	55,510
United States/OECD (%)[a]	27.7	26.6	30.3	30.3	33.8	32.9	19.8	22.3
United States/ worldwide (%)	21.0	18.8	NA	NA	NA	NA	NA	NA

NA = not available.

OECD = Organisation for Economic Co-operation and Development.

[a] OECD countries include those where data on internationally mobile students by field of study were available: Austria, Australia, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Japan, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

NOTE: Internationally mobile students are students who have crossed a national border and moved to another country with the objective of studying (i.e., mobile students).

SOURCE: UNESCO Institute for Statistics, special tabulations (2013).

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S&E students in Japan. The vast majority of the foreign students were from Asian countries. In 2012, Chinese students accounted for 70% of the foreign S&E undergraduate students and 59% of the foreign S&E graduate students in Japan. South Koreans were 18% of the foreign undergraduates and 9% of the foreign graduate students. Indonesia, Vietnam, Malaysia, Thailand, Mongolia, and Nepal were among the top 10 countries of origin for both undergraduates and graduate students (appendix table 2-45).

Foreign students constitute an increasing share of enrollment in Canadian universities at the undergraduate level. In 2010, foreign S&E students accounted for about 7% of undergraduate S&E enrollment in Canada, up from 5% in 2000. At the graduate level, the proportion of foreign students in S&E fields was stable during that period (19%). In 2010, at both the undergraduate and graduate levels, the highest percentages of foreign S&E students were in mathematics and computer sciences and in engineering. At the undergraduate level, China was the top country of origin of foreign S&E students in Canada, accounting for 13% of foreign undergraduate students, followed by France and the United States (11% each). At the graduate level, the top country of origin of foreign S&E students was France (13%), followed by Iran and China (11% each) (appendix table 2-46).

Although the United States hosts the largest number of international students worldwide, U.S. students constitute a relatively small share of foreign students worldwide. About 57,000 U.S. students (in all fields) were reported as foreign students by OECD and OECD-partner countries in 2010, far fewer than the number of foreign students from China, India, South Korea, Germany, Turkey, or France. The main destinations of U.S. students were the United Kingdom (15,600), Canada (9,100), Germany (3,900), France (3,400), New Zealand (3,200), and Australia (3,000)—mostly English-speaking OECD countries (OECD 2012).

Nearly 275,000 U.S. university students enrolled in study-abroad programs in the 2010–11 academic year (credit mobility), a 1% increase from the preceding year but a 78% rise from 2000–01 (IIE 2012). Nearly 40% were enrolled in programs during the summer term; more than one-third enrolled in programs lasting one semester, 13% in short-term programs lasting up to 8 weeks, 4% for the academic or the calendar year, and the rest for one or two quarters or a month. About 9% were master's and 1% were doctoral students; the rest were undergraduates, primarily juniors or seniors. Nearly two-thirds of the U.S. students studying abroad were women and more than three-quarters were white. More than one-third were studying in S&E fields: 23% in social sciences, 8% in physical or life sciences, 4% in engineering, 2% in mathematics or computer sciences, and 1% in agricultural sciences; these proportions have been stable since 2000–01. The leading destinations for study-abroad programs in the 2010–11 academic year were the United Kingdom, Italy, and Spain, followed by France and China.

According to a recent study conducted by IIE and Project Atlas, more than 43,000 U.S. students are enrolled in academic degree programs in the 13 countries represented (degree mobility). Most students were enrolled in master's degree programs (44%), followed by students in bachelor's degree programs (39%) and doctoral programs (19%). Almost three-quarters of them studied in Anglophone countries; the top destination was the United Kingdom. Humanities, social sciences, and business and management were the most popular broad fields of study for students pursuing a degree abroad (Belyavina and Bhandari 2012).

Conclusion

S&E higher education in the United States is attracting growing numbers of students. The number of bachelor's and master's degrees awarded in all fields and in S&E fields continues to rise, having reached new peaks in 2011. Most of the growth in undergraduate S&E education occurred in science fields, in particular in the social and behavioral sciences and in the biological sciences. In engineering, bachelor's degrees have increased consistently for the last 10 years but have not yet reached the record high levels attained in the 1980s. After a steep decline between 2004 and 2007, computer sciences degree awards began to rebound. The number of master's and doctoral degrees awarded grew in all major S&E fields. In the last decade, growth in doctoral degrees awarded occurred mostly in the natural sciences and engineering fields.

Over the last two decades, higher education spending and revenue patterns and trends have undergone substantial changes, which intensified during the recent economic downturn. Public institutions faced competing demands in a tight budget environment, caught between declining state appropriations and the need to maintain educational quality and access. Community colleges, which serve diverse groups of students and play a key role in increasing access to higher education, were particularly affected, as the number of students seeking an affordable college education increased.

Foreign student enrollment in S&E has recovered since the decline post-9/11. In recent years, foreign student enrollment has increased considerably at the undergraduate and graduate levels, both in S&E and non-S&E fields.

Globalization of higher education continues to expand. Universities in several other countries have expanded their enrollment of foreign S&E students. The United States continues to attract the largest number and fraction of internationally mobile students worldwide, although its share of foreign students in all fields has decreased in recent years. The share of international students in the natural sciences and engineering fields declined as well, but an increase in international students coming to the United States to study social and behavioral sciences has kept the overall S&E share stable.

Higher education is undergoing rapid transformation. The growth of distance and online education through MOOCs and similar innovations expands access to knowledge and has the potential to decrease the cost of some degrees, at the same time as pressures have been increasing to reduce rising costs. However, it is too early to assess whether MOOCs will be widely adopted by different types of institutions, whether increased access will be accompanied by increased learning, and what consequences online and distance innovations will bring to the higher education landscape.

Notes

1. Data on postdoctoral scientists and engineers are included in chapters 3 and 5. Data on stay rates of doctorate recipients are included in chapter 3.

2. U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), fall 2011, Institutional Characteristics component, special tabulation.

3. For a crosswalk between the Classification of Instructional Programs (CIP) codes and the academic fields in enrollment and completion tables, see https://webcaspar.nsf.gov/Help/dataMapHelpDisplay.jsp?subHeader=DataSourceBySubject&type=DS&abbr=DEGS&noHeader=1&JS=No, accessed 23 August 2013.

4. High Hispanic enrollment institutions are those whose undergraduate, full-time equivalent student enrollment is at least 25% Hispanic, according to fall 2011 data in the Integrated Postsecondary Education Data System, directed by the National Center for Education Statistics. HBCUs are listed by the White House Initiative on Historically Black Colleges and Universities. The Higher Education Act of 1965, as amended, defines an HBCU as "any historically black college or university that was established prior to 1964, whose principal mission was, and is, the education of black Americans, and that is accredited by a nationally recognized accrediting agency or association determined by the Secretary [of Education] to be a reliable authority as to the quality of training offered or is, according to such an agency or association, making reasonable progress toward accreditation."

5. Minority-serving institutions include HBCUs (see endnote 4), high Hispanic enrollment institutions, and tribal colleges.

6. See tables 5-8, 5-9, and 5-10 in NSF/NCSES 2013a for additional details.

7. U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), fall 2011, Institutional Characteristics component, special tabulation.

8. In 2011–12 IPEDS began asking institutions whether they were exclusively a distance education institution, that is, whether all of their programs were offered via distance education, defined as "education that uses one or more technologies to deliver instruction to students who are separated from the instructor and to support regular and substantive interaction between the students and the instructor synchronously or asynchronously." A distance education course is a course in which the instructional content is delivered exclusively via distance education. A distance education program is a program for which all the required coursework for program completion can be completed via distance education courses. Examinations, orientation, and practical experience components of courses or programs are not considered instructional content. For more details, see the IPEDS online glossary at http://nces.ed.gov/ipeds/glossary/.

9. For the definition of "net tuition revenue," see "Glossary." Definitions of standard expense categories are available at http://www.deltacostproject.org/resources/pdf/Delta-Spending-Trends-Production.pdf, and an explanation of revenue sources is available at http://www.deltacostproject.org/pdfs/Revenue_Trends_Production.pdf.

10. Another large source of revenue for very high research institutions is "hospitals, independent operations, and other sources," which includes revenue generated by hospitals operated by the institution and revenues independent of or unrelated to instruction, research, or public services.

11. In 2010, income from private and affiliated gifts, investment returns, and endowment income at private very high research institutions ($62,000 per FTE) was more than the income from net tuition ($23,000 per FTE) and federal appropriations ($28,000 per FTE) combined (appendix table 2-4).

12. Another large source of expenditures for very high research institutions is "auxiliary enterprises, hospitals and clinics, and independent and other operations." Auxiliary enterprises include dormitories, bookstores, and meal services.

13. The 4-year and graduate institutions category includes the following 2005 Carnegie institution types: doctorate-granting universities/high research activity, doctoral/research universities, master's colleges/universities, and baccalaureate colleges. The figures in this section correspond to the public institutions.

14. Community colleges are the public "associate's colleges" in the 2005 Carnegie Classification.

15. The proportion of U.S.-trained doctorate holders employed at community colleges in adjunct positions grew from 12% in 1993 to 28% in 2010, according to estimates from the Survey of Doctorate Recipients. This suggests that one of the ways community colleges may have reined in expenses during this period was to increase their reliance on adjuncts.

16. In this section, data on net tuition and fees paid by full-time undergraduate students are based on data reported to the College Board by colleges and universities in the Annual Survey of Colleges. Net tuition and fees equal published tuition and fees minus total grant aid and tax benefits. Data on net tuition revenues reported in the section "Trends in Higher Education Revenues and Expenditures" are based on IPEDS data. Net tuition revenue, in this case, is the amount of money the institution takes in from students after institutional grant aid is provided.

17. For more details, see Figure 2009_8 at http://trends.collegeboard.org/college-pricing/figures-tables/net-prices-by-income-over-time-public-sector and Figure 2009_9 at http://trends.collegeboard.org/college-pricing/figures-tables/net-prices-by-income-over-time-private-sector. Accessed 29 July 2013.

18. Clinical psychology programs and programs that emphasize professional practice (professional schools and PsyD programs) are associated with higher debt, but even in the more research-focused subfields of psychology, lower percentages of doctorate recipients were debt-free, and higher percentages had higher levels of debt, than those in other S&E fields. For information on debt levels of clinical versus nonclinical psychology doctorates in 1993–96, see *Psychology Doctorate Recipients: How Much Financial Debt at Graduation?* (NSF 00-321) at http://www.nsf.gov/statistics/issuebrf/sib00321.htm (accessed 6 November 2013).

19. The population projections in this section and in appendix table 2-15 are based on the latest population projections published by the Census Bureau, which are in turn based on the 2010 Census (http://www.census.gov/population/projections/data/national/2012/downloadablefiles.html, accessed 15 May 2013). In its publication "Projection of Education Statistics," NCES projects enrollment trends in postsecondary institutions. However, in the latest publication (Hussar and Bailey 2013), NCES used Census projections from 2008, which were based on the 2000 Census. Unlike the Census Bureau, NCES incorporates disposable income (a measure of ability to pay) and age-specific unemployment rates (a measure of opportunity costs) in its projections.

20. These data are from sample surveys and are subject to sampling error. Information on estimated standard errors can be found in appendix D of the annual report *The American Freshman: National Norms Fall 2012*, published by the Cooperative Institutional Research Program of the Higher Education Research Institute, University of California–Los Angeles (http://www.heri.ucla.edu/monographs/TheAmericanFreshman2012.pdf). Data reported here are significant at the 0.05 level.

21. The number of S&E degrees awarded to a particular freshman cohort is lower than the number of students reporting intentions to major in S&E. It reflects losses of students from S&E, gains of undecided students and students from non-S&E fields after their freshman year, and general attrition from bachelor's degree programs.

22. The PCAST report also included associate's degrees trends in the natural sciences and engineering. The proportion of associate's degrees in these fields was also fairly stable at about 5%, except in the early 2000s when it increased to 8%–9% because of the rise in the number of associate's degree awards in computer sciences, which declined after 2004.

23. The data in this section come from the Institute of International Education (IIE) and the Student and Exchange Visitor Information System (SEVIS). IIE conducts an annual survey of about 3,000 accredited U.S. higher education institutions. An international student in this survey is defined as anyone studying at an institution of higher education in the United States on a temporary visa that allows academic coursework, primarily F and J visas. SEVIS collects administrative data, including the numbers of all foreign national students enrolled in colleges and universities in the United States. Data on exchange visitors are not included in this chapter; some limited data on this topic can be found in chapter 3.

24. The figures include active foreign national students on F-1 visas in the SEVIS database, excluding those participating in optional practical training (OPT). Students with F visas have the option of working in the United States by engaging in OPT, temporary employment directly related to the student's major area of study, either during or after completion of the degree program. Students can apply for 12 months of OPT at each level of education. Starting in 2008, students in certain STEM fields became eligible for an additional 17 months of OPT. The number of students in OPT varies according to labor market conditions. According to data from SEVIS, the number of students with F1 visas in OPT declined sharply between November 2010 and November 2011 and rose back up steeply by November 2012 (68,510 in November 2010; 22,820 in November 2011; and 80,680 in November 2012).

25. These data include foreign students pursuing both bachelor's and associate's degrees. Comparable data for U.S. citizen and permanent resident students do not exist. However, the proportion of S&E associate's and bachelor's degree awards earned by U.S. citizens and permanent residents is considerably lower.

26. About 14% of recent S&E bachelor's degree recipients who earned their degree between 1 July 2007 and 30 June 2009 had previously earned an associate's degree (National Science Foundation, National Center for Science and Engineering Statistics, National Survey of Recent College Graduates 2010, special tabulation).

27. Data on degree completion from NCES were obtained from WebCASPAR (https://webcaspar.nsf.gov/). Data uploaded in WebCASPAR correspond to NCES provisional data, which undergo all NCES data quality control procedures and are imputed for nonresponding institutions. These data are used by NCES in their First Look (Provisional Data) publications.

28. Data for racial and ethnic groups are for U.S. citizens and permanent residents only.

29. Data on degree completion from NCES were obtained from WebCASPAR (https://webcaspar.nsf.gov/). Data uploaded in WebCASPAR correspond to NCES provisional data, which undergo all NCES data quality control procedures and are imputed for nonresponding institutions. These data are used by NCES in their First Look (Provisional Data) publications.

30. For longer trends in degrees, see NSB 2010. For more detail on enrollment and degrees by sex and by race and ethnicity, see NSF/NCSES 2013a.

31. Data for racial and ethnic groups are for U.S. citizens and permanent residents only.

32. The Survey of Graduate Students and Postdoctorates in Science and Engineering was redesigned in 2007. Because of methodological changes, the data collected from 2007 through 2010 are not strictly comparable to those collected before 2007. As a result, care should be used when assessing trends within the GSS data. Throughout the appendix tables in this chapter, "2007new" reports the data as collected in 2007, and "2007old" provides the data as they would have been collected in 2006. In addition, between 2008 and 2010, the survey conducted a more rigorous follow-up with institutions regarding the exclusion of practitioner-oriented graduate degree programs. Some or all of the declines in psychology and other health fields in 2008–10 are likely due to this increased effort to exclude practitioner-oriented graduate degree programs rather than changes in actual enrollments. Care should therefore be used when examining long-term trends. Because of this methodological change, in this section, "S&E" excludes psychology and other health fields. For a detailed discussion on the survey redesign, please see appendix A, "Technical Notes," in *Graduate Students and Postdoctorates in Science and Engineering: Fall 2007* (http://www.nsf.gov/statistics/nsf10307/).

33. Special tabulation NSRCG (2003, 2006, 2008, 2010).

34. See NSF/NCSES 2013a for more detail on enrollment of foreign students by sex.

35. The figures include active foreign national students on F-1 visas in the SEVIS database, excluding those on OPT (temporary employment directly related to the student's major area of study either during or after completion of the degree program). See endnote 24.

36. Data on degree completion from NCES were obtained from WebCASPAR (https://webcaspar.nsf.gov/). Data uploaded in WebCASPAR correspond to NCES provisional data, which undergo all NCES data quality control procedures and are imputed for nonresponding institutions. These data are used by NCES in their First Look (Provisional Data) publications.

37. Chapter 3 includes a sidebar on a 2012 NIH report discussing how employment patterns in the biological sciences have changed in the last two decades.

38. Data for racial and ethnic groups are for U.S. citizens and permanent residents only.

39. In 2008, NCES allowed optional reporting in three new doctoral degree categories: doctor's—research/scholarship, doctor's—professional practice, and doctor's—other. Degrees formerly classified as professional degrees (e.g., MDs and JDs) could then be reported as doctoral degrees, most often as doctor's—professional practice. Data for 2008 and 2009 included only those doctorates reported under the old category plus those reported as doctor's—research/scholarship. Data for 2010 and 2011 included data reported as doctor's—research/scholarship, as the old category was eliminated. As a result of these methodological changes, doctor's—research/scholarship degrees in "other health sciences" declined sharply between 2009 and 2010. To facilitate comparability over time, "S&E" excludes "other health sciences" throughout the sections "S&E Doctoral Degrees," "Doctoral Degrees by Sex," and "Doctoral Degrees by Race and Ethnicity."

40. Data on degree completion from NCES were obtained from WebCASPAR (https://webcaspar.nsf.gov/). Data uploaded in WebCASPAR correspond to NCES provisional data, which undergo all NCES data quality control procedures and are imputed for nonresponding institutions. These data are used by NCES in their First Look (Provisional Data) publications.

41. See table 32 in the *2011 Doctorate Recipients from U.S. Universities* report (NSF/NCSES 2012), where broad fields are aggregated as follows: life sciences includes agricultural sciences and natural resources, biological and biomedical sciences, and health sciences; physical sciences includes mathematics and computer and information sciences; and social sciences includes psychology.

42. For the corresponding proportion in the 1990s, see NSB 2008.

43. The number of S&E doctorate recipients from China surpassed that of Taiwan in 1990. Up until that year, Taiwanese students earned more U.S. S&E doctorates than Chinese, Indian, or South Korean students. (See NSB 2008 figure 2-25 and NSB 2010 figure 2-22.)

44. According to an international database compiled by the Program for Research on Private Higher Education, at the State University of New York at Albany, the United States and Japan have long-standing private higher education sectors, and Western Europe has an almost completely public higher education sector. Eastern and Central Europe and several African countries have recently seen growth in private higher education. In most countries in Latin America, more than half of all higher education institutions are private. For more information, see http://www.albany.edu/dept/eaps/prophe/index.html (accessed 15 May 2013).

45. These data are based on national labor force surveys and are subject to sampling error; therefore, small differences between countries may not be meaningful. The standard error for the U.S. percentage of 25–64-year-olds with a bachelor's or higher degree is roughly 0.1, and the standard error for the U.S. percentage of 25–34-year-olds with a bachelor's or higher degree is roughly 0.4.

46. In international degree comparisons, S&E does not include medical or health fields. This is because international sources cannot separate the MD degrees from degrees in the health fields, and the MDs are professional or practitioner degrees, not research degrees.

47. Internationally mobile students are students who have crossed a national or territorial border for the purposes of education and are now enrolled outside their country of origin. This concept is different from "foreign students," which

are those who are not citizens of the country where they are enrolled, but may, in some cases, be long-term residents or have been born in the country (OECD 2012).

48. The population of individuals ages 20–24 (a proxy for the college-age population) decreased in China, Europe, Japan, and the United States in the 1990s and is projected to continue decreasing in China, Europe (mainly Eastern Europe), Japan, South Korea, and South America. The U.S. population of 20–24-year-olds is projected to increase.

49. In Luxembourg, international students represent 41%, mostly due to the high level of integration with neighboring countries (OECD 2012).

Glossary

Baccalaureate-origin institution: The college or university from which an S&E doctorate recipient earned a bachelor's degree.

Credit mobility: Short-term, for-credit foreign study and exchange programs that last less than a full school year.

Degree or diploma mobility: For-credit foreign study programs in which students pursue a higher education degree outside their usual country of residence.

European Union (EU): As of June 2013, the European Union comprised 27 member nations: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Croatia joined the EU in July 2013. Unless otherwise noted, Organisation for Economic Co-operation and Development data on the EU include all 28 members; data on the EU from other sources are limited to the 27 nations that were members as of June 2013.

First university degree: A terminal undergraduate degree program; these degrees are classified as level 5A first university in the International Standard Classification of Education, which is developed by UNESCO, although individual countries use different names for the first terminal degree (e.g., *corso di Laurea* in Italy, *diplom* in Germany, *licence* in France, and *bachelor's degree* in the United States and in Asian countries).

G20: Group of Twenty brings together finance ministers and central bank governors from Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, the Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, and the EU.

Internationally mobile students: Students who have crossed a national or territorial border for purposes of education and are now enrolled outside their countries of origin. This term refers to degree mobility in data collected by UNESCO/UNESCO Institute for Statistics, OECD, and Eurostat and excludes students who travel for credit mobility.

Natural sciences: Include agricultural; biological; computer; earth, atmospheric, and ocean; and physical sciences and mathematics.

Net price: The published price of an undergraduate college education minus the average grant aid and tax benefits that students receive.

Net tuition revenue: Total revenue from tuition and fees (including grant and loan aid used by students to pay tuition); excludes institutional student aid that is applied to tuition and fees.

Tertiary-type A programs: Higher education programs that are largely theory based and designed to provide sufficient qualifications for entry to advanced research programs and to professions with high skill requirements, such as medicine, dentistry, or architecture. These programs have a minimum duration of 3 years, although they typically last 4 or more years and correspond to bachelor's or master's degrees in the United States.

Tertiary-type B programs: Higher education programs that focus on practical, technical, or occupational skills for direct entry into the labor market and have a minimum duration of 2 years. These programs correspond to associate's degree programs in the United States.

Underrepresented minorities: Blacks, Hispanics, and American Indians and Alaska Natives are considered to be underrepresented minorities in S&E.

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Chapter 3

Science and Engineering Labor Force

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Highlights

U.S. S&E Workforce: Definition, Size, and Growth

The S&E workforce can be defined in several ways: by workers in S&E occupations, by holders of S&E degrees, and by the use of S&E technical expertise on the job. The estimated size of the S&E workforce varies depending on the criteria chosen.

- In 2010, estimates of the size of the U.S. S&E workforce ranged from approximately 5 million to more than 19 million depending on the definition used.
- In 2010, there were about 5.4 million college graduates employed in S&E occupations in the United States. Occupations in the computer and mathematical sciences (2.4 million) and engineering (1.6 million) were the largest categories of S&E occupations. Occupations in the life sciences (597,000), social sciences (518,000), and physical sciences (320,000) each employed a smaller number of S&E workers.
- In 2010, about 19.5 million college graduates in the United States had a bachelor's or higher level degree in an S&E field of study. Almost three-fourths (74%) of these college graduates (14.5 million) held their highest level of degree (bachelor's, master's, professional, or doctorate) in an S&E field. Overall, the most common fields of S&E highest degrees were social sciences (40%) and engineering (23%). Computer and mathematical sciences, life sciences, and physical sciences together accounted for slightly more than one-third (38%) of individuals with S&E highest degrees.
- The application of S&E knowledge and skills is widespread across the U.S. economy and not just limited to S&E occupations. The number of college-educated individuals reporting that their jobs require at least a bachelor's degree level of technical expertise in one or more S&E fields (16.5 million) is significantly higher than the number in occupations with formal S&E titles (5.4 million).

The S&E workforce has grown steadily over time.

- Between 1960 and 2011, the number of workers in S&E occupations grew at an average annual rate of 3.3%, greater than the 1.5% growth rate for the total workforce.
- Data from more recent years indicate that trends in S&E employment compared favorably to overall employment trends during and after the 2007–09 economic downturn. Between 2006 and 2012, the number of workers employed in S&E occupations rose slightly, whereas the total workforce shrank.

S&E Workers in the Economy

Scientists and engineers work for all types of employers.

- By far the largest employer of scientists and engineers (individuals with an S&E degree or employed in an S&E occupation) is the business sector (70%), followed by the education sector (19%) and the government sector (11%). Within the business sector, for-profit businesses employ the largest number of scientists and engineers.
- Scientists and engineers with S&E doctorates are more evenly distributed between the business sector (46%) and the education sector (45%). Within the education sector, over 90% are found in 4-year academic institutions, including those in postdoctoral and other temporary positions.
- Small firms are important employers of those with S&E highest degrees (individuals who attained their highest level of degree in an S&E field of study). Firms with fewer than 100 persons employ 37% of such individuals in the business sector.
- Within the business sector, the industry with the largest number of workers in S&E occupations is the professional, scientific, and technical services industry.
- Employment in S&E occupations is geographically concentrated in the United States. The 20 metropolitan areas with the largest proportion of the workforce employed in S&E occupations accounted for 18% of nationwide S&E employment, compared to 8% of all employment.

S&E Labor Market Conditions

Workers with S&E degrees or in S&E occupations tend to earn more than other comparable workers.

- Half of the workers in S&E occupations earned $78,270 or more in 2012, more than double the median earnings ($34,750) of the total U.S. workforce.
- Employed college graduates with a highest degree in S&E earn more than those with non-S&E degrees. Moreover, within each broad degree field (S&E and non-S&E), those employed in S&E occupations earn more than those in non-S&E occupations.

Individuals whose work is associated with S&E are less often exposed to unemployment.

- Unemployment rates for those in S&E occupations tend to be lower than those for all college graduates and much lower than those for the overall labor force. In October 2010, an estimated 4.3% of scientists and engineers and 5.1% of all college-educated individuals in the labor force were unemployed. At the same time, the official unemployment rate for the entire U.S. labor force was 9.0%.
- Unemployment rates for S&E doctorate holders are generally lower than for those at other degree levels.

Demographics of the S&E Workforce

The U.S. S&E labor force is aging. However, in 2010, a larger proportion of older scientists and engineers reported being in the labor force than in 1993.

- The proportion of scientists and engineers in the U.S. labor force over age 50 increased from 20% in 1993 to 33% in 2010. The median age of such individuals was 44 years in 2010, compared to 41 years in 1993.
- Between 1993 and 2010, increasing percentages of scientists and engineers in their 60s reported that they were still in the labor force. Whereas 54% of scientists and engineers between the ages of 60 and 69 were employed in 1993, the comparable percentage rose to 63% in 2010.

Women remain underrepresented in the S&E workforce, although to a lesser degree than in the past.

- Despite accounting for half of the college-educated workforce, in 2010 women constituted 37% of employed individuals with a highest degree in an S&E field and 28% of employed individuals in S&E occupations.
- From 1993 to 2010, growth occurred in both the proportion of workers with a highest degree in an S&E field who are women (increasing from 31% to 37%) and the proportion of women in S&E occupations (increasing from 23% to 28%).
- Women employed in S&E occupations are concentrated in different occupational categories than are men, with relatively high proportions of women in the social sciences (58%) and life sciences (48%) and relatively low proportions in engineering (13%) and computer and mathematical sciences (25%).

Historically underrepresented racial and ethnic groups, particularly blacks and Hispanics, continue to display lower S&E participation rates relative to their presence in the U.S. population. Conversely, Asians and foreign-born individuals display higher S&E participation rates relative to their overall presence in the U.S. population.

- Hispanics, blacks, and American Indians or Alaska Natives together make up 26% of the U.S. population age 21 and older but a much smaller proportion of the S&E workforce: 10% of workers in S&E occupations and 13% of S&E highest degree holders.
- Asians work in S&E occupations at higher rates (19%) than their representation in the U.S. population age 21 and older (5%). Asians have a large presence in engineering and computer sciences occupations, particularly among computer software and hardware engineers, software developers, and postsecondary teachers in engineering.
- About 70% of workers in S&E occupations are non-Hispanic whites, which is comparable to their overall representation in the U.S. population age 21 and older (68%).
- Foreign-born individuals account for slightly more than one-fourth of all workers in S&E occupations, which is higher than their representation in the entire college-educated workforce (15%). Foreign-born workers employed in S&E occupations tend to have higher levels of education than their U.S. native-born counterparts.

A variety of indicators point to a decline in the immigration of scientists and engineers during the 2007–09 economic downturn. However, data since the downturn suggest that this decline may be temporary.

- After several years of growth, the number of temporary work visas issued to high-skill workers fell during the 2007–09 economic downturn. It has rebounded since then, although data for 2012 indicate that the issuance of temporary work visas has not yet reached the recent highs seen in 2007 and 2008.
- After rising for most of the decade 2000–09, the number of foreign recipients of U.S. S&E doctoral degrees declined in 2009 and 2010. It has risen slightly in 2011 but remains below the recent highs seen in 2007 and 2008.
- Among foreign-born U.S. S&E doctorate recipients with temporary visas at graduation, the proportion that remained in the United States 5 years after receiving their degrees rose during the first half of the decade of the 2000s, reaching 67% in 2005. The proportion declined during the economic downturn but rose to 66% in 2011.

Global S&E Labor Force

Worldwide, the number of workers engaged in research has been growing.

- Among countries with large numbers of researchers—defined as workers engaged in the creation and development of new knowledge, products, and processes—growth has been most rapid since the mid-1990s in China and South Korea.
- The United States and the European Union experienced steady growth but at a lower rate than in China or South Korea.
- Japan and Russia were exceptions to the worldwide trend. Between 1995 and 2011, the number of researchers in Japan remained largely unchanged, and in Russia the number declined.

Introduction

Chapter Overview

Policymakers and scholars consistently emphasize innovation based on S&E research and development as a vehicle for a nation's economic growth and global competitiveness. Workers with S&E expertise are an integral part of a nation's innovative capacity because of their high skill level, their creative ideas, and their ability not only to advance basic scientific knowledge but also to transform advances in fundamental knowledge into tangible products and services. As a result, these workers make important contributions to improving living standards and accelerating the pace of a nation's economic and productivity growth.

Chapter Organization

The U.S. workforce includes both individuals employed in S&E occupations and individuals educated in S&E fields but employed in a variety of non-S&E occupations. Many more individuals have S&E degrees than work in S&E occupations. Indicative of a knowledge-based economy, many individuals in non-S&E occupations report that their work nevertheless requires a bachelor's degree level of S&E expertise. Therefore, the first section in this chapter, "U.S. S&E Workforce: Definition, Size, and Growth," discusses the U.S. S&E workforce based on three measures: workers in S&E occupations, holders of S&E degrees, and use of S&E technical expertise on the job. This section also discusses the interplay between educational background and occupational choice as well as the growth in the U.S. S&E workforce over time.

The second section in this chapter, "S&E Workers in the Economy," examines the distribution of S&E workers across employment sectors. It describes the distribution of S&E workers across sectors (e.g., business, education, government) as well as within particular sectors (e.g., local, state, and federal government). This section also presents data on geographic distribution of S&E employment in the United States. Data on R&D activity and work-related training by S&E workers are also discussed.

The third section, "S&E Labor Market Conditions," looks at labor market outcomes for S&E workers. Data in this section focus on earnings and unemployment. Data on recent S&E graduates are also discussed, as are broader measures of labor underutilization that go beyond the conventional unemployment rate.

The next three sections cover labor force demographics. "Age and Retirement of the S&E Workforce" presents data on the age distribution and retirement patterns of S&E workers. "Women and Minorities in the S&E Workforce" focuses on S&E participation by women and by racial and ethnic minorities; this section also presents data on salary differences by sex and by race and ethnicity. "Immigration and the S&E Workforce" presents data on S&E participation by foreign-born individuals in the United States as well as the worldwide migration patterns of high-skill workers.

The final section in this chapter is "Global S&E Labor Force." Although there are indications that the global S&E labor force has grown, international data on the characteristics of this broader labor force are particularly limited and are not always comparable with data for the United States. In this final section, data from the Organisation for Economic Co-operation and Development (OECD) are used to present indicators of worldwide R&D employment.

This chapter uses a variety of data sources, including, but not limited to, the National Science Foundation's (NSF's) Scientists and Engineers Statistical Data System (SESTAT), the Census Bureau's American Community Survey (ACS), the Occupational Employment Statistics (OES) survey administered by the Bureau of Labor Statistics (BLS), and the Current Population Survey (CPS) sponsored jointly by the Census Bureau and BLS. Different sources cover different segments of the population and different levels of detail on different topics. (See table 3-1 and sidebar, "NSF's Scientists and Engineers Statistical Data System.") Although data collection methods and definitions can differ across surveys in ways that affect estimates, combining data from different sources facilitates an accurate and comprehensive picture of the very specialized S&E workforce. A particular measure or categorization of the workforce may be better suited for addressing some questions than others, and a particular data source may not include information in every category. Analyses of long-term trends, international trends, and comparison of S&E and non-S&E workers are discussed whenever data are available.

U.S. S&E Workforce: Definition, Size, and Growth

Definition of the S&E Workforce

Because there is no standard definition of S&E workers, this section uses multiple categorizations to measure the U.S. S&E workforce. In general, this section defines the S&E workforce to include people who either work in S&E occupations or hold S&E degrees.[1] The application of S&E knowledge and skills is not limited to jobs with formal S&E titles; the number of college graduates reporting that their jobs require at least a bachelor's degree level of knowledge in one or more S&E fields exceeds the number of workers employed in S&E occupations in the economy. Therefore, this section also presents data on the use of S&E technical expertise on the job to provide an estimate of the U.S. S&E workforce. The estimated number of scientists and engineers varies based on the criteria applied to define the S&E workforce.

U.S. federal occupation data classify workers by the activities or tasks they primarily perform in their jobs. The NSF and Census Bureau occupational data in this chapter come from federal statistical surveys in which individuals or household members provide information about job titles and work activities. This information is used to classify jobs

Table 3-1

Major sources of data on the U.S. labor force

Data source	Data collection agency	Data years	Major topics	Respondent	Coverage
Occupational Employment Statistics (OES)	Department of Labor, Bureau of Labor Statistics	Through 2012	Employment status Occupation Salary Industry Employer location (national, state, metropolitan statistical area)	Employing organizations	All full-time and part-time wage and salary workers in non-farm industries; does not cover self-employed, unincorporated firms, household workers, or unpaid family workers
Scientists and Engineers Statistical Data System—see sidebar "NSF's Scientists and Engineers Statistical Data System"	National Science Foundation, National Center for Science and Engineering Statistics	Through 2010	Employment status Occupation Job characteristics (work activities, technical expertise) Salary Detailed educational history Demographic characteristics	Individuals	Individuals with bachelor's degree or higher in S&E or S&E-related field or with non-S&E bachelor's but working in S&E or S&E-related occupation
American Community Survey (ACS)	Department of Commerce, Census Bureau	Through 2011	Employment status Occupation First bachelor's degree field Educational attainment Demographic characteristics	Households	U.S. population
Current Population Survey (CPS)	Department of Labor, Bureau of Labor Statistics	Through 2013	Employment status Occupation Educational attainment Demographic characteristics	Households	Civilian noninstitutional population age 16 and over

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into standard occupational categories based on the Standard Occupational Classification (SOC) system.[2] In contrast, the BLS-administered OES survey relies on employers to classify their workers using SOC definitions. Differences between employer- and individual-provided information can affect the content of occupational data.

NSF has developed a widely used set of SOC categories that it calls *S&E occupations*. Very broadly, these occupations include life scientists, computer and mathematical scientists, physical scientists, social scientists, and engineers. NSF also includes postsecondary teachers of these fields in S&E occupations. A second category of occupations, *S&E-related occupations*, includes health-related occupations, S&E managers, S&E technicians and technologists, architects, actuaries, S&E precollege teachers, and postsecondary teachers in S&E-related fields. The S&E occupations are generally assumed to require at least a bachelor's degree level of education in an S&E field. The vast majority of S&E-related occupations also require S&E knowledge or training, but an S&E bachelor's degree may not be a required credential for employment in some of these occupations. Examples include health technicians and computer network managers. Other occupations, although classified as *non-S&E occupations,* may include individuals who use S&E technical expertise in their work. Examples include technical writers who edit scientific publications and salespeople who sell specialized research equipment to chemists and biologists. The NSF occupational classification of S&E, S&E-related, and non-S&E occupations appears in table 3-2 along with the NSF educational classification of S&E, S&E-related, and non-S&E degree fields.

Other general terms, including science, technology, engineering, and mathematics (STEM), science and technology (S&T), and science, engineering, and technology (SET), are often used to designate the part of the labor force that works with S&E. These terms are broadly equivalent and have no standard definition.

The number of individuals who have S&E training or who reported applying S&E technical expertise in their jobs exceeds the number of individuals employed in S&E

NSF's Scientists and Engineers Statistical Data System

NSF's Scientists and Engineers Statistical Data System (SESTAT) provides detailed employment, education, and demographic data for scientists and engineers under age 76 residing in the United States. The 2010 SESTAT defines scientists and engineers as individuals who have college degrees in S&E or S&E-related fields or who are working in S&E or S&E-related occupations.[*] (See table 3-2 for definitions of S&E and S&E-related occupations.) Unless otherwise noted, the term "scientists and engineers" as used in this chapter refers to this broad SESTAT population. Data available through SESTAT are collected by three large demographic and workforce surveys of individuals conducted by NSF: the National Survey of College Graduates (NSCG), the National Survey of Recent College Graduates (NSRCG), and the Survey of Doctorate Recipients (SDR). SESTAT integrates the data from the three surveys, and together the data provide a comprehensive picture of scientists and engineers in the United States.

The NSCG is the central component of SESTAT, providing data that detail the characteristics of the entire college-educated population in the United States (regardless of their S&E background). Its population of college graduates includes individuals trained as scientists and engineers who hold at least a bachelor's degree. Because it covers the entire college graduate population residing in the United States, the NSCG provides information on individuals educated or employed in S&E fields as well as those employed or educated in non-S&E fields. The data presented in this chapter for all college graduates (regardless of S&E background) are based on the NSCG.

Whereas NSCG data cover the general college-educated population, the NSRCG supplements SESTAT by adding recent college graduates at the bachelor's and master's degree level. The 2010 NSRCG data represent almost 1.5 million recent bachelor's and master's graduates in science, engineering, and health (SEH) fields from academic years 2008 and 2009.

The SDR supplements SESTAT by adding doctoral scientists and engineers who earned their SEH doctorates from U.S. academic institutions. Data from the 2010 SDR were collected from doctoral graduates who received SEH research degrees from a U.S. academic institution before 1 July 2009.

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[*] For details on the 2010 SESTAT see http://www.nsf.gov/statistics/sestat/ and http://www.nsf.gov/statistics/infbrief/nsf13311/.

Table 3-2
Classification of degree fields and occupations

			Occupation classification	
Classification	Degree field	Occupation	STEM	S&T
S&E	Biological, agricultural, and environmental life sciences	Biological, agricultural, and environmental life scientists	X	X
	Computer and mathematical sciences	Computer and mathematical scientists	X	X
	Physical sciences	Physical scientists	X	X
	Social sciences	Social scientists	X	X
	Engineering	Engineers	X	X
		S&E postsecondary teachers	X	X
S&E-related	Health fields	Health-related occupations		
	Science and math teacher education	S&E managers	X	
	Technology and technical fields	S&E precollege teachers		
	Architecture	S&E technicians and technologists	X	X
	Actuarial science	Architects		
		Actuaries		
		S&E-related postsecondary teachers		
Non-S&E	Management and administration	Non-S&E managers		
	Education (except science and math teacher education)	Management-related occupations		
		Non-S&E precollege teachers		
	Social services and related fields	Non-S&E postsecondary teachers		
	Sales and marketing	Social services occupations		
	Arts and humanities	Sales and marketing occupations		
	Other fields	Arts and humanities occupations		
		Other occupations		

S&T = science and technology; STEM = science, technology, engineering, and mathematics.

NOTES: The designations STEM and S&T refer to occupations only. For more detailed classification of occupations and degrees by S&E, S&E-related, and non-S&E, see National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), http://sestat.nsf.gov.

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occupations. A relatively narrow definition of the S&E workforce consists of workers in occupations that NSF designates as S&E occupations. A much broader definition of an S&E worker, defined by SESTAT, includes any individual with at least a bachelor's (or higher) degree in an S&E or S&E-related field of study or a college graduate in any field employed in an S&E or S&E-related occupation. The S&E workforce may also be defined by the technical expertise or training required to perform a job. Unlike information on occupational categories or educational credentials, information on the use of technical knowledge, skills, or expertise in a person's job reflects that individual's subjective opinion about the content and characteristics of the job.[3] The next section provides estimates of the size of the S&E workforce using all three definitions.

Size of the S&E Workforce

Defined by occupation, the U.S. S&E workforce totals between 5.8 million and 6.0 million people according to the most recent estimates (table 3-3). Those in S&E occupations who had at least a bachelor's degree are estimated at between 4.3 million and 5.4 million (table 3-3).[4] By far the largest categories of S&E occupations are in computer and mathematical sciences and engineering, which together account for between three-fourths and four-fifths of all employed workers in S&E occupations (figure 3-1). Occupations in the life sciences, social sciences, and physical sciences each employ a smaller proportion of S&E workers.

As noted earlier, S&E degree holders greatly outnumber those currently employed in S&E occupations. In 2010, about 19.5 million college graduates in the United States had a bachelor's or higher level degree in an S&E field of study (table 3-3). Almost three-fourths of these college graduates (14.5 million) attained their highest degree in an S&E field (in this chapter, these individuals are referred to as S&E highest degree holders). An individual's highest degree is often an accurate representation of the skills and credentials that one employs in the labor market, which is why the data presented in this chapter by educational attainment are often provided for highest degree. Overall, social sciences and engineering were the most common degree fields among individuals with S&E highest degrees (figure 3-2). Of the 14.5 million S&E highest degree holders, slightly more than one-fourth attained a master's degree (3 million) or doctorate (979,000) as their highest degree.[5]

The majority of individuals with a highest degree in S&E reported that their job was either closely or somewhat related to their field of highest degree (table 3-3). This is despite

Table 3-3

Measures and size of U.S. S&E workforce: 2010, 2011, and 2012

Measure	Education coverage	Data source	Workers
Occupation			
Employed in S&E occupations	All education levels	2012 BLS OES	5,968,000
Employed in S&E occupations	Bachelor's and above	2010 NSF/NCSES SESTAT	5,398,000
Employed in S&E occupations	All education levels	2011 Census Bureau ACS	5,756,000
Employed in S&E occupations	Bachelor's and above	2011 Census Bureau ACS	4,279,000
Education			
At least one degree in S&E field	Bachelor's and above	2010 NSF/NCSES SESTAT	19,493,000
Highest degree in S&E field	Bachelor's and above	2010 NSF/NCSES SESTAT	14,457,000
Job closely related to highest degree	Bachelor's and above	2010 NSF/NCSES SESTAT	5,396,000
S&E occupation	Bachelor's and above	2010 NSF/NCSES SESTAT	2,796,000
Other occupation	Bachelor's and above	2010 NSF/NCSES SESTAT	2,600,000
Job somewhat related to highest degree	Bachelor's and above	2010 NSF/NCSES SESTAT	3,358,000
S&E occupation	Bachelor's and above	2010 NSF/NCSES SESTAT	966,000
Other occupation	Bachelor's and above	2010 NSF/NCSES SESTAT	2,392,000
Job requires S&E technical expertise at bachelor's level			
In one or more S&E fields	Bachelor's and above	2010 NSF/NCSES SESTAT NSCG	16,456,000
Engineering, computer science, mathematics, or natural sciences	Bachelor's and above	2010 NSF/NCSES SESTAT NSCG	11,710,000
Social sciences	Bachelor's and above	2010 NSF/NCSES SESTAT NSCG	7,443,000

ACS = American Community Survey; BLS = Bureau of Labor Statistics; NSCG = National Survey of College Graduates; NSF/NCSES = National Science Foundation, National Center for Science and Engineering Statistics; OES = Occupational Employment Statistics Survey; SESTAT = Scientists and Engineers Statistical Data System.

NOTES: Estimates of the S&E workforce vary across the example surveys because of differences in the scope of the data collection (SESTAT surveys collect data from individuals with bachelor's degrees and above only); because of the survey respondent (SESTAT surveys collect data from individuals, OES collects data from establishments, and ACS collects data from households); or because of the level of detail collected on an occupation, which aids in classifying a reported occupation into a standard occupational category. All of these differences can affect the estimates. For example, the SESTAT estimate of the number of workers in S&E occupations includes postsecondary teachers of S&E fields; however, postsecondary teachers in ACS are grouped under a single occupation code regardless of field and are therefore not included in the ACS estimate of the number of workers in S&E occupations.

SOURCES: BLS, 2012 OES; Census Bureau, 2011 ACS; NSF/NCSES, 2010 NSCG, and 2010 SESTAT integrated file.

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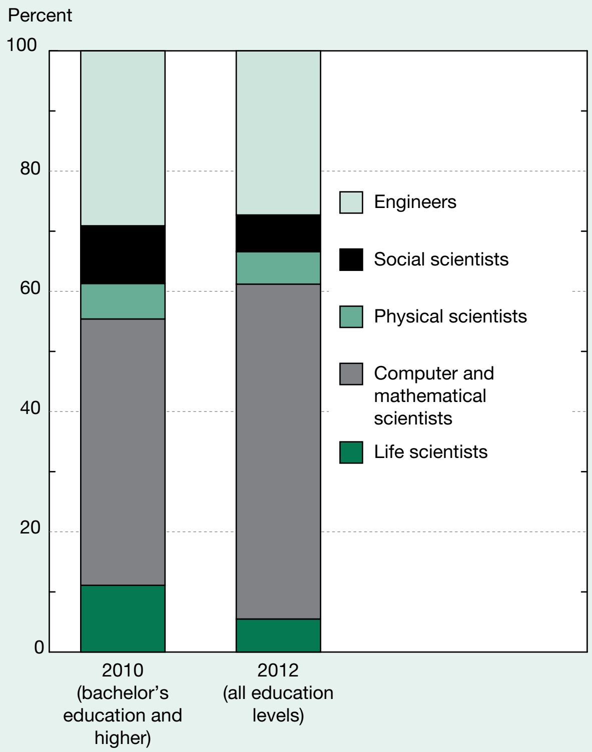
the fact that many of these individuals were employed in occupations not categorized as S&E. This suggests that the application of S&E knowledge and skills is widespread across the U.S. economy and not just limited to S&E occupations.

The extensive use of S&E expertise in the workplace is also evident from the number of college graduates who indicate that their jobs require technical expertise at the bachelor's degree level in S&E fields. According to the 2010 National Survey of College Graduates (NSCG), 16.5 million college graduates reported that their jobs require at least this level of technical expertise in one or more S&E fields (table 3-3). This figure is much higher than the estimated number of college graduates employed in S&E occupations (5.4 million).

Growth of the S&E Workforce

The S&E workforce has grown faster over time than the overall workforce. According to Census Bureau data, employment in S&E occupations grew from about 1.1 million in 1960 to about 5.8 million in 2011.[6] This represents an average annual growth rate of 3.3%, compared to the 1.5% growth in total employment during this period. As a proportion of all employment, S&E occupational employment grew from 1.6% in 1960 to 4.1% in 2011.

Figure 3-1
Employment in S&E occupations, by broad occupational category: 2010 and 2012



SOURCES: Bureau of Labor Statistics, Occupational Employment Statistics Survey, 2012; National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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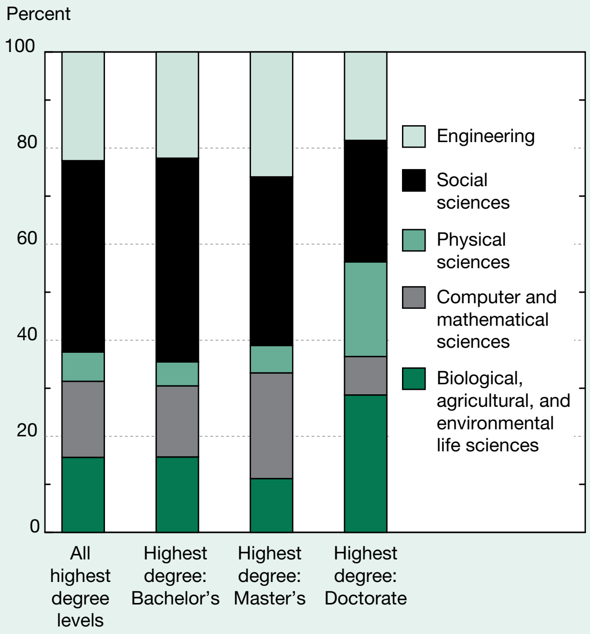
Data from more recent years indicate that trends in S&E employment compared favorably to overall employment trends during and after the 2007–09 economic downturn. OES employment estimates from BLS indicate that the size of the S&E workforce rose slightly from 5.4 million in May 2006 to 5.8 million in May 2009 and then remained relatively steady through May 2012, reaching a level of 6 million. In contrast, the total workforce during this period declined from 133 million in May 2006 to 131 million in May 2009 and then to 130 million in May 2012. The broader STEM aggregate (including S&E technicians, S&E managers, etc.) remained relatively steady at 7.9 million in May 2012, compared with 7.8 million in May 2009 and 7.4 million in May 2006. BLS projects that between 2010 and 2020 S&E occupations—particularly computer and mathematical sciences, life sciences, and social sciences-related occupations—will grow at a faster rate than the total workforce. (See sidebar, "Projected Growth of Employment in S&E Occupations.")

The growth in the number of individuals with S&E degrees in recent years can be examined using data from NSF's SESTAT. The number of S&E highest degree holders employed in the United States grew from 9.6 million to 11.4 million between 2003 and 2010, with most broad fields exhibiting growth (figure 3-3). Similarly, employment in S&E occupations among college degree holders rose from 4.8 million to 5.4 million during this timeframe. Although individuals with advanced degrees beyond the bachelor's level

Figure 3-2
S&E degrees among college graduates, by field and level of highest degree: 2010



NOTE: All degree levels include professional degrees not shown separately.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Projected Growth of Employment in S&E Occupations

The most recent Bureau of Labor Statistics (BLS) occupational projections, for the period 2010–20, suggest that total employment in occupations that NSF classifies as S&E will increase at a faster rate (18.7%) than employment in all occupations (14.3%) (figure 3-A; table 3-A). These projections are based only on the demand for narrowly defined S&E occupations and do not include the wider range of occupations in which S&E degree holders often use their training.

BLS also projects that, for the period 2010–20, job openings in NSF-identified S&E occupations will represent a slightly larger proportion of current employment than openings in all other occupations: 39.6% versus 38.3% (figure 3-B). Job openings include both growth in total employment and openings caused by attrition.

Of the BLS-projected job openings in NSF-identified S&E occupations, 59% are in computer and mathematical scientist occupations, the largest sub-category of S&E occupations (table 3-A). These occupations also have the largest growth rate (23.1%). Life sciences and social sciences occupations, which account for a much smaller proportion of S&E occupations, have the next highest projected growth rates: 20.4% and 18.5%, respectively. Job openings in the social sciences are projected to be particularly high, representing half of the current employment in that field. Physical scientists and engineering occupations are projected to grow at rates slightly lower than the rate for all occupations. Total job openings in physical sciences, however, are expected to represent a larger share of current employment than openings in all occupations.

In addition to S&E occupations, table 3-A also shows selected other occupations that contain significant numbers of S&E-trained workers. Among these, the health care practitioners and technicians occupation, which employs more workers than all S&E occupations combined, is projected to grow at 25.9%, nearly double the rate of growth in all occupations. The postsecondary teachers occupation, which includes all fields of instruction, and the S&E managers occupation are projected to grow 17.4% and 14.0%, respectively, both of which are lower than the projected growth rate in S&E occupations but close to (S&E managers) or higher than (postsecondary teachers) the projected growth rate in all occupations. In contrast, BLS projects that computer programmers and S&E technicians will grow more slowly than all occupations as well as all S&E occupations.

Employment projections are uncertain.[*] Many industry and government decisions that affect hiring are closely linked to national and global fluctuations in aggregate economic activity, which are difficult to forecast long in advance. In addition, technological and other innovations will influence demand for workers in specific occupations. The assumptions underlying projections are sensitive to fundamental empirical relationships, and, as a result, may become less accurate as overall economic conditions change.

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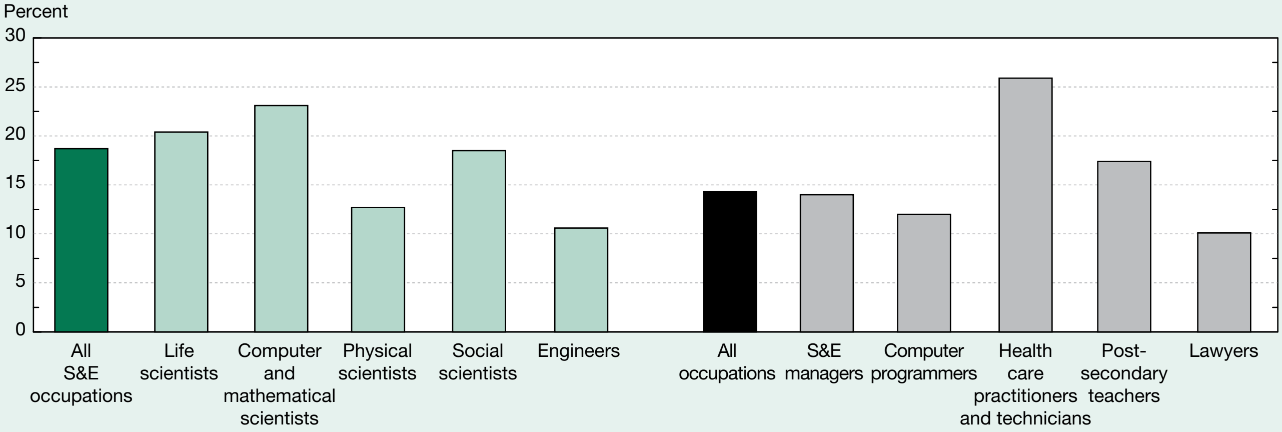
[*] Although BLS does a reasonable job of projecting employment in many occupations, the mean absolute percentage error in the 1996 forecast of employment in detailed occupations in 2006 was 17.6% (Wyatt 2010). The inaccuracies in the 1996 projection of 2006 employment were primarily driven by not projecting the housing bubble and increases in oil prices (Wyatt 2010).

Figure 3-A

Bureau of Labor Statistics projected increases in employment for S&E and selected other occupations: 2010–20



SOURCE: Bureau of Labor Statistics, Employment Projections program, 2010–20, special tabulations (2013) of 2010–20 Employment Projections. See appendix table 3-2.

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Projected Growth of Employment in S&E Occupations—continued

Table 3-A

Bureau of Labor Statistics projections of employment and job openings in S&E and other selected occupations: 2010–20

(Thousands)

Occupation	BLS National Employment Matrix 2010 estimate	BLS projected 2020 employment	Job openings from growth and net replacements, 2010–20	10-year growth in total employment (%)	10-year job openings as percentage of 2010 employment
All occupations	143,068	163,537	54,787	14.3	38.3
All S&E	5,546	6,585	2,197	18.7	39.6
Computer and mathematical scientists	3,157	3,886	1,290	23.1	40.9
Life scientists	286	344	106	20.4	37.1
Physical scientists	282	318	122	12.7	43.2
Social scientists and related occupations	302	358	152	18.5	50.4
Engineers	1,519	1,679	526	10.6	34.6
S&E-related occupations					
S&E managers	534	609	186	14.0	34.8
S&E technicians	808	873	275	8.0	34.1
Computer programmers	363	407	128	12.0	35.3
Health care practitioners and technicians	7,799	9,819	3,591	25.9	46.0
Selected other occupations					
Postsecondary teachers	1,756	2,062	586	17.4	33.4
Lawyers	728	802	212	10.1	29.1

BLS = Bureau of Labor Statistics.

NOTES: Estimates of current and projected employment for 2010–20 are from BLS's National Employment Matrix; data in the matrix are from the Occupational Employment Statistics (OES) survey and the Current Population Survey (CPS). Together, these sources cover paid workers, self-employed workers, and unpaid family workers in all industries, agriculture, and private households. Because data are derived from multiple sources, they can often differ from employment data provided by OES, CPS, or other employment surveys alone. BLS does not make projections for S&E occupations as a group; numbers in the table are based on the sum of BLS projections for occupations that the National Science Foundation considers as S&E. See appendix table 3-2.

SOURCE: BLS, Employment Projections program, 2010–20, special tabulations (2013) of 2010–20 Employment Projections.

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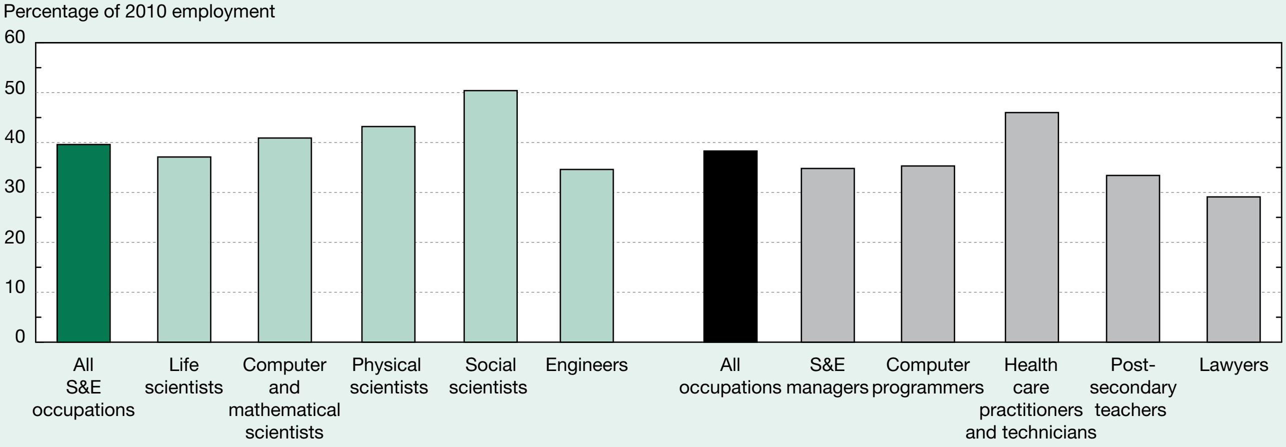
Figure 3-B

Bureau of Labor Statistics projected job openings in S&E and selected other occupations: 2010–20



SOURCE: Bureau of Labor Statistics, Employment Projections program, 2010–20, special tabulations (2013) of 2010–20 Employment Projections. See appendix table 3-2.

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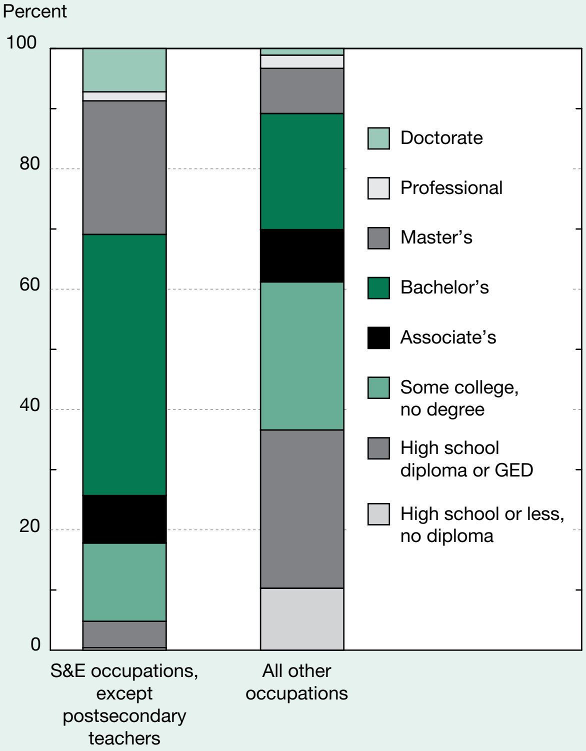
account for a minority of the college graduate population, between 2003 and 2010 the growth in S&E degree holders with advanced degrees generally outpaced the growth in individuals with bachelor's degrees in most broad fields (with the exception of social sciences) (figure 3-3). (See chapter 2 for a fuller discussion of S&E degrees.)

A number of factors likely contributed to the growth in the U.S. S&E labor force over time: the rising demand for S&E skills in a global and highly technological economic landscape; increases in U.S. S&E degrees earned by women, by racial and ethnic minority groups, and by foreign-born individuals; temporary and permanent migration to the United States of those with foreign S&E educations; and the relatively small proportion of scientists and engineers retiring from the S&E labor force. The demographic sections of this chapter provide data on aging and retirement patterns of scientists and engineers as well as on S&E participation by women, by racial and ethnic minorities, and by foreign-born individuals.

Educational Distribution of Workers in S&E Occupations

Workers in S&E occupations have undergone more formal education than the general workforce (figure 3-4). Data from the 2011 ACS indicate that a larger proportion of workers in nonacademic S&E occupations (74%) hold a bachelor's or higher degree than workers in all other occupations (30%).[7] The proportion of workers with advanced degrees beyond the bachelor's level is 31% in S&E occupations, compared to 11% in all other occupations. About 7% of all S&E workers (except postsecondary teachers) have doctorates.

Figure 3-4
Educational attainment, by type of occupation: 2011



GED = General Equivalency Diploma.

SOURCE: Census Bureau, American Community Survey (2011).

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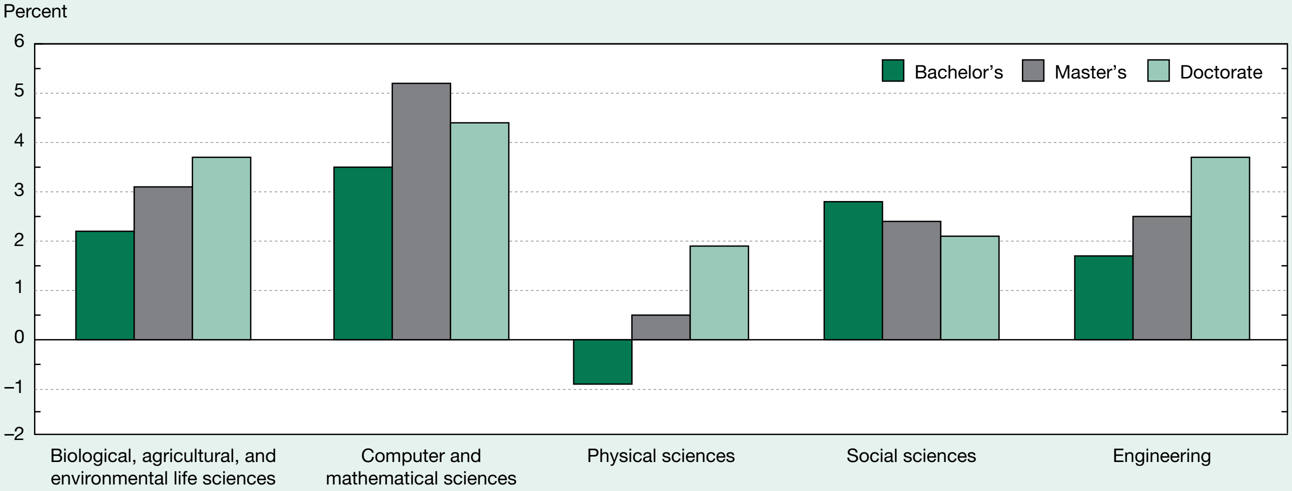
Figure 3-3
Average annual growth in the number of employed individuals whose highest degree is in S&E, by field and level of highest degree: 2003–10



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Science and Engineering Statistical Data System (SESTAT) (2003 and 2010), http://sestat.nsf.gov.

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Compared with the rest of the workforce, a very small minority of those employed in S&E occupations have only a high school degree. Many individuals enter the S&E workforce with marketable technical skills from technical or vocational schools (with or without an earned associate's degree) or college courses, and many acquire these skills through workforce experience or on-the-job training. In information technology, and to some extent in other occupations, employers frequently use certification exams, not formal degrees, to judge skills. (See sidebar, "The U.S. S&E Workforce Without a Bachelor's Degree" and the discussion in chapter 2.)

According to the 2010 SESTAT data, the vast majority (81%) of college graduates employed in S&E occupations have at least one S&E degree (table 3-4), suggesting that formal S&E training is the usual pathway for obtaining employment in these occupations. However, the importance of formal S&E training in the same broad field as one's S&E occupation varies across occupational categories. Among computer and mathematical scientists, for example, less than half (44%) have a bachelor's or higher level degree in the field of computer and mathematical sciences. The proportion is significantly higher in other broad S&E occupational categories: 73% of life scientists, 72% of physical scientists, 77% of social scientists, and 81% of engineers have a bachelor's or higher level degree in their respective broad field. Slightly more than one-fourth (28%) of computer and mathematical scientists do not have any S&E degree. The next section presents data on the proportion of S&E degree holders who obtain employment in S&E and non-S&E occupational categories.

The U.S. S&E Workforce Without a Bachelor's Degree

Although the Scientists and Engineers Statistical Data System (SESTAT) provides detailed information on college graduate scientists and engineers, it lacks similar data on individuals who do not have a bachelor's degree. The Census Bureau's American Community Survey (ACS) provides nationally representative occupational data for workers at all levels of education.[*] In 2011, about one-fourth of S&E workers age 25 and older did not have a bachelor's degree. This sidebar looks at the demographic, educational, and employment characteristics of these S&E workers without a bachelor's degree.[†]

Relative to college graduate workers employed in S&E occupations, a disproportionate number of those without a bachelor's degree employed in S&E occupations were black or Hispanic and native U.S. born. In 2011, about 9% of S&E workers without a bachelor's degree were black, and another 9% were Hispanic. In contrast, 6% of college-educated S&E workers were black and 5% were Hispanic. Asians represented only 3% of S&E workers without a bachelor's degree, compared to 19% of S&E workers with a bachelor's degree. In 2011, only 8% of S&E workers without a college degree were foreign born, compared to about one-fourth of college-educated S&E workers.

S&E workers without a bachelor's degree were mostly concentrated in computer occupations, with 69% employed in the field. In comparison, 44% of the college-educated S&E workers held computer jobs. Among computer occupations, computer support specialists, network and computer systems administrators, and other computer occupations together represented about half of the S&E workers without a bachelor's degree employed in computer occupations. Unlike the computer field, life sciences, physical sciences, and social sciences occupations had much smaller proportions of workers without a bachelor's degree. About 3% of the S&E workforce without a bachelor's degree were employed in these areas combined, compared to about one-fifth of the college-educated S&E workforce.

Relative to other occupations, S&E occupations provide stable employment with good earnings for workers without a college degree. In 2011, the median earnings among workers 25 years of age and older, without a bachelor's degree, and employed in S&E occupations ($60,000) was twice as high as the median earnings among comparable workers employed in other occupations ($30,000). The unemployment rate among these workers in S&E occupations was 6%, about half the rate in other occupations (11%).

Workers employed in S&E occupations had more formal training (even if they did not have a bachelor's degree) than those employed in other occupations, so it is not surprising that salaries were higher in S&E jobs. About one-third of the workers without a bachelor's degree employed in S&E occupations had an associate's degree, compared to 14% of those employed in other occupations.

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[*] For methodological reasons, estimates from ACS and SESTAT differ slightly even for the college graduate population, which both surveys cover. For example, the two surveys vary in the level of detail collected on work activities, which affects how workers are coded into standard occupational categories. In addition, ACS collects data from households, whereas SESTAT collects data from individuals. Finally, the analysis using ACS data counts postsecondary teachers of S&E as working in non-S&E occupations because the Census Bureau data do not identify them by field.

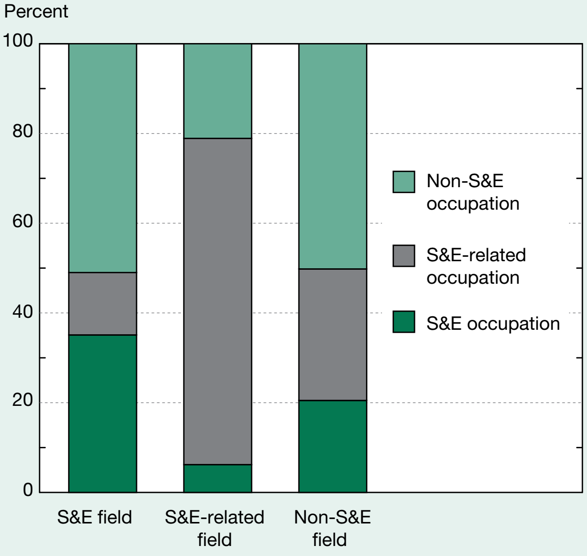
[†] This sidebar defines the S&E workforce by workers in S&E occupations (except postsecondary teachers in S&E fields). The ACS data do not allow for separate identification of postsecondary teachers by fields. See appendix table 3-1 for a list of S&E occupations in the 2011 ACS.

Occupational Distribution of S&E Degree Holders and Relationship between Jobs and Degrees

NSF's SESTAT provides information on the degree and occupational choices of scientists and engineers in the United States, thus enabling a comparison of the interplay between degree and occupation for members of the S&E workforce with and without a highest degree in an S&E discipline. Although an S&E degree is often necessary to obtain S&E employment, the data indicate that many individuals with S&E degrees pursue careers outside of S&E. The majority of workers with S&E training who work in non-S&E jobs reported that their work is nonetheless related to their S&E training, suggesting that the application of S&E skills and expertise extends well beyond the jobs NSF classifies as S&E. (The next section, "S&E Workers in the Economy," provides data on R&D activity of scientists and engineers employed in S&E and non-S&E occupations.)

Only about half of S&E highest degree holders are employed in an S&E (35%) or S&E-related (14%) occupation; the rest are employed in non-S&E occupations. Figure 3-5 shows the occupational distribution of the S&E workforce with S&E, S&E-related, and non-S&E highest degrees. The largest category of non-S&E jobs for S&E highest degree holders is management and management-related occupations (2.1 million workers), followed by sales and marketing occupations (995,000 workers) (appendix table 3-3). Other non-S&E occupations with a large number of S&E-trained workers include social services occupations (400,000) and

Figure 3-5
Occupational distribution of scientists and engineers, by broad field of highest degree: 2010



NOTE: Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Table 3-4
Educational background of college graduates employed in S&E occupations, by broad S&E occupational category: 2010
(Percent)

Educational background	All S&E occupations	Biological, agricultural, and environmental life scientists	Computer and mathematical scientists	Physical scientists	Social scientists	Engineers
Total (*n*)	5,398,000	597,000	2,394,000	320,000	518,000	1,569,000
At least one S&E degree	81.1	86.3	72.1	96.9	81.9	89.5
At least one S&E degree in field	81.1	73.2	44.2	72.2	76.8	81.0
Highest degree in field	74.1	66.3	40.1	66.3	67.4	73.4
All degrees in S&E	69.3	71.4	61.8	88.1	56.2	80.5
No S&E degrees but at least one S&E-related degree	4.7	7.4	4.6	2.5	2.1	5.1
No S&E or S&E-related degree but at least one non-S&E degree	14.2	6.5	23.4	0.6	16.0	5.3

NOTES: At least one S&E degree in field is the proportion of workers in a particular S&E occupational category with at least one degree in the same broad field. Highest degree in field is the proportion of workers in a particular S&E occupational category with highest degree in the same broad field. For example, among computer and mathematical scientists, these data refer to the proportion with at least one college-level or higher degree in the broad field of computer and mathematical sciences and the proportion with highest degree in the broad field of computer and mathematical sciences, respectively. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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college and precollege teaching in non-S&E areas (358,000). S&E highest degree holders also work in S&E-related jobs (14%) such as health occupations (532,000), S&E managerial positions (417,000), S&E technicians or technologists positions (405,000), and precollege teaching in S&E areas (196,000).

Most individuals who have S&E highest degrees but are not working in S&E occupations do not see their field of highest degree as entirely irrelevant to their work. Rather, most indicate that their jobs are either closely (35%) or somewhat (32%) related to their highest degree field (table 3-5). Among S&E highest degree holders in non-S&E managerial and management-related occupations, for example, 33% indicate that their jobs are closely related, and another 40% say that their jobs are somewhat related, to their S&E degree. Among those in social services and related occupations, 73% say that their jobs are closely related, and another 21% say that their jobs are somewhat related, to their S&E degree. Among workers in sales and marketing, 50% characterize their jobs as closely or somewhat related to their S&E degree.

Unlike members of the S&E workforce with an S&E highest degree, half or more of the S&E workforce with S&E-related or non-S&E highest degrees obtain employment in their respective broad occupational category (figure 3-5). For those with an S&E-related highest degree, the largest category of jobs is health occupations (3.2 million); for those with a non-S&E highest degree, the largest category of jobs is management and management-related occupations (862,000) (appendix table 3-3). Significant numbers of the S&E workforce with a non-S&E highest degree also work in health occupations (604,000), in precollege teaching in S&E areas (536,000), or as lawyers or judges (571,000).

The pattern of significant proportions of S&E highest degree holders obtaining employment in areas other than S&E occupations has been robust over time. SESTAT data from 1993 indicate that 36% of all scientists and engineers with S&E highest degrees were employed in S&E occupations, and the rest held positions in areas other than S&E.

The proportion of S&E highest degree holders who go on to work in S&E occupations varies substantially by S&E degree fields and levels. Individuals with social sciences highest degrees are the least likely to work in S&E occupations; these individuals primarily obtain non-S&E employment (figure 3-6). Only about 13% of social sciences highest degree holders work in S&E occupations, whereas 80% work in non-S&E occupations. Similar proportions of life sciences highest degree holders work in S&E occupations (30%) and in S&E-related occupations (26%) such as health occupations, and less than half (44%) work in non-S&E occupations. In contrast, individuals with computer and mathematical sciences (54%), physical sciences (51%), or engineering (58%) highest degrees are much more likely to work in S&E occupations. Computer and mathematical sciences highest degree holders are the most likely to obtain employment in the broad S&E field in which they were trained (51%), whereas social sciences highest degree holders are the least likely to do so (8%).

This pattern of field differences generally characterizes individuals whose highest degree is at either a bachelor's or master's degree level. At the doctoral level, the size of these field differences shrinks substantially (figure 3-7). S&E doctorate holders most often work in an S&E occupation similar to their doctoral field.

Whereas figure 3-7 shows the proportion of S&E degree holders employed in S&E occupations, figure 3-8 shows the proportion of S&E degree holders (regardless of occupational categories) who reported that their work is related to their S&E degree. Workers with more advanced S&E training are more likely than those with only bachelor's level degrees to work in a job that is related to their field of highest degree. Up to 5 years after receiving their degrees, 97% of S&E doctorate holders say that they have jobs closely or somewhat related to their degree field, compared with 92% of master's degree holders and 73% of bachelor's degree holders (figure 3-8). In general, higher proportions of employed individuals with natural sciences and engineering highest degrees compared with those with social sciences highest degrees

Table 3-5

Relationship of highest degree to job among S&E highest degree holders not in S&E occupations, by degree level: 2010

Highest degree	Workers (*n*)	Degree related to job (%) Closely	Somewhat	Not
All degree levels[a]	7,386,000	35.2	32.4	32.4
Bachelor's	5,902,000	31.1	33.1	35.8
Master's	1,242,000	51.8	28.7	19.5
Doctorate	236,000	49.6	34.3	16.1

[a] Includes professional degrees not broken out separately.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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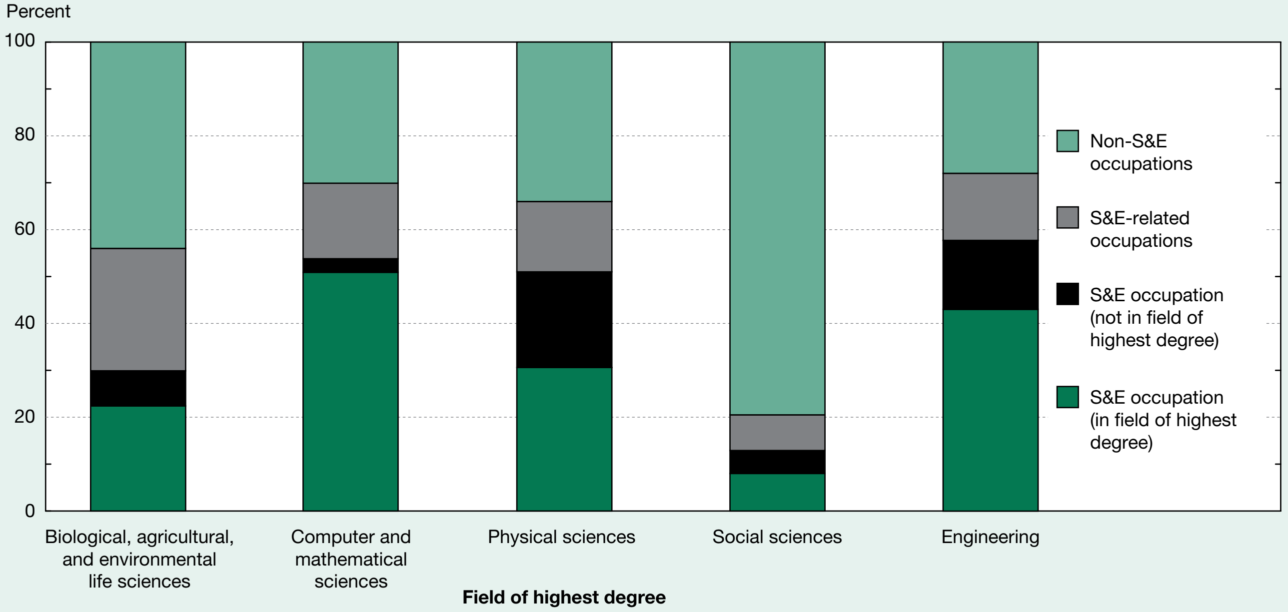
Figure 3-6
Occupational distribution of S&E highest degree holders, by field of highest degree: 2010



NOTES: Detail may not add to total because of rounding. For each broad S&E highest degree field, S&E occupation (in field of highest degree) includes individuals who report being employed in an occupation in the same broad category. For example, for highest degree holders in computer and mathematical sciences, S&E occupation (in field of highest degree) includes those who report computer or mathematical sciences as their occupation, and S&E occupation (not in field of highest degree) includes those who report an S&E occupation other than computer or mathematical sciences occupations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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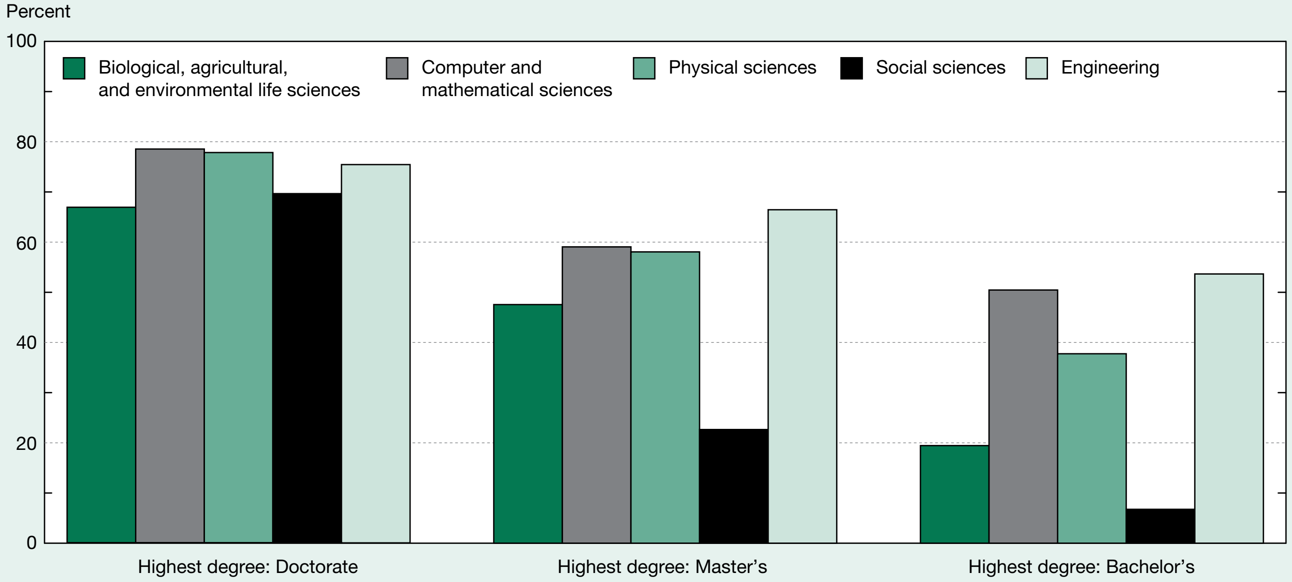
Figure 3-7
S&E degree holders working in S&E occupations, by level and field of S&E highest degree: 2010



NOTE: Individuals may have degrees in more than one S&E degree field.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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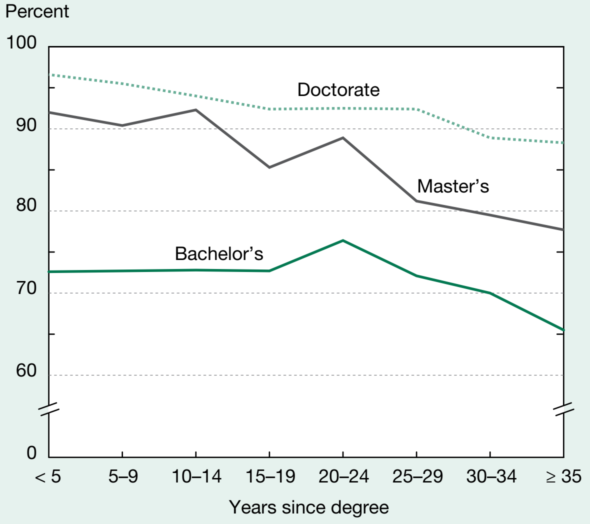
indicate that their jobs are related to their field of highest degree. Thus, among the SESTAT population of scientists and engineers in 2010, 75% of life sciences highest degree holders, 77% of physical sciences highest degree holders, 87% of computer and mathematical sciences highest degree holders, and 88% of engineering highest degree holders reported that their jobs were either closely or somewhat related to their highest degree field compared with 66% of social sciences highest degree holders. This is not surprising given that individuals trained in the social sciences most often obtain employment in non-S&E occupations.

The pattern of a stronger relationship between S&E jobs and S&E degrees at higher degree levels is robust across career stages, as seen in comparisons among groups of bachelor's, master's, and doctoral degree holders at comparable numbers of years since receiving their degrees (figure 3-8). For each group, the relationship between job and field of highest degree becomes weaker over time. Possible reasons for this decline include changes in career interests, development of skills in different areas, promotion to general management positions, or realization that some of the original training has become obsolete. Despite these potential factors, the career-cycle decline in the relevance of an S&E degree appears modest.

Figure 3-8
S&E degree holders employed in jobs related to highest degree, by level of and years since highest degree: 2010



NOTE: Data include those who report their job is either closely related or somewhat related to the field of their highest degree.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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S&E Workers in the Economy

To understand the economic and scientific contributions of scientists and engineers, it is important to know how they are distributed across the economy and what kind of work they perform. This section examines the characteristics of organizations that employ scientists and engineers, including sector and size of employing organizations. This section also describes the distribution of S&E workers within particular sectors. The data indicate that individuals trained in S&E fields or working in S&E occupations are found in all sectors, including for-profit businesses; non-profit organizations; public and private educational institutions; and local, state, and federal government. This section also examines self-employed scientists and engineers, as well as the concentration of S&E workers by industry sectors and by geography.

The S&E labor force is often seen as a major contributor to innovation. Work such as patenting activity, R&D activity, and work-related training are indicators of worker skill level, productivity, and innovative capacity. In addition to collecting information on formal education and employment, SESTAT gathers data on the degree to which workers engage in such activities. This section concludes with data on these activities.

Throughout this section, data are provided for the broad SESTAT population of scientists and engineers, including those employed in S&E or S&E-related occupations as well as those with S&E or S&E-related bachelor's or higher level degrees. Whenever possible, the data distinguish between individuals with S&E degrees and those working in S&E occupations.

Employment Sectors

The business sector is by far the largest employer of the broad S&E workforce covered by SESTAT, employing about 70% of individuals trained or working in S&E in 2010 (table 3-6). The education sector, including private and public institutions, employs 19% of the SESTAT population of scientists and engineers, and the government sector, including federal, state, and local government, employs another 11%. Within the business sector, for-profit businesses account for a larger number of scientists and engineers than non-profit organizations or the self-employed; within the education sector, 2-year and precollege institutions employ a larger number of scientists and engineers than 4-year institutions.

The relative distribution in the business, education, and government sectors has remained relatively stable since the early 1990s (figure 3-9). Nonetheless, some minor shifts occurred between 1993 and 2010:

- The proportion of scientists and engineers working in 4-year educational institutions dropped slightly (from 9.3% to 7.9%).

Table 3-6
Employment sector of scientists and engineers, by broad occupational category and degree field: 2010

Employment sector	All employed scientists and engineers	Highest degree in S&E	S&E occupations	S&E-related occupations	Non-S&E occupations
Total (*n*)	21,903,000	11,385,000	5,398,000	6,957,000	9,549,000
Business/industry (%)	69.8	71.8	70.3	68.3	70.7
For-profit businesses	52.5	58.6	62.1	45.3	52.3
Nonprofit organizations	10.7	7.0	4.6	17.6	9.1
Self-employed, unincorporated businesses	6.6	6.2	3.6	5.4	9.3
Education (%)	19.0	15.5	17.6	23.0	16.9
4-year institutions	7.9	8.6	14.3	7.4	4.7
2-year and precollege institutions	11.1	6.9	3.3	15.7	12.2
Government (%)	11.2	12.6	12.2	8.7	12.4
Federal	4.5	5.4	6.3	3.7	4.2
State/local	6.6	7.3	5.9	5.0	8.2

NOTE: Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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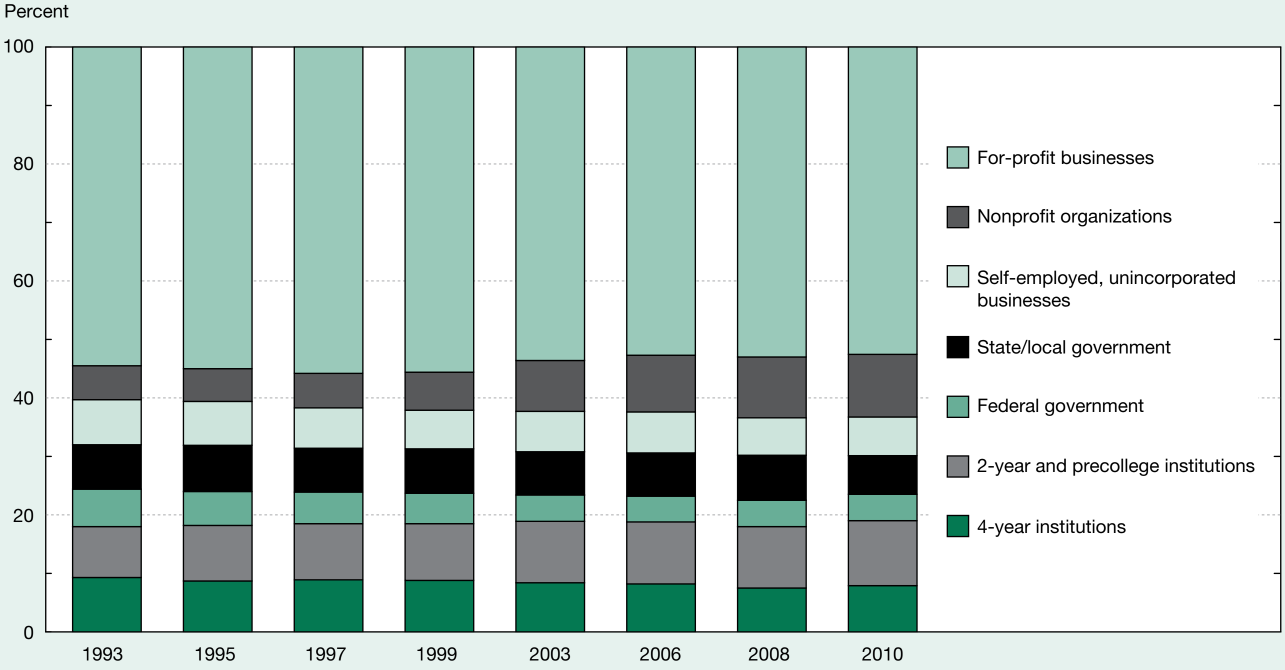
Figure 3-9
Employed scientists and engineers, by employment sector: 1993–2010



NOTES: During 1993–99, scientists and engineers include those with one or more S&E degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E occupation. During 2003–10, scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (1993–2010), http://sestat.nsf.gov.

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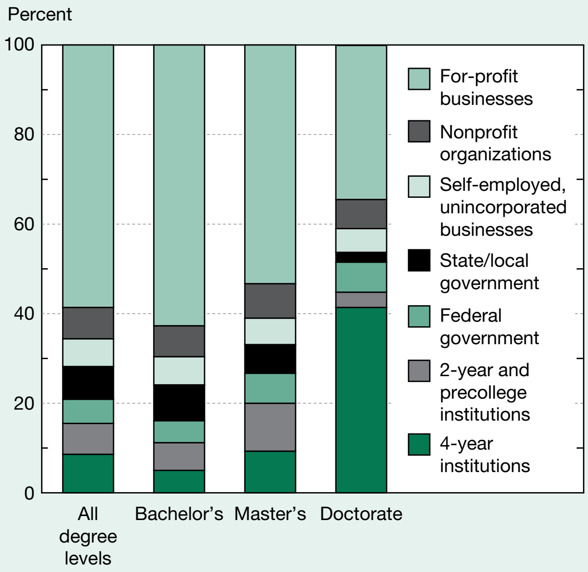
- The proportion of scientists and engineers working in the federal government declined by almost one-third (from 6.4% to 4.5%).
- The proportion of scientists and engineers working in the non-profit sector nearly doubled (from 5.8% to 10.7%).

Some differences exist in the concentration of particular groups of S&E workers across employment sectors. For example, academic institutions are the largest employer of the SESTAT population with doctorates, even though the business sector is the largest employer of the overall SESTAT population. Whereas individuals employed in engineering occupations and computer and mathematical sciences occupations are largely concentrated in the business sector, those employed as life scientists and social scientists are more evenly distributed between the business and education sectors. The following discussion provides a deeper analysis of the economic sectors in which scientists and engineers work.

Education Sector

Overall, the education sector employs nearly one-fifth of the broad S&E workforce covered by SESTAT (table 3-6). Depending on the population, however, the proportion working within different parts of the education sector varies. For example, within the education sector, the vast majority of S&E highest degree holders whose highest degree is at the doctoral level work in 4-year institutions, but the majority of those whose highest degree is at the bachelor's level work in 2-year and precollege institutions (figure 3-10; appendix table 3-4). In addition to tenure or tenure-track faculty, the doctorate population in the education sector includes individuals who hold postdoctoral appointments and other temporary positions, work in various other S&E teaching and research jobs, perform administrative functions, and are employed in a wide variety of non-S&E occupations. (See chapter 5 for additional details on academic employment of science, engineering, and health [SEH] doctorates.)

Figure 3-10
S&E highest degree holders, by degree level and employment sector: 2010



NOTE: All degree levels include professional degrees not reported separately.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Of scientists and engineers who are employed in S&E occupations, 18% work in the education sector (table 3-6). Within the education sector, the majority of those employed in S&E occupations are concentrated in 4-year institutions (81%). In comparison, the great majority of workers in S&E-related or non-S&E occupations in the education sector are found in 2-year and precollege institutions (68% and 72%, respectively). These workers in these types of institutions are primarily teachers. Within S&E occupations, larger proportions of life, physical, and social scientists work in the education sector than engineers or computer and mathematical scientists (figure 3-11).

Business Sector

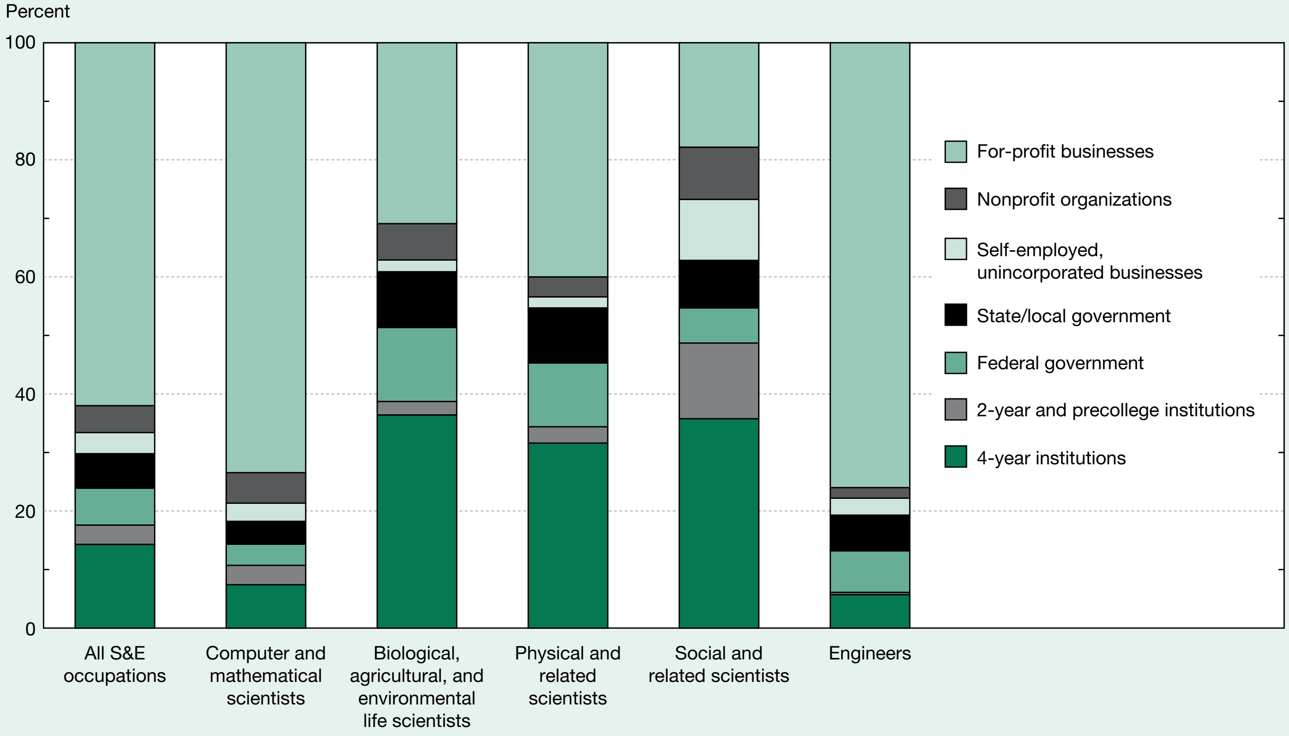
For-profit businesses. For-profit businesses employ the largest proportion of scientists and engineers (table 3-6). For the broad SESTAT population with doctorates, however, for-profit businesses are second to 4-year educational institutions (figure 3-10; appendix table 3-4). Approximately three-fourths of scientists and engineers working in computer and mathematical sciences occupations (73%) and in engineering occupations (76%) are employed by for-profit businesses. The proportions are much lower for those in other S&E occupations, ranging from 18% for social scientists to 40% for physical scientists (figure 3-11).

Non-profit organizations. Non-profit organizations have shown substantial growth in the percentage of scientists and engineers that they employ (figure 3-9). This growth is driven primarily by those working in S&E-related occupations, which include health-related jobs. Among all scientists and engineers employed in S&E-related occupations, 18% work in non-profit organizations (table 3-6). Among those in S&E occupations, the proportion working in non-profit organizations is much smaller (5%), although the proportion varies significantly across S&E occupational categories: from 2% of engineers to 9% of social scientists are employed by these organizations (figure 3-11).

Self-employment. In 2010, almost 4.2 million scientists and engineers (19%) reported being self-employed in either an unincorporated or incorporated business, professional practice, or farm (table 3-7).[8] Scientists and engineers working in S&E-related or non-S&E occupations reported higher levels of self-employment (18% and 24%, respectively) than those working in S&E occupations (12%). Among S&E highest degree holders, those with professional degrees

Figure 3-11

Broad S&E occupational categories, by employment sector: 2010



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010) http://sestat.nsf.gov.

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Table 3-7

Self-employed scientists and engineers, by education, occupation, and type of business: 2010

(Percent)

Characteristic	Total	Unincorporated business	Incorporated business
All self-employed scientists and engineers	19.0	6.6	12.4
Highest degree in S&E field	17.9	6.2	11.7
Biological, agricultural, and environmental life sciences	17.8	6.3	11.5
Computer and mathematical sciences	14.8	4.5	10.3
Physical sciences	17.3	5.9	11.4
Social sciences	18.9	7.8	11.1
Engineering	18.7	4.7	14.0
S&E highest degree level			
Bachelor's	19.4	6.3	13.1
Master's	14.7	5.9	8.8
Doctorate	11.7	5.3	6.4
Professional	47.8	39.1	8.7
Occupation			
S&E occupation	12.0	3.6	8.4
Biological, agricultural, and environmental life scientists	6.2	2.0	4.2
Computer and mathematical scientists	11.7	3.1	8.6
Physical scientists	7.5	1.9	5.6
Social scientists	16.4	10.4	6.0
Engineers	14.1	2.9	11.2
S&E-related occupations	18.4	5.4	13.0
Non-S&E occupations	23.5	9.3	14.2

NOTE: Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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reported significantly higher rates of self-employment (48%) than those with a bachelor's degree (19%), master's degree (15%), or doctorate (12%) as their highest degree.

Incorporated businesses account for the majority of self-employed scientists and engineers, with the exception of those with a highest degree at the professional level or those in social sciences occupations, who primarily work in unincorporated businesses (table 3-7). The higher levels of unincorporated self-employment among social scientists and professional degree holders are largely driven by psychologists. About one-third of those working as psychologists (32%) are self-employed, mostly in unincorporated businesses. Nearly half of those whose highest degree at the professional level is in a field of psychology (48%) are self-employed, again primarily in unincorporated businesses.

Government Sector

Federal government. The U.S. federal government is a major employer of scientists and engineers. According to data from the U.S. Office of Personnel Management, in 2012 the federal government employed approximately 325,000 persons in S&E occupations, which represents about 15% of the federal civilian workforce. Federal workers in S&E jobs are almost evenly distributed among computer and mathematical sciences occupations (33%); engineering occupations (32%); and life sciences, physical sciences, and social sciences occupations (36%).[9] The vast majority (80%) of the federal workers in S&E occupations have a bachelor's or higher level degree.

The five federal agencies with the largest proportions of scientists and engineers in their workforce are those with strong scientific missions: the National Aeronautics and Space Administration (NASA) (65%), the Nuclear Regulatory Commission (NRC) (62%), the Environmental Protection Agency (EPA) (60%), NSF (40%), and the Department of Energy (33%). The Department of Defense employs the largest number of scientists and engineers (150,000), accounting for 46% of the federal S&E workforce.[10]

Among federal workers hired in 2012, about 9% were in S&E occupations. Nearly one-third of these newly hired workers were in occupations related to information technology.

State and local government. In 2010, SESTAT estimated that almost 1.5 million scientists and engineers (7%) were working in state and local governments in the United States (table 3-6). Public educational institutions, which are included in the education sector, are not included in this statistic. The state and local government sector hires a larger proportion of scientists and engineers with bachelor's or master's degrees than of those with doctorates (figure 3-10). Approximately 6% of scientists and engineers employed in S&E occupations are employed by state and local governments (table 3-6). Within S&E occupations, larger proportions of life scientists, physical scientists, social scientists, and engineers work in state and local governments relative to computer and mathematical scientists (figure 3-11).

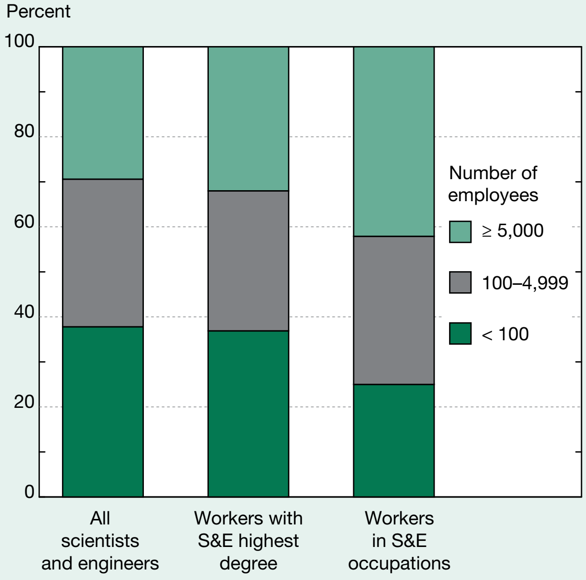
Employer Size

The vast majority of educational institutions and government entities that employ individuals trained in S&E fields or working in S&E occupations are larger employers (i.e., having 100 or more employees). These large organizations employ 88% of scientists and engineers in the education sector and 92% of those in the government sector. In contrast, scientists and engineers working in the business sector are more broadly distributed across firms of many sizes (figure 3-12; appendix table 3-5).

Workers employed in the business sector in S&E occupations are more densely concentrated in larger firms than the broad SESTAT population or even than all those with S&E highest degrees (figure 3-12; appendix table 3-5). The largest firms (those with 5,000 or more employees) employ 42% of college-educated workers in S&E occupations, compared to 30% of the broad SESTAT population. The proportion in firms with 100 or more employees is 75% for S&E occupations compared with 62% for all scientists and engineers. Within the business sector, workers at different degree levels are distributed similarly across firms of different sizes (figure 3-13).

Many scientists and engineers who are self-employed work in businesses with 10 or fewer employees. In all, 82% of self-employed individuals in unincorporated businesses and 41% of self-employed individuals in incorporated businesses

Figure 3-12
Scientists and engineers employed in the business sector, by employer size: 2010



NOTE: Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher, or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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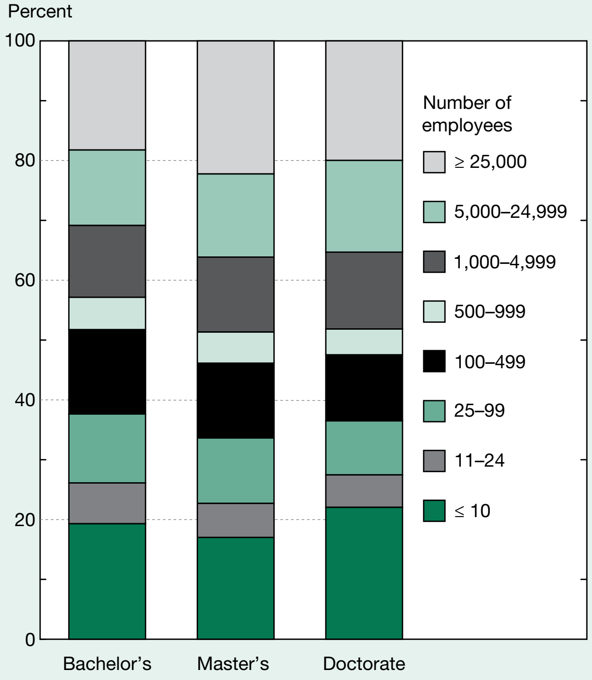
work in businesses with 10 or fewer employees. In contrast, only 5% of all other scientists and engineers work in businesses with 10 or fewer employees. Many of these scientists and engineers likely think of themselves as independent professionals rather than small business owners.

Industry Employment

The OES survey provides detailed estimates for employment in S&E occupations by type of industry; however, it excludes the self-employed and those employed in agriculture and in recent startups. Industries vary in their proportions of S&E workers (table 3-8). In 2012, the industry group with the largest S&E employment was professional, scientific, and technical services, which employed about 1.8 million (31%) S&E workers, followed by manufacturing, which employed 887,000 (15%) S&E workers (table 3-8). The government, which includes federal, state, and local government, employed 636,000 (11%) S&E workers; educational services, which includes private and public educational institutions, employed another 684,000 (12%) S&E workers. These four industry groups—professional, scientific, and technical services; manufacturing; government; and educational services—had a disproportionate concentration of S&E jobs. Together, these industry groups employed about two-thirds of all workers in S&E occupations (68%), compared with one-third of workers in all occupations (32%).

Figure 3-13
S&E highest degree holders employed in the business sector, by highest degree level and employer size: 2010



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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S&E employment intensity, defined by an industry's S&E employment as a proportion of its total employment, was highest in professional, scientific, and technical services (24%) followed by information (17%) and management of companies and enterprises (13%) (table 3-8). The broad industry groups with S&E employment intensity below the national average (4.6%) together employed 59% of all workers in 2012 but only 14% of workers in S&E occupations. These groups with S&E employment intensity below the national average include large employers such as health care and social assistance, retail trade, and accommodation and food services.

Employment by Metropolitan Area

The availability of a skilled workforce is an important predictor of a region's population, productivity, and technological growth (Carlino, Chatterjee, and Hunt 2001; Glaeser and Saiz 2003). The federal government uses standard definitions to describe geographical regions in the United States for comparative purposes. It designates very large metropolitan areas, sometimes dividing them into smaller metropolitan divisions that can also be substantial in size (Office of Management and Budget 2009).

This section presents the following indicators of the availability of S&E workers in a metropolitan area: (1) the number of S&E workers in the metropolitan area or division, (2) the proportion of the entire metropolitan area workforce in S&E occupations, and (3) the proportion of the nationwide S&E workforce in the metropolitan area. Data on the metropolitan areas with the largest proportion of workers in S&E occupations appear in table 3-9. These estimates are affected by the geographic scope of each metropolitan area, which can vary significantly. In particular, comparisons between areas can be strongly affected by how much territory outside the urban core is included in the metropolitan area.

S&E employment in the United States is geographically concentrated; that is, a small number of geographic areas account for a significant proportion of S&E jobs. For example, the 20 metropolitan areas listed in table 3-9 account for 18% of nationwide employment in S&E jobs, compared to about 8% of employment in all occupations.

Scientists and Engineers and Innovation-Related Activities

Who Performs R&D?

Because R&D creates new types of goods and services that can fuel economic and productivity growth and enhance living standards, individuals with S&E expertise who use their knowledge in R&D attract special interest. This section uses SESTAT data to examine the R&D activity of scientists and engineers. In this section, R&D activity is defined as the proportion of workers who reported basic research, applied research, design, or development as a primary or secondary work activity in their principal job (i.e., activities

Table 3-8
Employment in S&E occupations, by major industry sector: May 2012

Industry sector	Workers employed (*n*) All occupations	Workers employed (*n*) S&E occupations	U.S. total S&E employment in industry (%)	Industry workforce in S&E occupations (%)
U.S. total—all industries	130,287,700	5,968,240	100	4.6
Agriculture, forestry, fishing, and hunting	393,840	1,110	0.0	0.3
Mining	783,110	62,260	1.0	8.0
Utilities	552,750	49,160	0.8	8.9
Construction	5,611,950	53,070	0.9	0.9
Manufacturing	11,866,540	887,060	14.9	7.5
Wholesale trade	5,623,510	235,120	3.9	4.2
Retail trade	14,982,710	50,970	0.9	0.3
Transportation and warehousing	5,014,660	41,070	0.7	0.8
Information	2,688,380	446,310	7.5	16.6
Finance and insurance	5,535,000	299,180	5.0	5.4
Real estate, rental, and leasing	1,928,950	12,110	0.2	0.6
Professional, scientific, and technical services	7,768,610	1,831,940	30.7	23.6
Management of companies and enterprises	2,003,680	259,200	4.3	12.9
Administrative and support and waste management and remediation	7,991,260	180,950	3.0	2.3
Educational services	12,683,810	683,510	11.5	5.4
Health care and social assistance	17,720,090	187,780	3.1	1.1
Arts, entertainment, and recreation	1,937,910	9,050	0.2	0.5
Accommodation and food services	11,675,540	2,570	0.0	0.0
Other services (except federal, state, and local government)	3,809,410	40,030	0.7	1.1
Federal, state, and local government (OES designation)	9,716,010	635,760	10.7	6.5

OES = Occupational Employment Statistics.

NOTES: Industries are defined by the North American Industry Classification System (NAICS). The OES Survey does not cover employment among self-employed workers and employment in the following industries: crop production (NAICS 111); animal production (NAICS 112); fishing, hunting, and trapping (NAICS 114); and private households (NAICS 814). As a result, the data do not represent total U.S. employment. Differences between any two industry sectors may not be statistically significant.

SOURCE: Bureau of Labor Statistics, OES Survey (May 2012).

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that rank first or second in total work hours from a list of 14 activities).[11]

The SESTAT data from 2010 indicate that 27% of employed scientists and engineers reported R&D as a primary or secondary work activity. However, the proportion who do so varies substantially across occupations and degrees (figure 3-14). In general, SESTAT respondents employed in S&E occupations are the most likely to perform R&D as a primary or secondary work activity (57%), but a considerable proportion of those in S&E-related (21%) or non-S&E occupations (16%) also reported R&D as a primary or secondary activity. This indicates that R&D activity spans a broad range of occupations.

Nearly half of the scientists and engineers who have a highest degree in a non-S&E field but are employed in an S&E job reported R&D activity (47%), although they did so less often than those who have a highest degree in an S&E field and are employed in an S&E job (60%). Many S&E degree holders subsequently earn degrees in other fields, such as medicine, law, or business. The SESTAT data from 2010 indicate that the majority of scientists and engineers (67%) with a highest degree in a non-S&E field also obtained other degrees in S&E or S&E-related fields.

Those with doctorates account for a disproportionate segment of R&D performers. These individuals constitute only 5% of all SESTAT respondents but 11% of SESTAT respondents who reported R&D as a major work activity. However, the majority of R&D performers in the S&E workforce have bachelor's (53%) or master's (32%) degrees.

Among the SESTAT population employed in S&E occupations, life scientists (75%) reported the highest rates of R&D activity, whereas social scientists (49%) and computer and mathematical scientists (46%) reported the lowest rates (table 3-10). In most occupations, those with doctorates indicated higher rates of R&D activity than those with a bachelor's or master's degree as their highest degree (table 3-10).[12]

SEH doctorate holders in later career stages reported lower rates of R&D activity than those in earlier career stages (figure 3-15). Thus, 55% of those who received their SEH doctorate in 1990 or earlier reported R&D activity in 2010, compared to 67% of those who received their doctorates between 1991 and 2009. The decline in R&D activity over the course of individuals' careers may reflect movement into management, growth of other career interests, or possession of scientific knowledge and skills that are no longer in demand. It may also reflect increased opportunity for more experienced scientists to perform functions involving the interpretation and use of, as opposed to the creation and development of, scientific knowledge.

For the most part, scientists and engineers performing R&D activity are distributed similarly across broad employment sectors as scientists and engineers who do not perform R&D as a primary or secondary work activity. About 70% of scientists and engineers in each group are employed in the business sector (68% and 71%, respectively), about 20% are employed in the education sector (21% and 18%, respectively), and 11% are employed in the government sector. However, within the education sector, 4-year institutions employ 66% of SESTAT respondents who perform R&D as a primary or secondary work activity, compared to 31% of those who do not.

Patenting Activity

The U.S. Patent and Trademark Office (USPTO) grants patents to inventions that are new, useful, and not obvious. Patenting is a limited but useful indicator of the inventive activity of scientists and engineers. Not all patent applications received by the USPTO are granted, not all granted patents result in commercial products, and not all R&D leads to patents because inventors often protect commercially useful discoveries in other ways such as copyrights and trade secrets. NSF data indicate that, among U.S.-trained SEH doctorates, 16% reported patenting activity during the period from 2003 to 2008 (National Science Board [NSB] 2012).[13] Patenting activity varied significantly across disciplines, with doctorate holders in engineering and physical sciences reporting the highest rates and those in mathematics, statistics, and psychology reporting the lowest rates. Doctorate holders in engineering and physical sciences also reported the highest average number of patent applications per person and the highest average number of patents granted. For an in-depth analysis of the relevant data, see the NSB *Science and Engineering Indicators 2012* (NSB 2012).

Work-Related Training

In addition to formal education, workers very often engage in work-related training. Such training can contribute to innovation and productivity growth by enhancing skills, efficiency, and knowledge. In 2010, 55% of scientists and engineers in the labor force reported participating in work-related training within the past 12 months of being surveyed (table 3-11). Among those who were employed, workers in S&E-related jobs (health-related occupations, S&E managers, S&E precollege teachers, and S&E technicians and technologists) exhibited higher rates of participation (73%) than workers in S&E (55%) or non-S&E jobs (61%). In general, employed scientists and engineers reported higher rates of

Table 3-9

Metropolitan areas with largest proportion of workers in S&E occupations: May 2012

	Workers employed (*n*)		Metropolitan area workforce in S&E occupations (%)	U.S. total S&E employment in metropolitan area (%)
Metropolitan area	All occupations	S&E occupations		
U.S. total	130,287,700	5,968,240	4.6	100.0
San Jose–Sunnyvale–Santa Clara, CA	898,610	142,430	15.9	2.4
Boulder, CO	159,440	21,160	13.3	0.4
Huntsville, AL	203,400	26,590	13.1	0.4
Corvallis, OR	33,310	4,170	12.5	0.1
Framingham, MA, NECTA Division	157,290	19,550	12.4	0.3
Durham–Chapel Hill, NC	272,250	32,690	12.0	0.5
Washington-Arlington-Alexandria, DC-VA-MD-WV, Metropolitan Division	2,343,510	265,370	11.3	4.4
Lowell-Billerica-Chelmsford, MA-NH, NECTA Division	116,620	12,830	11.0	0.2
Seattle-Bellevue-Everett, WA, Metropolitan Division	1,409,500	148,670	10.5	2.5
Bethesda-Rockville-Frederick, MD, Metropolitan Division	560,000	54,380	9.7	0.9
Bloomington-Normal, IL	86,920	8,280	9.5	0.1
Kennewick-Pasco-Richland, WA	97,300	8,850	9.1	0.1
Boston-Cambridge-Quincy, MA, NECTA Division	1,711,350	154,470	9.0	2.6
San Francisco–San Mateo–Redwood City, CA, Metropolitan Division	1,000,430	89,480	8.9	1.5
Ann Arbor, MI	193,760	16,870	8.7	0.3
Fort Collins–Loveland, CO	132,630	11,060	8.3	0.2
Ames, IA	40,270	3,280	8.1	0.1
Olympia, WA	93,850	7,520	8.0	0.1
Austin–Round Rock–San Marcos, TX	812,600	64,780	8.0	1.1
College Station–Bryan, TX	92,990	7,370	7.9	0.1

NECTA = New England City and Town Area.

NOTES: The data exclude metropolitan statistical areas where S&E proportions were suppressed. Larger metropolitan areas are broken into component metropolitan divisions. Differences between any two areas may not be statistically significant.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (May 2012).

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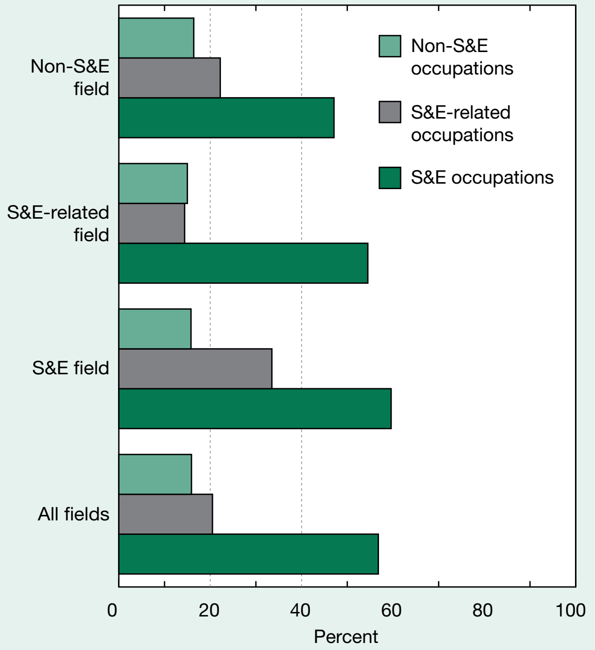
participation (63%) than unemployed scientists and engineers (30%). Women participated in work-related training at a higher rate than men: 58% of women compared with 52% of men (appendix table 3-6). This difference exists among most groups defined by labor force status or highest degree level.

Figure 3-14
Employed scientists and engineers with R&D activity, by broad field of highest degree and broad occupational category: 2010



NOTES: Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation. R&D activity here refers to the share of workers reporting basic research, applied research, design, or development as a primary or secondary work activity in their principal job—activities ranking first or second in work hours.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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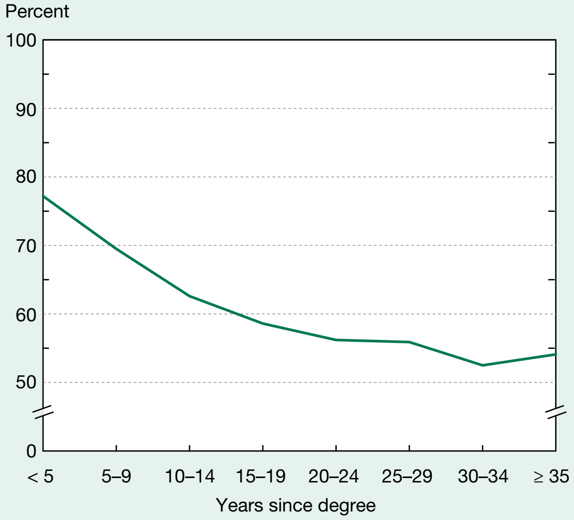
Figure 3-15
Employed SEH doctorate holders with R&D activity, by years since doctoral degree: 2010



SEH = science, engineering, and health.

NOTE: R&D activity here refers to the share of workers reporting basic research, applied research, design, or development as a primary or secondary work activity in their principal job—activities ranking first or second in work hours.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (SDR) (2010), http://sestat.nsf.gov.

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Table 3-10
R&D activity rate of scientists and engineers employed in S&E occupations, by broad occupational category and level of highest degree: 2010
(Percent)

Highest degree level	Biological, agricultural, and environmental life scientists	Computer and mathematical scientists	Physical scientists	Social scientists	Engineers
All degree levels	75.2	45.5	70.3	49.4	66.5
Bachelor's	66.9	44.0	65.6	47.6	62.9
Master's	74.5	46.3	65.5	46.8	70.0
Doctorate	86.8	64.1	80.0	54.2	83.9

NOTES: All degree levels include professional degrees not broken out separately. R&D activity rate is the proportion of workers who report that basic research, applied research, design, or development is a primary or secondary work activity in their principal job—activities ranking first or second in work hours.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Among scientists and engineers who participated in work-related training within the 12 months before being surveyed, most did so to improve skills or knowledge in their current occupational field (52%) (appendix table 3-7).[14] Others did so for licensure/certification in their current occupational field (24%) or because it was required or expected by their employer (15%). Relative to those who were employed or not in the labor force, those who were unemployed more often reported that they engaged in work-related training to facilitate a change to a different occupational field. Not surprisingly, those who were not in the labor force more often reported that they engaged in this activity for leisure or personal interest than those who were in the labor force.

Table 3-11
Scientists and engineers participating in work-related training, by labor force status and occupation: 2010

Labor force status and occupation	Number	Percent
All scientists and engineers	14,688,000	54.6
Employed	13,894,000	63.4
S&E occupations	2,950,000	54.6
Biological, agric ultural, and environmental life scientists	351,000	58.8
Computer and mathematical scientists	1,154,000	48.2
Physical scientists	166,000	51.9
Social scientists	343,000	66.2
Engineers	937,000	59.7
S&E-related occupations	5,085,000	73.1
Non-S&E occupations	5,859,000	61.4
Unemployed	297,000	29.9
S&E occupations	54,000	25.0
Biological, agricultural, and environmental life scientists	5,000	21.7
Computer and mathematical scientists	20,000	21.5
Physical and related scientists	4,000	36.4
Social and related scientists	4,000	33.3
Engineers	21,000	27.6
S&E-related occupations	72,000	39.6
Non-S&E occupations	171,000	30.1
Not in labor force	497,000	12.5

NOTES: Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation in 2010. Unemployed individuals are those not working but who looked for a job in the preceding 4 weeks. For unemployed, the last job held was used for classification. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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S&E Labor Market Conditions

This section looks at a variety of labor market indicators to assess the overall health of the labor market for scientists and engineers. Indicators of labor market participation (such as rates of unemployment and involuntarily working out of one's degree field) and earnings provide meaningful information on economic rewards and the overall attractiveness of careers in S&E fields. Many labor market indicators are lagging indicators, which change some time after other indicators show that the economy has begun to follow a particular trend. For example, although the most recent recession officially began in December 2007 and ended in June 2009, unemployment rates continued to rise after the recession had officially ended.[15] Rates of unemployment, rates of working involuntarily out of one's field of highest degree, and earnings should all be considered in this context.

Unemployment

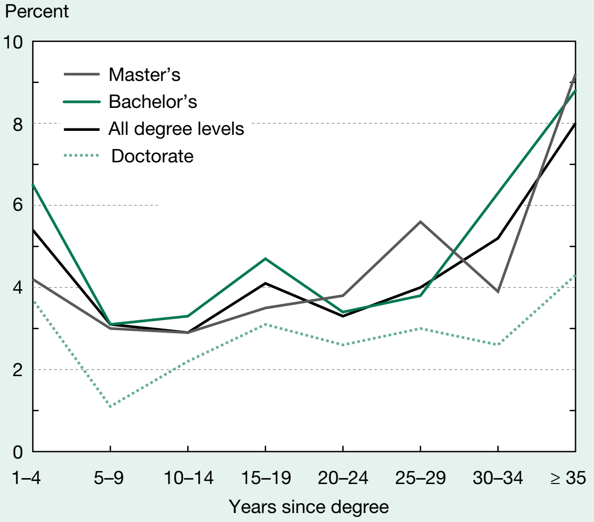
In general, those who hold S&E degrees or work in S&E occupations have had lower rates of unemployment than the broader labor force. However, the S&E workforce is not exempt from unemployment due to overall business cycles or to specific events affecting individuals in their fields. In October 2010, an estimated 4.3% of the broad SESTAT population were unemployed (appendix table 3-8). At the same time, the official unemployment rate reported by BLS for the entire U.S. labor force was about twice as high, 9.0%.[16] According to the NSCG, the unemployment rate for all college graduates was 5.1% in the same period. Thus, joblessness among scientists and engineers compares favorably with the rates for the labor force as a whole and the college-educated labor force.

In 2010, scientists and engineers employed in non-S&E occupations generally had a higher unemployment rate (5.6%) than those employed in S&E occupations (unemployment rates ranged from 2.3% among social scientists to 4.6% among engineers) (appendix table 3-8). Advanced degree holders are less vulnerable to unemployment than those with only bachelor's degrees (appendix table 3-8). Nonetheless, a comparison of SESTAT data from 2006, before the onset of the economic downturn, and from 2010, after the downturn ended, shows clear evidence that the SESTAT population of scientists and engineers were affected by the broader economic conditions: unemployment rates for comparable groups were generally higher in 2010 than in 2006.[17] For example, between 2006 and 2010, the unemployment rate among scientists and engineers with a highest degree at the bachelor's level rose from 2.9% to 4.9%; among those with a doctorate, the rate rose from 1.6% to 2.6%. During the same period, unemployment rates nearly doubled among engineers (from 2.4% in 2006 to 4.6% in 2010) and among scientists and engineers employed in non-S&E occupations (from 3.0% in 2006 to 5.6% in 2010).

The extent of unemployment also varies by career stages. Scientists and engineers in the early- to mid-stages of their career cycles (about 5 to 30 years after obtaining their highest degree) are less likely to be jobless than those at earlier points in their careers (figure 3-16). As workers strengthen their skills by acquiring labor market experience and adding on-the-job knowledge to their formal training, their work situations become more secure. However, among scientists and engineers in the later stages of their careers (about 35 or more years after obtaining their highest degree), the unemployment rates are higher than for those who are in the early- to mid-career stages. This suggests that over time scientists and engineers either become more selective about the work they are willing to do or find their skills becoming obsolete, which results in higher unemployment toward the later stages of their careers.

CPS data allow for analysis of unemployment rates over the past three decades.[18] CPS data indicate that workers employed in S&E occupations have historically experienced lower unemployment rates than the overall labor market (figure 3-17). CPS data for the period 1983–2012 indicate that the unemployment rate for college-educated individuals in S&E occupations ranged from a low of 1.3% to a high of 4.3%, which contrasted favorably with rates for the entire college-educated labor force (ranging from 1.8% to 7.8%). The unemployment rate for S&E technicians and computer programmers ranged from 2.1% to 7.4%; in comparison, the unemployment rate for the entire labor force ranged from 4.0% to 9.6%.

Figure 3-16
Unemployment rates of scientists and engineers, by level of and years since highest degree: 2010



NOTES: All degree levels include professional degrees not shown separately. Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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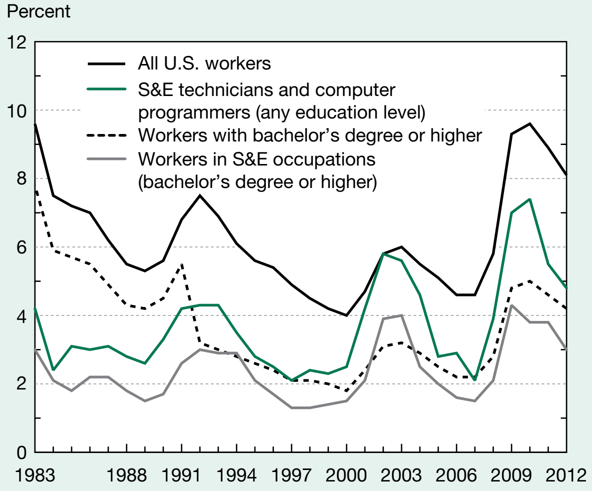
Figure 3-17
Unemployment rate, by occupation: 1983–2012



SOURCES: National Bureau of Economic Research, Merged Outgoing Rotation Group files (1983–2012); Bureau of Labor Statistics, Current Population Survey (1983–2012).

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During the economic downturn that began in late 2007, unemployment rates among workers employed in S&E occupations generally followed the historic pattern (figure 3-18). Unemployment peaked at 5.7% in S&E occupations and 6.1% in the broader STEM occupations, which include S&E occupations as well as computer programmers, technicians, and S&E managers. In comparison, peak unemployment in all occupations was considerably higher (10.5%). In addition to lower rates, unemployment in S&E occupations began declining earlier than in all occupations. As of early 2013, however, unemployment rates among all workers (7.7%) as well as S&E workers (3.0%) were still higher than in the beginning of 2008 (5.4% and 2.1%, respectively).

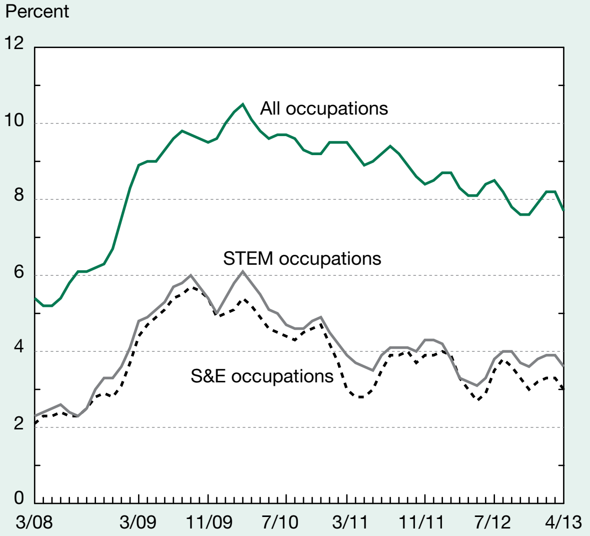
Broader Measures of Labor Underutilization

The most commonly cited unemployment measure is the percentage of people who are not working but who have looked for work in the preceding 4 weeks. This is the official unemployment rate (U3). In addition to U3, BLS reports five other measures (table 3-12), which provide narrower (U1 and U2) or broader (U4–U6) measures of unemployment than the standard measure (U3). These additional measures, called "alternative measures of labor underutilization," provide additional detail about differences in employment patterns between the S&E labor force and the overall labor force (appendix table 3-9).

Trends in indicators of labor underutilization during the economic downturn that began at the end of 2007 consistently indicate that workers whose most recent job was in an S&E occupation experienced lower underutilization rates than the general labor force (figure 3-19). In addition to lower U3, workers in S&E occupations experienced lower long-term unemployment (U1), defined as unemployment lasting 15 weeks or longer, throughout the economic downturn. Although U1 in S&E occupations stabilized and began gradually declining in the latter part of 2009, U1 in all occupations continued to rise until the beginning of 2010. Beginning around the end of 2009, the rate of long-term unemployment in the general labor force exceeded the rate of standard unemployment for those in S&E occupations.

The most comprehensive labor underutilization indicator (U6) includes various kinds of workers who are not employed full time but would like to be. More than the standard unemployment rate, this indicator captures the difference between workers' labor market aspirations and outcomes. The gap between this measure and the standard unemployment rate among workers in S&E occupations is substantially smaller than the comparable gap in the general labor force (appendix table 3-9). This suggests that underutilized workers—that is, those who work part time but would like to obtain full-time employment or those who would like to work but have stopped looking for employment—are a more significant factor among the general labor force than among those in S&E occupations.

Figure 3-18
Unemployment rates for workers in S&E, STEM, and all occupations: March 2008–April 2013



STEM = science, technology, engineering, and mathematics.

NOTES: Data for S&E, STEM, and all occupations include people at all education levels. Estimates are not seasonally adjusted. Estimates are made from pooled microrecords of the Current Population Survey (CPS) and, although similar, are not the same as the 3-month moving average.

SOURCE: Bureau of Labor Statistics, CPS, Public-Use Microdata Sample (PUMS), January 2008–April 2013.

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Table 3-12
Alternative measures of labor underutilization

Measure	Definition
U1.........	Percentage of the labor force unemployed for 15 weeks or longer
U2.........	Percentage of the labor force who lost jobs or completed temporary work
U3.........	Official unemployment rate: percentage of the labor force without jobs who have actively looked for work within the past 4 weeks
U4.........	U3 + percentage of the labor force who are discouraged workers (those who have stopped looking for work)
U5.........	U4 + percentage of the labor force who are marginally attached workers (those who would like to work but have not looked for work recently)
U6.........	U5 + percentage of the labor force who are part-time workers but want to work full time

SOURCE: Bureau of Labor Statistics, http://www.bls.gov/lau/stalt.htm.

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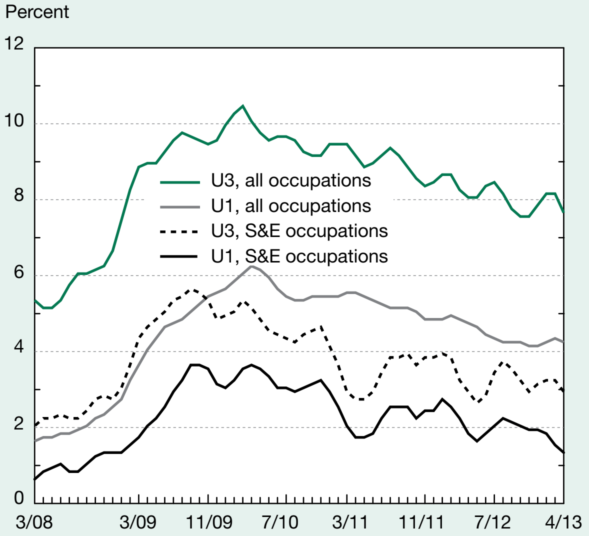
Figure 3-19
Measures of labor underutilization for workers in S&E and all occupations: March 2008–April 2013



U1 = percentage of labor force unemployed for 15 weeks or more; U3 = percentage of labor force without jobs who have looked for work in past 4 weeks (official unemployment rate).

NOTES: Data for S&E and all occupations include workers at all education levels. Estimates are not seasonally adjusted. Estimates are made from the pooled microrecords of the Current Population Survey and, although similar, are not the same as the 3-month moving average.

SOURCE: Bureau of Labor Statistics, Current Population Survey, Public-Use Microdata Sample (PUMS), January 2008–April 2013.

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Involuntarily Working Out of One's Field of Highest Degree

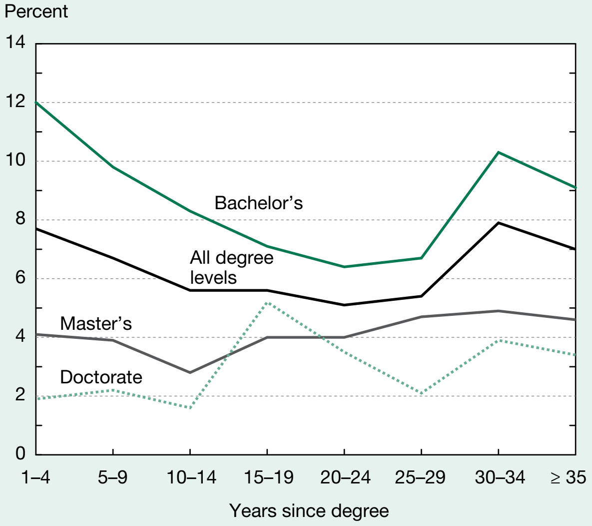
SESTAT data provide information on the relevance of individuals' educational background for their principal job. SESTAT also provides data on why individuals obtain employment outside of their field of highest degree. The SESTAT population of scientists and engineers who reported that a lack of suitable jobs in their field of highest degree was the reason for their working out of field are identified as those who are working involuntarily out of field (IOF). The size of this group as a proportion of all employed scientists and engineers is considered the IOF rate.

Of the nearly 22 million employed scientists and engineers in 2010, almost 1.4 million reported working out of the field of their highest degree because of a lack of suitable jobs in their degree field, indicating an IOF rate of 6.4%. SESTAT respondents were allowed to report more than one reason for working out of field. Other reasons included pay and promotion opportunities (reported by 2.1 million individuals), change in career or professional interests (1.8 million), working conditions (2.1 million), family-related reasons (1 million), job location (1.9 million), and other reasons (400,000). When asked about the single most important reason for working in a job not related to their field of highest degree, pay and promotion opportunities were cited by most, followed by change in career interests and lack of a suitable job in their field of highest degree.

IOF rates vary by degree fields and levels. Scientists and engineers with a highest degree in engineering and computer and mathematical sciences display lower IOF rates than those with physical, life, or social sciences degrees (table 3-13). Advanced degree holders are less likely to work involuntarily out of field than those with bachelor's degrees only: in 2010, the IOF rate was 2.9% for the SESTAT population with doctorates, 4.0% for those with master's degrees, and 8.8% for those with bachelor's degrees only. However, among bachelor's degree holders, IOF rates gradually decline across career stages up to mid- to late career points, and then gradually rise (figure 3-20). In comparison, among holders of master's degrees and doctorates, IOF rates remain stable over the long term.

Figure 3-20

Scientists and engineers who are working involuntarily out of field, by level of and years since highest degree: 2010



NOTES: Involuntarily out-of-field rate is the proportion of all employed individuals who reported working in a job not related to their field of highest degree because a job in that field was not available. Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Table 3-13

Scientists and engineers who are working involuntarily out of field, by S&E degree field: 1993–2010

(Percent)

S&E degree field	1993	1995	1997	1999	2003	2006	2008	2010
All scientists and engineers	7.8	7.7	7.3	5.4	5.9	6.2	5.3	6.4
Highest degree in S&E field	9.2	8.9	8.5	6.3	7.8	8.1	7.1	8.4
Biological, agricultural, and environmental life sciences	10.3	10.2	10.0	8.3	10.1	9.7	10.1	10.1
Computer and mathematical sciences	5.3	4.1	4.0	2.9	4.9	5.7	4.5	5.1
Physical sciences	9.7	10.2	10.0	7.6	8.8	8.6	7.1	8.2
Social sciences	13.3	12.7	12.1	8.7	10.1	10.6	9.2	11.3
Engineering	4.4	4.4	3.9	2.7	4.2	4.5	3.6	4.9

NOTES: During 1993–99, scientists and engineers include those with one or more S&E degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E occupation. During 2003–10, scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation. The involuntarily out-of-field rate is the proportion of all employed individuals who report that their job is not related to their field of highest degree because a job in their highest degree field was not available.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (1993–2010), http://sestat.nsf.gov.

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Earnings

Based on the OES survey, the estimated annual earnings of individuals in S&E occupations are considerably higher than those of the total workforce. Median annual earnings in 2012 in S&E occupations (regardless of education level or field) was $78,270, which is more than double the median for all U.S. workers ($34,750) (table 3-14). This is not surprising given the level of formal education and overall technical skills associated with S&E occupations. The difference in average (mean) earnings was less dramatic but still quite wide, with individuals in S&E occupations earning considerably more on average ($82,930) than workers in all occupations ($45,790). Median S&E earnings ranged from $67,660 among social scientists to $86,500 among engineers. The 2009–12 annual growth in mean and median earnings for S&E occupations were generally similar to those for all employed U.S. workers in the OES data.

According to SESTAT, the annual median salary for individuals trained or employed in S&E ($65,000) is higher than that for all college-educated individuals ($56,000). The 2010 NSCG data indicate that the annual median salary for college-educated workers with a highest degree in S&E ($65,000) or S&E-related fields ($68,000) is more than for those with non-S&E degrees ($50,000) (table 3-15). Within each broad degree field, however, those employed in S&E occupations earn more than those in non-S&E occupations. For example, among individuals with a highest degree in a non-S&E field, the annual median salary for those employed

Table 3-14
Annual earnings and earnings growth in science, technology, and related occupations: May 2009–May 2012

Occupation	2009 annual earnings ($)	2012 annual earnings ($)	Annual growth rate 2009–12 (%)	2009 annual earnings ($)	2012 annual earnings ($)	Annual growth rate 2009–12 (%)
	Mean			Median		
All U.S. employment	43,460	45,790	1.8	33,190	34,750	1.5
STEM occupations	76,600	82,160	2.4	71,080	75,840	2.2
S&E occupations	78,480	82,930	1.9	74,380	78,270	1.7
Computer and mathematical scientists	76,280	80,080	1.6	72,930	76,170	1.5
Life scientists	77,400	79,430	0.9	68,240	69,980	0.8
Physical scientists	78,880	83,750	2.0	71,670	74,880	1.5
Social scientists	69,140	73,230	1.9	63,130	67,660	2.3
Engineers	86,140	91,450	2.0	82,130	86,500	1.7
Technology occupations	72,500	78,740	2.8	60,650	65,300	2.5
S&E-related occupations (not listed above)	70,980	74,840	1.8	58,910	61,540	1.5
Health-related occupations	70,840	74,740	1.8	58,670	61,320	1.5
Other S&E-related occupations	77,930	80,380	1.0	71,020	72,950	0.9

STEM = science, technology, engineering, and mathematics.

NOTES: See table 3-2 for definitions of S&E, S&E-related, and STEM occupations. Occupational Employment Statistics (OES) employment data do not cover employment in agriculture, private household, or among self-employed and therefore do not represent total U.S. employment.

SOURCE: Bureau of Labor Statistics, OES Survey (May 2009 and May 2012).

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Table 3-15
Median salaries for employed college-educated individuals, by broad field of highest degree and broad occupational category: 2010
(Median annual salary, dollars)

Highest degree field	All occupations	S&E occupations	S&E-related occupations	Non-S&E occupations
All degrees	56,000	75,000	65,000	50,000
S&E	65,000	78,000	65,000	50,000
S&E-related	68,000	72,000	70,000	50,000
Non-S&E	50,000	70,000	53,000	50,000

NOTES: See table 3-2 for definitions of S&E, S&E-related, and non-S&E degrees and occupations. Salaries are rounded to the nearest $1,000.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Survey of College Graduates (2010).

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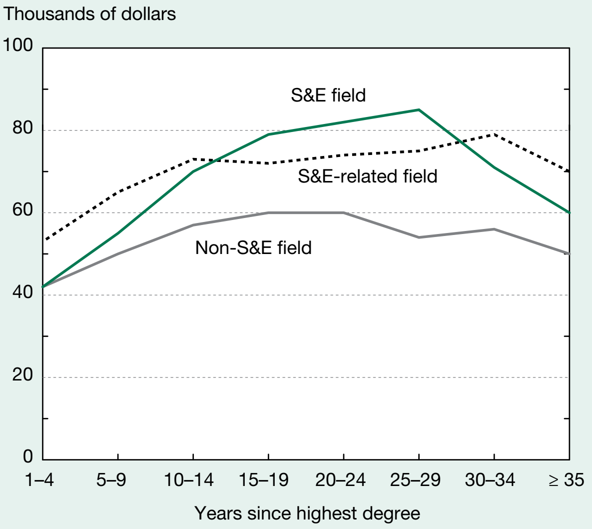
in an S&E occupation ($70,000) is more than for those employed in a non-S&E occupation ($50,000); among individuals with a highest degree in an S&E or S&E-related field, those employed in an S&E or S&E-related occupation earn more than those employed in a non-S&E occupation.

The earnings premium enjoyed by college-educated individuals with an S&E or S&E-related degree is present at all career stages. Figure 3-21 presents data on median salaries for groups with S&E, S&E-related, or non-S&E highest degrees at comparable numbers of years since receiving their highest degrees. Although median salaries are similar in the beginning for S&E and non-S&E degree holders, both of which are lower than that for S&E-related degree holders, the rise in earnings associated with career progression is much steeper among individuals with S&E degrees.

Earnings vary by degree levels. In 2010, the annual median salaries among scientists and engineers with bachelor's or master's as highest degree levels were $57,000 and $68,000, respectively. Those with doctorates ($85,000) or professional degrees ($116,000) earned significantly more. The pattern by degree level holds across career stages (figure 3-22).

S&E highest degree holders earn more than non-S&E highest degree holders at the master's degree and doctoral levels (figure 3-23). Among professional degree holders, in contrast, non-S&E degree holders earn more than S&E degree holders.

Figure 3-21
Median salaries for employed college-educated individuals, by broad field of highest degree and years since highest degree: 2010



NOTE: See table 3-2 for classification of S&E, S&E-related, and non-S&E degree fields.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Survey of College Graduates (2010).

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Among employed individuals without a bachelor's degree, S&E occupations provide stable jobs with competitive salaries relative to those workers in non-S&E occupations. (See sidebar, "The U.S. S&E Workforce Without a Bachelor's Degree.")

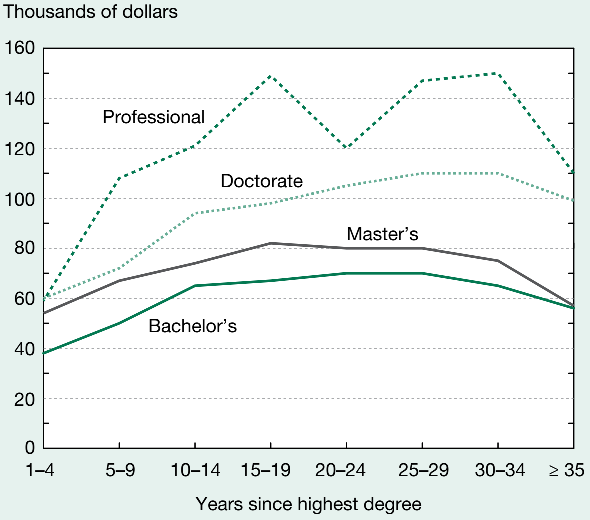
Recent S&E Graduates

In today's knowledge-based and globally integrated economy marked by rapid information flow and development of new knowledge, products, and processes, demand for certain skills and abilities may change fast. The employment outcomes of recent graduates are an important indicator of current changes in labor market conditions. Compared with experienced S&E workers, recent S&E graduates more often bring new ideas and newly acquired skills to the labor market. This section examines the employment outcomes of recent recipients of S&E bachelor's, master's, and doctoral degrees.

General Labor Market Indicators for Recent Graduates

Table 3-16 summarizes some basic labor market statistics in 2010 for recent recipients of S&E degrees; *recent* here is defined as between 1 and 5 years since receiving the degree.

Figure 3-22
Median salaries for employed scientists and engineers, by level of and years since highest degree: 2010



NOTE: Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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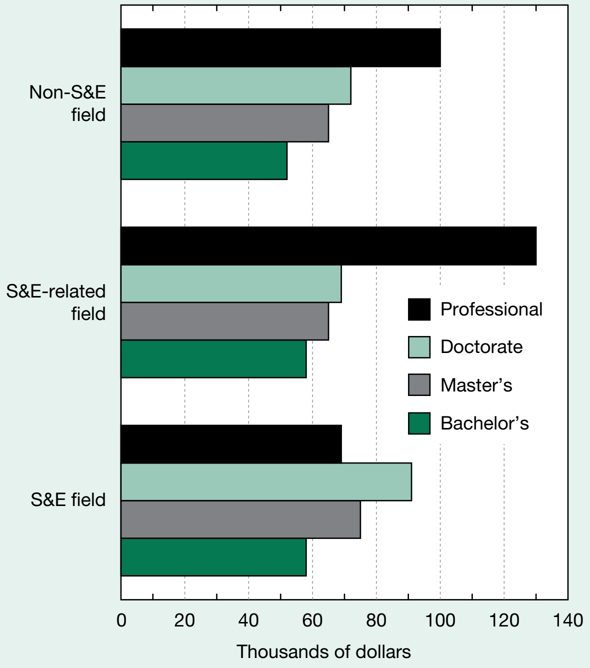
Among the nearly 22 million employed SESTAT respondents in October 2010, about 1.8 million are *recent* S&E degree recipients. Overall, the unemployment rate among these recent graduates was 6.6%, higher than the 4.3% unemployment rate seen among the entire SESTAT population of scientists and engineers. However, none of the recent graduating groups by S&E degree field or level exceeded the unemployment rate of 9.0% for the entire U.S. labor force.

Among recent bachelor's degree holders, the unemployment rate averaged 7.7%, ranging from 5.2% for those with physical sciences degrees to 8.8% for those with social sciences degrees. Overall, unemployment was generally lower for those with doctorates than for those with less advanced degrees. Early in their careers, as individuals gather labor market experience and on-the-job skills, they tend to have a higher incidence of job change and unemployment, which may partially explain some of the higher unemployment rates seen among those with a bachelor's degree as their highest level degree.

A useful but more subjective indicator of labor market conditions for recent graduates is the proportion who report that their job is unrelated to their highest degree field because a job in their degree field was not available (working involuntarily out of field or IOF rate). Of the 1.8 million employed scientists and engineers who received their highest degree in an S&E field in the previous 5 years, 10.8% indicated working involuntarily out of field (table 3-16).

Figure 3-23

Median salaries for employed scientists and engineers, by broad field and level of highest degree: 2010



NOTES: See table 3-2 for definitions of S&E, S&E-related, and non-S&E degrees. Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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A larger proportion of recent S&E degree recipients reported working out of field because a suitable job was not available (10.8%) compared to the overall SESTAT population of scientists and engineers (6.4%). When asked about the single most important reason for working out of field, the most frequently cited reason by recent S&E degree recipients was lack of a suitable job in their degree field (cited by 29% of recent S&E degree recipients working out of field), followed by pay and promotion opportunities (20%) and change in career or professional interests (13%). The responses provided by the entire SESTAT population working out of field (regardless of graduation year) were similar, but the factors were ranked differently: the most commonly cited reason was pay and promotion opportunities (cited by 26% of all SESTAT respondents working out of field), followed by change in career or professional interests (21%) and lack of a suitable job in their degree field (19%).

Among recent bachelor's degree holders, the IOF rate in 2010 averaged 13.5%, but it ranged from 4.1% for recent engineering graduates to 18.0% for recent graduates in the social sciences (table 3-16). In all degree fields for which reliable estimates are available, the IOF rate was lower for advanced degree (master's) holders than for those with bachelor's degrees only.

The median salary for recent S&E bachelor's degree recipients in 2010 was $35,000, ranging from $30,000 in life sciences and physical sciences to $57,000 in engineering (table 3-16). Recent master's degree recipients had a median salary of $55,000, and recent doctorate recipients had a median salary of $60,000.

In 2010, among recent S&E degree recipients, those who received their degrees in 2008 or 2009, after the economic downturn began, had higher unemployment rates and IOF rates (7.4% and 12.6%, respectively) than those who received their degrees between 2005 and 2007 (6.0% and 9.5%, respectively) (appendix table 3-10). In particular, among recent master's degree holders, the unemployment rate was higher for the group receiving degrees between 2008 and 2009 than the group receiving degrees between 2005 and 2007; among recent bachelor's degree holders, the IOF rate was higher for the group receiving degrees between 2008 and 2009 than the group receiving degrees between 2005 and 2007. The doctorate population in these two groups reported similar unemployment rates and IOF rates in 2010.

Recent Doctorate Recipients

The career rewards of highly skilled individuals in general, and doctorate holders in particular, often extend beyond salary and employment to the more personal rewards of doing the kind of work for which they have trained. No single standard measure satisfactorily reflects the state of the doctoral S&E labor market. This section discusses a range of relevant labor market indicators, including unemployment rates, IOF employment, employment in academia compared with other sectors, employment in postdoctoral positions, and salaries. Although a doctorate opens both career and salary opportunities, these opportunities may come at the price of many years of lost labor market earnings. For some doctorate holders, an ensuing postdoctoral position can further extend this period of low earnings.

Unemployment. As of October 2010, the 2.3% unemployment rate (table 3-17) for SEH doctorate recipients up to 3 years after receiving their doctorates was almost identical to the unemployment rate for all SEH doctorates (2.4%); it was considerably lower than the unemployment rate of the civilian labor force in general (9.0%) and the unemployment rate for the entire SESTAT population regardless of level or year of award of highest degree (4.3%).

Working involuntarily out of field. About 1.8% of the employed recent SEH doctorate recipients reported that they took a job that was not related to the field of their doctorate because a suitable job in their field was not available (table 3-17). This compared favorably with the IOF rate for the entire SESTAT population (6.4%).

Tenure-track positions. Although many science doctorate recipients aspire to tenure-track academic appointments (Sauermann and Roach 2012), most end up working in other positions and sectors. In 2010, about 15% of those who had earned their SEH doctorate within the previous 3 years had a tenure or tenure-track faculty appointment, a proportion that has held broadly steady since 1993 (table 3-18). Across the broad SEH fields, this proportion varied significantly, from about 7% to 8% among recent doctorates in life sciences, physical sciences, and engineering to about 41% among those in the social sciences.

The proportion of SEH doctorates who hold a tenure or tenure-track faculty appointment increases the more time has passed since earning their doctorate. In 2010, the proportion of SEH doctorates with tenure or tenure-track appointments who had been in the labor market for 3 to 5 years was higher (20%) than the rate among those who had completed their doctorate within 3 years (15%) (table 3-18). The extent of the increase varies across the broad areas of training. In the social sciences, for example, a relatively large percentage of individuals get into a tenure or tenure-track position within 3 years of obtaining their doctorate, and the increase associated with 3 to 5 years of labor market exposure is not as dramatic as in some other fields, such as physical sciences or mathematics and statistics. (See chapter 5 for a discussion of trends in tenure-track positions as a proportion of all academic positions.)

The availability of tenure-track positions may be counterbalanced by the availability of desirable nonacademic employment opportunities. Although the proportion of individuals who obtain tenure or tenure-track employment within 3 years of completing their doctorates has remained

Table 3-16

Labor market indicators for recent S&E degree recipients up to 5 years after receiving degree, by level and field of highest degree: 2010

Indicator and highest degree level	All S&E fields	Biological, agricultural, and environmental life sciences	Computer and mathematical sciences	Physical sciences	Social sciences	Engineering
Unemployment rate (%)						
All degree levels	6.6	6.1	6.7	4.2	8.0	4.4
Bachelor's	7.7	7.3	8.2	5.2	8.8	5.6
Master's	4.0	2.3	2.6	5.3	5.9	2.9
Doctorate	1.6	2.8	S	S	S	3.6
Involuntarily out-of-field (IOF) rate (%)						
All degree levels	10.8	10.2	7.5	9.9	15.6	3.7
Bachelor's	13.5	12.4	10.6	10.9	18.0	4.1
Master's	4.7	4.8	1.4	S	6.3	3.0
Doctorate	1.7	S	S	S	S	S
Median annual salary ($)						
All degree levels	40,000	35,000	55,000	36,000	33,000	60,000
Bachelor's	35,000	30,000	50,000	30,000	31,000	57,000
Master's	55,000	48,000	68,000	32,000	39,000	73,000
Doctorate	60,000	47,000	85,000	55,000	62,000	85,000

S = suppressed for reasons of confidentiality and/or reliability.

NOTES: Median annual salaries are rounded to the nearest $1,000. All degree levels includes professional degrees not broken out separately. Data include degrees earned from October 2005 to October 2009. The IOF rate is the proportion of all employed individuals who report that their job is not related to their field of highest degree because a job in their highest degree field was not available.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Table 3-17

Employment characteristics of recent SEH doctorate recipients up to 3 years after receiving doctorate, by field of degree: 2001–10

	Recent doctorates (*n*)					Unemployment rate (%)					Involuntarily out-of-field rate (%)				
Field of doctorate	2001	2003	2006	2008	2010	2001	2003	2006	2008	2010	2001	2003	2006	2008	2010
All recent SEH doctorates	48,700	43,700	49,500	52,600	52,700	1.3	2.5	1.2	1.5	2.3	2.8	2.1	1.4	1.3	1.8
Biological, agricultural, and environmental life sciences	12,300	11,200	12,600	13,400	14,100	1.4	2.4	0.9	1.7	1.5	2.6	1.0	0.3	1.0	1.5
Computer and information sciences	1,600	1,400	1,500	2,400	2,500	0.3	4.1	1.9	S	S	S	S	2.6	1.4	S
Mathematics and statistics	2,200	1,600	2,000	2,400	2,400	0.2	3.4	S	S	S	1.4	3.4	2.2	1.1	S
Physical sciences	7,700	6,500	7,400	7,500	7,700	1.5	1.3	1.1	3.0	2.6	5.4	4.2	2.6	2.3	1.4
Psychology	7,200	6,300	7,000	5,800	5,400	1.5	2.7	1.2	0.8	3.8	3.0	1.5	1.4	0.8	2.0
Social sciences	5,800	6,000	6,200	5,900	6,000	1.6	3.1	1.4	2.1	3.4	3.3	3.0	2.3	3.4	3.5
Engineering	9,400	8,000	9,500	12,000	11,300	1.5	3.0	1.8	1.2	2.7	2.0	3.0	1.6	0.7	1.9
Health	2,400	2,700	3,200	3,300	3,400	0.4	0.7	0.9	1.2	S	S	1.1	S	S	S

S = suppressed for reasons of confidentiality and/or reliability.

SEH = science, engineering, and health.

NOTES: Involuntarily out-of-field rate is the proportion of all employed individuals who report working in a job not related to their field of doctorate because a job in that field was not available. Data for 2001 and 2006 include graduates from 12 months to 36 months prior to the survey reference date; data for 2003, 2008, and 2010 include graduates from 15 months to 36 months prior to the survey reference date. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (SDR) (2001–10), http://sestat.nsf.gov.

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Table 3-18

Employed SEH doctorate recipients holding tenure and tenure-track appointments at academic institutions, by field of and years since degree: 1993–2010

(Percent)

Years since doctorate and field	1993	1995	1997	1999	2001	2003	2006	2008	2010
< 3 years									
All SEH fields	18.1	16.3	15.8	13.5	16.5	18.6	17.7	16.2	14.7
Biological, agricultural, and environmental life sciences	9.0	8.5	9.3	7.7	8.6	7.8	7.2	6.5	7.6
Computer and information sciences	31.5	36.5	23.4	18.2	20.7	32.5	31.2	22.0	20.8
Mathematics and statistics	40.9	39.8	26.9	18.9	25.2	38.4	31.6	31.3	26.1
Physical sciences	8.8	6.9	8.5	7.8	10.0	13.3	9.8	8.8	6.8
Psychology	12.8	13.6	14.7	16.0	15.6	14.6	17.0	18.1	16.0
Social sciences	43.5	35.9	37.4	35.4	38.5	44.8	39.3	45.4	41.1
Engineering	15.0	11.5	9.4	6.4	11.3	10.8	12.4	9.3	7.5
Health	33.9	34.2	30.1	28.1	32.1	30.3	36.2	27.7	24.2
3–5 years									
All SEH fields	27.0	24.6	24.2	21.0	18.5	23.8	25.9	22.9	19.7
Biological, agricultural, and environmental life sciences	17.3	17.0	18.1	16.4	14.3	15.5	13.7	14.3	10.6
Computer and information sciences	55.7	37.4	40.7	25.9	17.3	32.2	45.7	37.8	22.2
Mathematics and statistics	54.9	45.5	48.1	41.0	28.9	45.5	50.6	40.7	41.7
Physical sciences	18.8	15.5	14.5	11.9	15.8	18.3	19.7	16.5	14.7
Psychology	17.0	20.7	16.8	17.6	17.5	19.9	23.8	18.3	19.1
Social sciences	54.3	52.4	50.4	46.5	38.8	46.0	50.4	48.9	46.7
Engineering	22.7	19.3	19.4	12.6	10.8	15.9	16.3	15.5	13.0
Health	47.4	40.2	41.1	39.5	25.1	40.8	43.1	34.4	33.3

SEH = science, engineering, and health.

NOTES: Proportions are calculated on the basis of all doctorates working in all sectors of the economy. Data for 1993–99, 2001, and 2006 include graduates from 12 months to 60 months prior to the survey reference date; data for 2003, 2008, and 2010 include graduates from 15 months to 60 months prior to the survey reference date.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (1993–2010), http://sestat.nsf.gov.

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broadly stable since 1993, the proportion of graduates with tenure or tenure-track positions within 3 to 5 years of receiving their doctorates has declined since 1993 in most broad areas of SEH training (table 3-18). One of the steepest declines occurred in computer sciences despite the high demand for computer sciences faculty.

Salaries for recent SEH doctorate recipients. For all SEH degree fields in 2010, the median annual salary for recent doctorate recipients within 5 years after receiving their degrees was $66,000. Across various SEH degree fields, median annual salaries ranged from a low of $50,000 in biological sciences to a high of $94,000 in computer and information sciences (table 3-19). Between 2008 and 2010, a period marked by the economic downturn and its immediate aftermath, median salaries for recent recipients of doctoral degrees in most SEH areas either stayed the same or declined slightly (the median salary for recent SEH doctorate recipients in 2008 was $67,000).

By type of employment, salaries for recent doctorate recipients ranged from $42,000 for postdoctoral positions in 4-year institutions to $90,000 for those employed in the business sector (table 3-20). Each sector, however, exhibited substantial variation depending on SEH fields of training.

Postdoctoral Positions

A significant number of new S&E doctorate recipients take a postdoctoral appointment (generally known as a postdoc) as their first position after receiving their doctorate.

Table 3-19

Salaries for recent SEH doctorate recipients up to 5 years after receiving degree at selected percentiles, by field of degree: 2010

(Dollars)

Field of doctorate	25th percentile	50th percentile	75th percentile
All SEH fields	47,000	66,000	90,000
Biological, agricultural, and environmental life sciences	42,000	50,000	71,000
Computer and information sciences	75,000	94,000	120,000
Mathematics and statistics	51,000	64,000	95,000
Physical sciences	45,000	60,000	84,000
Psychology	47,000	60,000	77,000
Social sciences	50,000	63,000	84,000
Engineering	67,000	87,000	101,000
Health	57,000	75,000	92,000

SEH = science, engineering, and health.

NOTES: Salaries are rounded to the nearest $1,000. Data include graduates from 15 months to 60 months prior to the survey reference date.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2010), http://sestat.nsf.gov.

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Table 3-20

Median salaries for recent SEH doctorate recipients up to 5 years after receiving degree, by field of degree and employment sector: 2010

(Dollars)

Field of doctorate	All sectors	Education: 4-year institutions: All positions	Education: 4-year institutions: Tenured or tenure-track position	Education: 4-year institutions: Postdoc	Education: 2-year or precollege institutions	Government	Business/ industry
All SEH fields	66,000	52,000	65,000	42,000	52,000	76,000	90,000
Biological, agricultural, and environmental life sciences	50,000	45,000	60,000	42,000	45,000	65,000	73,000
Computer and information sciences	94,000	70,000	74,000	47,000	S	99,000	111,000
Mathematics and statistics	64,000	56,000	62,000	51,000	58,000	S	95,000
Physical sciences	60,000	47,000	60,000	42,000	51,000	71,000	86,000
Psychology	60,000	55,000	57,000	42,000	59,000	78,000	65,000
Social sciences	63,000	58,000	63,000	44,000	57,000	85,000	98,000
Engineering	87,000	59,000	80,000	42,000	S	86,000	95,000
Health	75,000	69,000	72,000	41,000	51,000	85,000	93,000

S = suppressed for reasons of confidentiality and/or reliability.

SEH = science, engineering, and health.

NOTES: Salaries are rounded to the nearest $1,000. Data include graduates from 15 months to 60 months prior to the survey reference date. The 2-year or precollege institutions include 2-year colleges and community colleges or technical institutes and also preschool, elementary, middle, or secondary schools. The 4-year institutions include 4-year colleges or universities, medical schools, and university-affiliated research institutes.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2010), http://sestat.nsf.gov.

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Postdoc positions are defined as temporary, short-term positions, primarily for acquiring additional training in an academic, government, industry, or non-profit setting.[19] This section looks at employment characteristics of postdocs.

The incidence of SEH doctorate holders taking postdoc positions during their careers has risen over time. Among U.S. SEH doctorate holders who received their doctorate before 1972, 31% reported having had a postdoc position earlier in their careers; this proportion rose to 46% among 2002–05 graduates (NSB 2010). Although individuals in postdoc positions often perform cutting-edge research, these positions generally offer lower salaries than permanent positions, which essentially adds to the costs of doctoral studies and has the unintended consequence of making science careers less desirable to potential graduate students. The growing number of postdoc positions, as well as the rise in average postdoc tenure, has received much attention in science policy in recent years (e.g., NIH 2012). Neither the reasons for this growth nor its effects on the state of scientific research are well understood. However, possible contributing factors include increases in competition for tenure-track academic research jobs, the need for collaborative research in large teams, the influx of graduate students in SEH areas with strong postdoc traditions, and the need for additional specialized training. (See sidebar, "Employment of Biomedical Sciences Doctorates.")

Number of postdocs. In October 2010, NSF's Survey of Doctorate Recipients (SDR) estimated that 30,800 U.S. SEH doctorate recipients were employed in postdoc positions. The vast majority of these postdoc positions were in 4-year academic institutions (75%), with the remainder in industry (16%) and government (10%). The fall 2010 and fall 2011 estimates from NSF's Survey of Graduate Students and Postdoctorates in Science and Engineering, which covers academic postdocs, were 63,400 and 62,900, respectively (NSF/NCSES 2013a and 2013b). These estimates cover different segments of the postdoc population. The Survey of Graduate Students and Postdoctorates in Science and Engineering gathers information on postdocs from U.S. academic graduate departments, regardless of where these individuals earned their doctorates. It does not cover individuals in nonacademic employment, at some university research centers, or at academic departments that lack graduate programs. In contrast, the SDR covers U.S. residents with research doctorates in SEH fields from U.S. universities, but not those with doctorates from non-U.S. universities. As a result, the SDR omits a large number of postdocs who are foreign trained. The two survey estimates overlap in some populations (U.S.-trained doctorates and those working in academia), but differ in others (the Survey of Graduate Students and Postdoctorates in Science and Engineering covers foreign-trained doctorates, but not those in the industry or government sectors). In addition, the titles of postdoc researchers vary across organizations and often change as individuals advance through their postdoc appointment; both of these factors further complicate the data collection process (NIH 2012).[20]

Postdocs by academic discipline. Although postdocs are increasingly common in SEH fields, the extent to which a postdoc appointment is part of an individual's career path varies greatly across SEH fields. In the field of life sciences, for example, postdocs have historically been more common than in other SEH fields. According to NSF's Survey of Earned Doctorates (SED), the proportion of new doctorate recipients in 2011 indicating that they would take a postdoc appointment after graduation ranged from nearly 70% in life sciences (including agricultural sciences/natural resources, biological/biomedical sciences, and health sciences) to 37% in the social sciences (appendix table 3-11). SDR data indicate that in 2010 about half of those who had received their doctorates in the previous 3 years in biological/agricultural/environmental life sciences (53%) or physical sciences (47%) were employed in postdoc positions, compared to only 11% in the social sciences (figure 3-24). Within physical sciences, chemistry and physics have particularly strong postdoc traditions.

Postdoc compensation. Low compensation for postdocs is frequently raised as a concern by those who are worried about the effect of the increasing number and length of postdoc positions on the attractiveness of science careers. In 2010, the median salary for postdocs who had received their doctorate within the past 5 years was just over half (57%) the median salary paid to non-postdocs (table 3-21). This proportion ranged from about half among individuals with doctorates in engineering (48%) and computer and information sciences (50%) to about three-quarters among those with doctorates in social sciences (69%) and mathematics and statistics (76%).

Among recent graduates, similar proportions of postdocs and non-postdocs have access to certain employer-provided benefits, such as health insurance (95% of postdocs and 92% of non-postdocs) and paid vacation, sick, or personal days (87% of postdocs and 86% of non-postdocs). However, a much smaller proportion of recent graduates in postdoc positions have access to employer-provided pensions or retirement plans (56% of postdocs and 84% of non-postdocs). Information on the quality of these benefits—for example, the coverage and premium of health insurance plans, number of personal days offered by employer, and type of retirement benefits—is not available.

Reasons for taking postdoc positions. The 2010 SDR asked individuals in postdoc positions to report their reason for accepting these appointments. When asked about the primary reason, most responses were consistent with the traditional objective of a postdoc position as a type of advanced apprenticeship for career progression, such as "postdoc generally expected in field," "additional training in PhD field," "additional training in an area outside of PhD

Employment of Biomedical Sciences Doctorates

Employment patterns in the biomedical sciences have changed in the past two decades. The growth in the number of doctorates trained in the field has far surpassed the growth in academic positions, contributing to lengthy postdoc appointments, stiff competition for academic jobs, and an increasing proportion of doctorates going into positions that are not research-intensive (National Institutes of Health [NIH] 2012). According to the Survey of Doctorate Recipients (SDR), between 1993 and 2010, the number of U.S.-educated doctorate holders in the biomedical sciences substantially rose (from about 105,000 to nearly 180,000).* Over this same time, the proportion employed in academia declined (58% to 51%) as did the proportion employed in tenure or tenure-track positions (35% to 26%) despite the fact that both increased in absolute number. The proportion of U.S.-educated doctorate holders who reported research (basic or applied) as their primary or secondary work activity also declined in the education sector (from 75% to 70%). In contrast, the proportion of biomedical sciences doctorates employed in the business sector rose (from 31% to 39%). The majority of the increase in the business sector was driven by those whose jobs did not involve research as their primary or secondary work activity. The proportion of biomedical sciences doctorates reporting that they are employed in jobs closely related to their doctoral degree has declined over this same time (from 68% to 60%), whereas the proportion employed in jobs "somewhat" related to their doctorate has increased (from 24% to 32%). The available data cover the U.S.-educated doctorate holders; the data on foreign-trained doctorates in the field, a segment of the workforce that has grown significantly (NIH 2012), are not comprehensive. The information on postdoc researchers is also not comprehensive.

Despite the persistence of generally favorable employment indicators for biomedical sciences doctorates (the unemployment rate was around 2% in 1993 and 2010, and the rate of working involuntarily out of field was around 3% in both periods), the changes in the employment patterns have generated significant concerns in the profession. Concerns center on the rising number of research doctorates unable to find tenure-track academic research positions, the increasing number and length of postdoc appointments, the influx of foreign-trained doctorates seeking academic positions, and the rising number of early career doctorates taking positions that are not research-intensive and for which current graduate programs may not provide appropriate preparation. In addition, the overall training period, including PhD and postdoc research, is longer in the biomedical sciences than in other comparable disciplines, such as chemistry, physics, and mathematics (NIH 2012). Furthermore, average starting salaries are lower among doctorates in the biomedical sciences than in other fields, such as chemistry, clinical and health fields, and economics (NIH 2012).

In light of the changes in the profession and the resulting concern in the science community, NIH convened a working group consisting of biomedical educators and other experts on the biomedical workforce to develop a set of policy recommendations to support a robust and viable workforce.† The working group recently presented specific recommendations targeted at enhancing graduate training, postdoc research experience, and data collection and dissemination regarding the biomedical workforce. The following is a summary of the main recommendations of this working group:

- ♦ To prepare early career scientists for a wide range of career options, encourage graduate programs to undertake innovative approaches. These may include offering alternative degree programs, such as master's programs, and providing training in areas that are generally not covered in a research-oriented doctoral program, such as project management, business entrepreneurship skills, working in small businesses, and teaching in academic institutions that are not research-intensive.
- ♦ To shorten the length of training in the field, limit the number of years that a graduate student may be supported by NIH funds (any combination of training grants, fellowships, and research project grants).
- ♦ To improve the quality of training and mentoring received by graduate students and postdoc researchers, increase the proportion of trainees supported by NIH training grants and fellowships relative to the proportion supported by NIH research project grants without increasing the total number of graduate student and postdoc researcher positions.
- ♦ Improve postdoc compensation and benefits, and facilitate the prompt transitions of postdocs and doctoral students into permanent positions by developing individual career development opportunities.
- ♦ Encourage institutions receiving NIH funds to gather and share comprehensive information on career outcomes of their PhD trainees and postdoc researchers, such as completion rates, time to degree, time in postdoc training, and post-training career outcome. This will help prospective graduate students and postdocs contemplating careers in the biomedical sciences to make informed decisions in a changing biomedical labor market.
- ♦ Encourage NIH, through collaboration with other federal agencies, to undertake initiatives to enhance the collection, analysis, and dissemination of information on biomedical sciences doctorates and postdocs.

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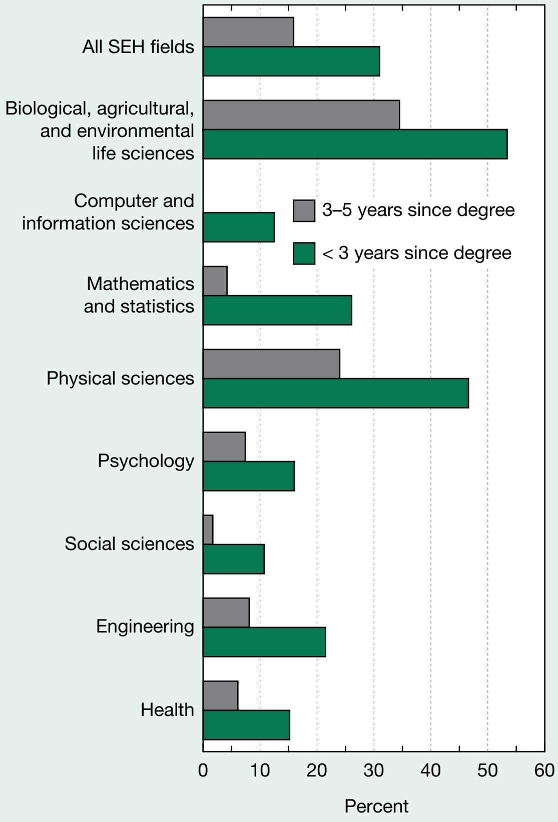
* See NIH (2012) for a discussion on the fields of science considered as biomedical sciences. Based on the report, the following degree categories from the SDR are included in the data presented in this sidebar: biochemistry and biophysics, bioengineering and biomedical engineering, cell and molecular biology, microbiological sciences and immunology, zoology, biology (general), botany, ecology, genetics (animal and plant), nutritional science, pharmacology (human and animal), physiology and pathology (human and animal), and other biological sciences.

† For detailed information, see the NIH report available at http://acd.od.nih.gov/Biomedical_research_wgreport.pdf (accessed 16 November 2013).

Figure 3-24
Recent U.S. SEH doctorate recipients in postdoc positions, by field of and years since doctorate: 2010



SEH = science, engineering, and health.

NOTES: Proportions are calculated on the basis of all doctorates working in all sectors of the economy. Data include graduates from 15 months to 60 months prior to the survey reference date (October 2010). The 3–5 year estimate for Computer and information sciences is suppressed for reasons of confidentiality and/or reliability.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2010), http://sestat.nsf.gov.

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field," or "work with a specific person or place." However, 13% of those in postdoc appointments reported lack of other employment as the primary reason for accepting these positions. In life sciences and physical sciences, the two broad fields with relatively high levels of postdoc appointments, the proportions of those reporting lack of other employment as the primary reason for accepting a postdoc position were low (11% and 17%, respectively) compared with the proportion of those in the social sciences (30%), an area where postdocs are typically not as common.

Table 3-21
Median salaries for recent U.S. SEH doctorate recipients in postdoc and non-postdoc positions up to 5 years after receiving degree: 2010
(Dollars)

Field of doctorate	All positions	Postdocs	Non-postdocs
All SEH fields	66,000	43,000	76,000
Biological, agricultural, and environmental life sciences	50,000	42,000	65,000
Computer and information sciences	94,000	48,000	97,000
Mathematics and statistics	64,000	53,000	70,000
Physical sciences	60,000	44,000	76,000
Psychology	60,000	43,000	64,000
Social sciences	63,000	44,000	64,000
Engineering	87,000	44,000	91,000
Health	75,000	47,000	77,000

SEH = science, engineering, and health.

NOTES: Salaries are rounded to the nearest $1,000. Data include graduates from 15 months to 60 months prior to the survey reference date.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2010), http://sestat.nsf.gov.

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Age and Retirement of the S&E Workforce

This section focuses on indicators of the aging of the S&E workforce, for example, the retirement patterns of S&E workers and workforce participation levels among older individuals. The high concentration of S&E workers over age 50 suggests that the S&E workforce will soon experience high levels of turnover. The age distribution and retirement patterns of S&E workers have important implications for the supply of S&E expertise in the economy. An aging S&E labor force may translate into rising output and productivity as S&E workers acquire additional skills, gain experience, and improve their judgment. Consequently, the retirement of experienced workers could mean loss of valuable S&E expertise and knowledge. However, the retirement of older workers also makes room for newly trained S&E workers who may bring updated skills and new approaches to solving problems (Stephan and Levin 1992).

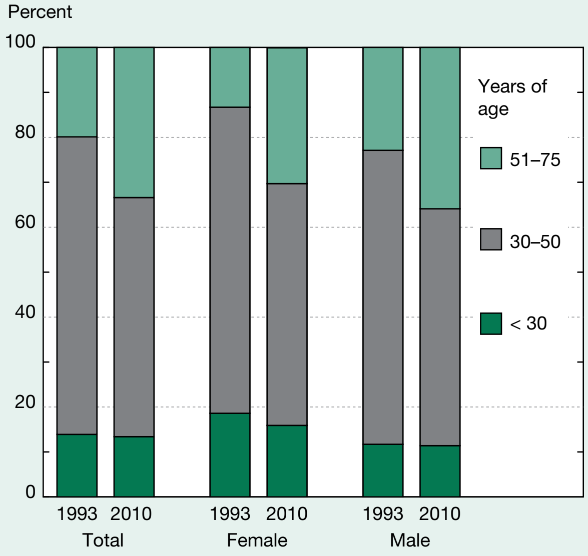
The aging of the S&E labor force is reflected in rising median ages. In 2010, the median age of scientists and engineers in the labor force was 44 years, compared to 41 years in 1993. Another indicator of the aging of the S&E labor force is the increasing percentage of individuals in this labor force over age 50 (between the ages of 51 and 75) (figure 3-25). In 1993, about 1 in every 5 scientists and engineers in the labor force was in that age group (20%), whereas by 2010 the proportion rose to 1 out of 3 (33%).

Between 1993 and 2010, the proportion of scientists and engineers in the labor force over 50 years of age rose for both men and women; however, the female labor force continues to be younger relative to their male counterparts (figure 3-25). In 2010, 30% of female scientists and engineers in the labor force were between 51 and 75 years of age, compared to 36% of male scientists and engineers in the labor force. In 2010, the median ages in the SESTAT population were 42 years for women and 45 years for men, whereas in 1993 the median ages were 38 and 42, respectively.

Age Differences among Occupations

SESTAT respondents working in S&E occupations are younger than those in S&E-related or non-S&E occupations (figure 3-26). In 2010, 26% of those in S&E occupations were between 51 and 75 years of age compared with 34% of those in S&E-related occupations and 36% of those in non-S&E occupations. The median age of the SESTAT population employed in S&E occupations was 42 years, compared to 44 years among those employed in S&E-related occupations and 45 years among those employed in non-S&E occupations.

Figure 3-25
Age distribution of scientists and engineers in the labor force, by sex: 1993 and 2010



NOTES: For 1993 data, scientists and engineers include those with one or more S&E degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E occupation. For 2010 data, scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation. The Scientists and Engineers Statistical Data System (SESTAT) does not cover scientists and engineers over age 75.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (1993, 2010), http://sestat.nsf.gov.

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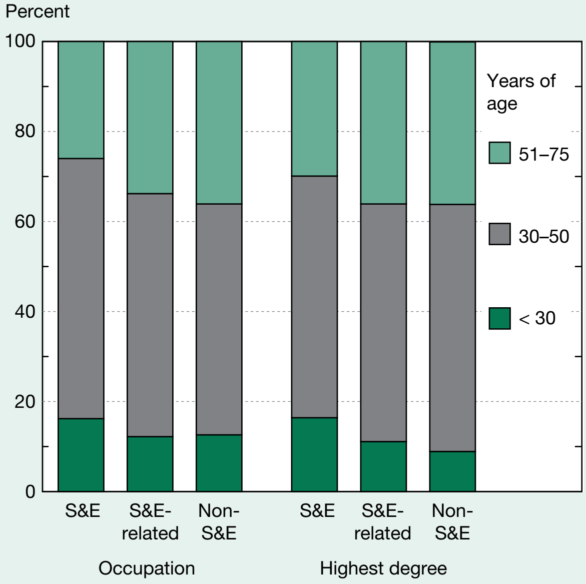
The age differences across S&E and non-S&E occupations were more pronounced for men than for women. Among male scientists and engineers, 27% of those employed in S&E occupations were between the ages of 51 and 75 compared with 41% of those employed in non-S&E occupations. Among female scientists and engineers, 24% of those employed in S&E occupations were between the ages of 51 and 75 compared with 30% of those employed in non-S&E occupations.

Age Differences among Degree Fields

Similar to the trend seen across broad occupational categories, S&E highest degree holders are generally younger than those holding highest degrees in S&E-related or non-S&E fields (figure 3-26). In 2010, 30% of S&E highest degree holders were between 51 and 75 years of age compared with 36% of those with highest degrees in S&E-related or non-S&E fields. However, degree holders in different S&E fields varied in their ages. S&E highest degree holders in the physical sciences, particularly the men in this group, were older than those in other S&E fields (appendix table 3-12). S&E highest degree holders in computer and mathematical

Figure 3-26
Age distribution of employed scientists and engineers, by broad occupational category and broad field of highest degree: 2010



NOTES: Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation. The Scientists and Engineers Statistical Data System (SESTAT) does not cover scientists and engineers over age 75.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (2010), http://sestat.nsf.gov.

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sciences, in social sciences, and in engineering were relatively young.

Within broad degree areas, the age profile of different degree fields varies (appendix table 3-12). For example, within computer and mathematical sciences degree fields, 16% of highest degree holders in computer and information sciences were between 51 and 75 years of age compared with 39% of highest degree holders in mathematics and statistics. In all broad S&E fields of highest degree except computer and mathematical sciences, women were younger than their male counterparts (appendix table 3-12).

Retirement

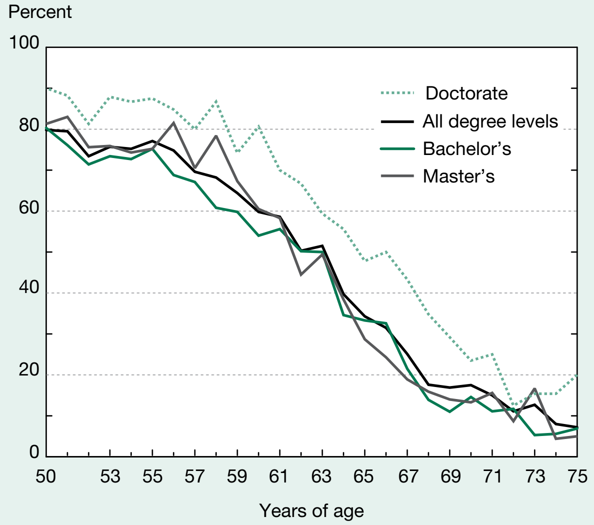
The increasing proportion of the SESTAT labor force over 50 years of age raises the issue of how impending retirement will affect the supply of S&E workers. Patterns of labor force participation among older individuals provide useful information about potential retirement ages and how retirement ages may have changed over time.

Recent patterns of leaving the labor force and shifting to part-time work among older members of the workforce suggest that after age 55 the labor force participation rate among scientists and engineers begins to decline and is markedly reduced by the time workers reach their late 60s. One indication of the relationship between age and the level of labor force participation is illustrated by figure 3-27, which shows the proportions of older scientists and engineers working full time. In 2010, at age 50, 80% of scientists and engineers worked full time (35 hours or more per week) in their principal job. Among individuals in their mid- to late-50s, this proportion dropped steeply. Among those in their mid-60s, for example, only about one-third worked full time. The overall pattern of declining full-time participation starting in individuals' mid- to late-50s held at all degree levels, although doctorate holders generally worked full time at higher rates than bachelor's degree holders (figure 3-27).

Between 1993 and 2010, increasing proportions of SESTAT respondents in their 60s reported still being in the labor force. Whereas 69% of SESTAT respondents between the ages of 60 and 64 were in the labor force in 1993, this proportion rose to 74% in 2010. For those between the ages of 65 and 69, the proportion rose from 39% in 1993 to 47% in 2010.

Reasons provided by SESTAT respondents for labor force nonparticipation or part-time work status also shed light on the relationship between age and retirement. In 2010, about 2.5 million scientists and engineers reported that they were out of the labor force because of retirement. The vast majority (87%) of retired individuals were 60–75 years of age, and half of the retired individuals (51%) were between the ages of 67 and 75. Individuals with doctorates reported lower rates of retirement than those without doctorates (figure 3-28).

Figure 3-27
Older scientists and engineers who work full time, by age and highest degree level: 2010



NOTES: All degree levels include professional degrees not reported separately. Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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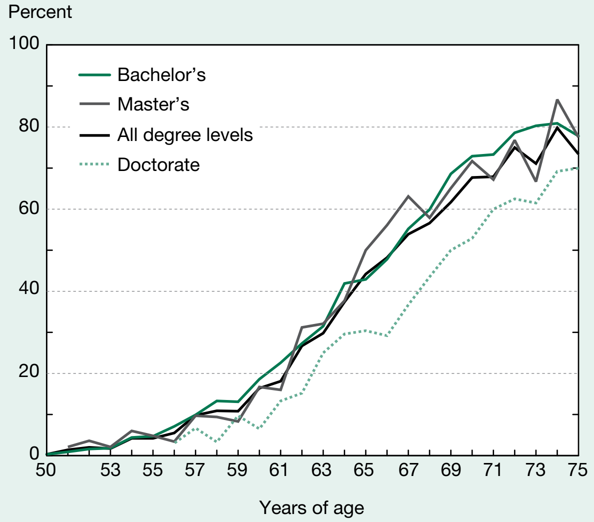
Figure 3-28
Older scientists and engineers who report not working because of retirement, by age: 2010



NOTES: All degree levels include professional degrees not reported separately. The missing data points are suppressed for reasons of confidentiality and/or reliability. Scientists and engineers include those with one or more S&E or S&E-related degrees at the bachelor's level or higher or those who have only a non-S&E degree at the bachelor's level or higher and are employed in an S&E or S&E-related occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Retirement, however, does not always mean that workers permanently leave the labor force. After nominally retiring from their jobs, some workers continue to work part time, work in a different capacity, or decide to return to the labor market at a later time. About 1.4 million scientists and engineers employed in 2010 reported that they had previously retired from a job. A total of 653,000 scientists and engineers working part time in 2010 reported their reason for working part time as having "previously retired or semi-retired." Individuals who chose to stay in or return to the labor market following an occurrence of retirement were younger (median age 62) than those who were out of the labor force following retirement (median age 67).

Compared to all employed scientists and engineers included in SESTAT, the 1.4 million SESTAT respondents who stayed in or returned to the workforce after having retired from a previous position were less likely to hold S&E jobs (18% versus 25% for all employed SESTAT respondents) or to work in areas closely related to their highest degree (46% versus 58% for all employed SESTAT respondents) and more likely to be self-employed in unincorporated businesses (17% versus 7% for all employed SESTAT respondents).

Women and Minorities in the S&E Workforce

As researchers and policymakers increasingly emphasize the need for expanding S&E capabilities in the United States, many view demographic groups with lower rates of S&E participation as an underutilized source of human capital for S&E work. Historically, in the United States, S&E fields have had particularly low concentrations of women and members of many racial and ethnic minority groups (i.e., blacks, Hispanics, American Indians or Alaska Natives), both relative to the concentrations of these groups in other occupational or degree areas and relative to their representation in the general population. However, women and racial and ethnic minorities increasingly have been choosing a wider range of degrees and occupations over time. This section presents data on S&E participation by women and by racial and ethnic minorities. It also presents data on earnings differentials by sex and by race and ethnicity.

Women in the S&E Workforce

Historically, men have outnumbered women by wide margins with regards to both S&E employment and S&E training. Although the number of women in S&E occupations or with S&E degrees nearly doubled over the past two decades, the disparity has narrowed only modestly. The imbalance is still particularly pronounced in S&E occupations. In 2010, women constituted only 28% of workers in these occupations, even though they accounted for nearly half of the college-educated workforce. Among S&E degree holders, the disparity was smaller but nonetheless significant, with women representing 37% of employed individuals with a highest degree in S&E (figure 3-29).

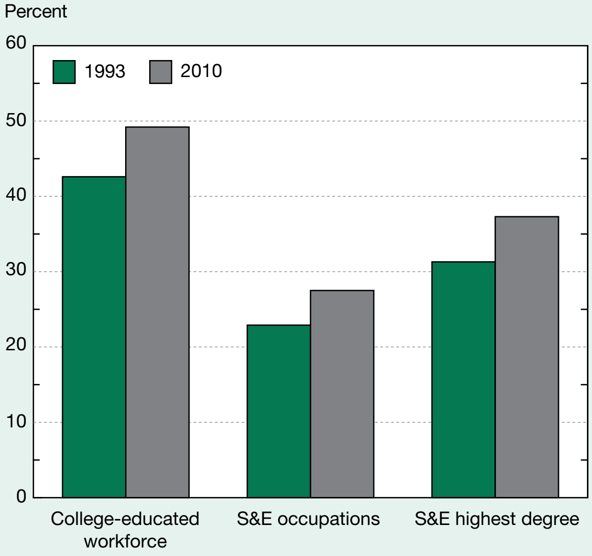
Women in S&E Occupations

Although women represented only 28% of individuals in S&E occupations in 2010, women's presence varies widely across S&E occupational fields (appendix table 3-13). The percentage of female S&E workers is lowest in engineering, where women constituted 13% of the workforce in 2010. Among engineering occupations with large numbers of workers, the disparity between men and women is greatest among mechanical engineers, with women accounting for only 7% of the workforce. Other large engineering occupations in which women account for about 11% to 12% of the workforce include electrical and computer hardware engineers and aerospace, aeronautical, and astronautical engineers.

Other disproportionately male S&E occupations include physical scientists (30% women) and computer and mathematical scientists (25% women). Within the physical sciences occupations, physicists and astronomers have the largest imbalance (18% women). Within the computer and mathematical sciences occupations, the largest component, computer and information scientists, has the smallest proportion of women (23%). The mathematical scientists component is much closer to parity (46% women).

In 2010, sex parity in S&E occupations was close among life scientists (48% women). Within the life sciences occupations, biological and medical scientists, the largest component, had reached gender parity (52% women). The field of social sciences was majority female (58%). Occupations within the social sciences, however, varied with respect to the proportion of female workers. Thus, women accounted for slightly more than one-third of economists (37%) but

Figure 3-29
Women in the workforce and in S&E: 1993 and 2010



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) and National Survey of College Graduates (NSCG) (1993 and 2010), http://sestat.nsf.gov.

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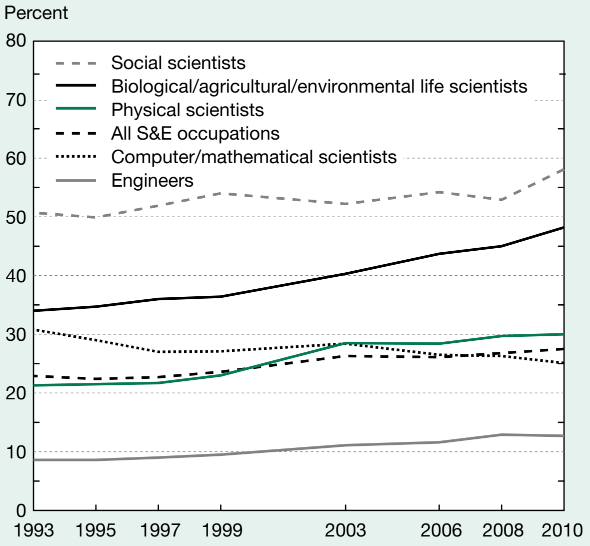
more than two-thirds of psychologists (70%). Psychologists, estimated at about 171,000 total workers in SESTAT (appendix table 3-13), was an example of a large S&E occupation with substantially more women than men.

In contrast to jobs in S&E occupations, a majority of jobs in S&E-related occupations (56%) are held by women (appendix table 3-13). The largest component, health-related occupations, employed a large number of women (68% women), primarily as nurse practitioners, pharmacists, registered nurses, dietitians, therapists, physician assistants, and health technologists and technicians.

Since the early 1990s, the number of women working in each broad S&E occupational category has risen significantly. The rate of growth has been strongest among life scientists, computer and mathematical scientists, and social scientists. These three broad S&E fields together employed 80% of women in S&E occupations in 2010, compared with 59% of men in S&E occupations. Between 1993 and 2010, the number of women more than doubled among life scientists (an increase of 162%) and nearly doubled among social scientists (an increase of 87%). The number of men also grew, but the rate of growth for women was greater than that for men, resulting in an increase in the proportion of female life scientists and female social scientists (figure 3-30).

During the same period, the number of women in computer and mathematical sciences occupations nearly doubled (an increase of 97%). However, unlike the other broad S&E occupational categories, the rate of growth in male participation was larger (161%) than that of women, resulting in an overall decline in the proportion of women from 31% to 25%. These trends made the gender disparity among computer and mathematical scientists second only to engineers. The declining proportion of women in the computer and mathematical sciences occupations reflects increasing disparities in participation among those whose highest degree is at the bachelor's degree level. Among computer and mathematical scientists with a doctoral degree, the proportion of women increased, from 16% in 1993 to 20% in 2010.

Figure 3-30
Women in S&E occupations: 1993–2010



NOTE: National estimates were not available from the Scientists and Engineers Statistical Data System (SESTAT) in 2001.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (1993–2010), http://sestat.nsf.gov.

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During the past two decades, women have also increased their proportion among workers in engineering (from 9% to 13%) and in the physical sciences (from 21% to 30%). In these two occupational categories, this increase was led by an expansion of women's numbers in the workforce (by 67% in engineering and 60% in physical sciences) while men's numbers barely changed between 1993 and 2010.

Women among S&E Highest Degree Holders

The sex disparity among employed S&E highest degree holders is less than the disparity among those in S&E occupations. In 2010, among individuals with a highest degree in an S&E field, women constituted 37% of those who were employed, up from 31% in 1993. The pattern of variation in the proportion of men and women among degree fields echoes the pattern of variation among occupations associated with those fields (appendix table 3-14). In 2010, 54% of S&E highest degree holders in the social sciences fields were women, as were 48% of those with a highest degree in the biological and related sciences. Men outnumbered women among computer sciences and mathematics highest degree holders (28% women) and among physical sciences highest degree holders (27% women). Disparities, however, were greatest among those with a highest degree in engineering (only 14% women). In all fields except computer and mathematical sciences, the proportion of women in the workforce with associated highest degrees has been increasing over the past two decades. In computer and mathematical sciences, this proportion has declined even as the number of women with a highest degree in the field has risen.

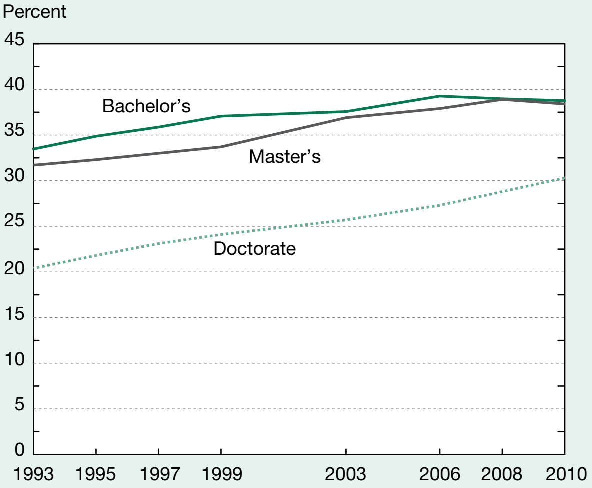
Sex differences are not limited to the field of degree, but also extend to the level of S&E degree. Men outnumber women among S&E highest degree holders at the bachelor's, master's, and doctoral levels. Moreover, the sex disparity is higher among S&E doctorate holders than among S&E bachelor's or master's degree holders. For example, in 2010 women accounted for 38% of those whose highest degree in S&E was at the bachelor's or master's level but 30% of those whose highest degree in S&E was at the doctoral level (figure 3-31). At the doctoral level, however, the proportion of women has been steadily increasing. The trend at the bachelor's and master's levels has been somewhat different: although the proportion of women in the workforce rose from 1993 to 2003, it remained mostly steady from 2003 to 2010 (figure 3-31).

Working men and women with S&E highest degrees also differ in the extent to which they are employed in the same field as their S&E highest degree. However, this disparity is largely the result of women having a high concentration in the two degree areas—social sciences and life sciences—where degree holders most often work in non-S&E occupations. In 2010, these two broad fields accounted for three-fourths of all employed women with S&E highest degrees, compared with 41% of all employed men with S&E highest degrees (appendix table 3-14). (See sidebar, "S&E Credentials and the Male-Female Gap in S&E Employment.")

Across all S&E degree areas, 19% of women with an S&E highest degree are employed in the S&E field in which they earned their degree compared with 32% of men (appendix table 3-15). However, within the majority of degree areas (life sciences, social sciences, and engineering), similar proportions of men and women are employed in the S&E field in which they earned their degree. Computer and mathematical sciences fields are exceptions, where a larger proportion of men (54%) than women (43%) work in an occupation that matches their degree field and a larger proportion of women (38%) than men (27%) work in non-S&E occupations. Among those with life sciences degrees, although a similar proportion of men (23%) and women (22%) work in their degree field, a larger proportion of women (35%) than men (18%) are employed in S&E-related occupations. These sex differences in the degree fields of life sciences and computer and mathematical sciences are primarily driven by those whose highest degrees are at the bachelor's or master's levels.

Men and women with a highest degree in an S&E field also differ in their labor force nonparticipation rates. Compared with men, women were more likely to be out of the labor force (22% versus 14% for men). The difference in nonparticipation was particularly pronounced between the ages of 30 and 65 (figure 3-32). In 2010, 19% of the women in this age group with an S&E highest degree were out of the labor force compared with 7% of the men. Many women in this group identified family reasons as an important factor: 48% of women reported that family was a factor for their labor force nonparticipation compared with 9% of men. Within this age range, women were also much more likely than men to report that they did not need to work or did not want to work (41% of women versus 26% of men). Men, on the other hand, were much more likely than women to cite retirement as a reason for not working (28% of women versus 71% of men).

Figure 3-31
Employed women with highest degree in S&E, by degree level: 1993–2010



NOTE: National estimates were not available from the Scientists and Engineers Statistical Data System (SESTAT) in 2001.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (1993–2010), http://sestat.nsf.gov.

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Minorities in the S&E Workforce

The participation of underrepresented racial and ethnic minorities in the S&E workforce has been a concern of policymakers who are interested in the development and employment of diverse human capital to maintain the United States' global competitiveness in S&E. This section addresses the level of diversity in S&E by race and Hispanic ethnicity.[21] Like the preceding section, this section draws on data from NSF's SESTAT surveys to report on levels of S&E participation: first across occupations and then across the overall workforce with S&E degrees.

Whether defined by occupation, S&E degree, or the combined criteria used in SESTAT, the majority of scientists and engineers in the United States are non-Hispanic whites. The next largest group of scientists and engineers are Asians. On the other hand, several racial and ethnic minority groups, including blacks, Hispanics, and American Indians or Alaska Natives, have low levels of participation in S&E fields both compared with other groups and compared with their proportion in the population (table 3-22).

Race and Ethnicity Trends in S&E Occupations

In 2010, among the 5.4 million workers employed in S&E occupations, 70% were white, which is similar to the proportion (68%) in the U.S. population age 21 and older (table 3-22). However, S&E participation by whites varied across the broad S&E occupational categories, from 65% of computer and mathematical scientists to 81% of social scientists (appendix table 3-16). The concentration of whites in some occupations was more pronounced: they accounted for approximately 90% of workers among forestry and conservation scientists, geologists and earth scientists, and political scientists.

Asians, with nearly a million workers in S&E occupations, accounted for 19% of S&E employment. Among the overall population age 21 and older, their proportion was much smaller (5%). Asians had a large presence in computer and engineering fields, constituting 33% of computer software engineers, 30% of software developers, 40% of computer hardware engineers, 27% of bioengineers or biomedical engineers, and 35% of postsecondary teachers in engineering (appendix table 3-16). On the other hand, the proportion of Asians in social sciences occupations was much lower both compared with their participation in other S&E fields and compared with whites. For example, Asians accounted for just 6% of workers in social sciences occupations.

The social sciences are the one S&E occupational category in which the proportions of blacks (5%) and Hispanics (6%) are similar to that of Asians (6%) (appendix table 3-16). As a result, underrepresented racial and ethnic minorities (blacks, Hispanics, and American Indians or Alaska Natives) collectively outnumber Asians among social scientists. In the other broad S&E occupational categories, Asians represent a larger segment than all underrepresented racial and ethnic minorities combined.

In general, the proportions of Hispanics across the broad S&E occupational categories were roughly similar (between 5% and 6%), whereas blacks had higher rates of participation among computer and mathematical scientists (6%) relative to life scientists (3%), physical scientists (3%), and engineers (4%) (appendix table 3-16). Hispanics had a particularly large presence among sociologists (13%); psychologists (7%); aeronautical, aerospace, and astronautical engineers (9%); and civil engineers (8%). Blacks had relatively high participation rates among computer support specialists (16%), information security analysts (14%), and sociologists (13%).

Over the past two decades, the U.S. workforce in S&E occupations has been becoming more diverse with increasing proportions of Asians, blacks, and Hispanics and a decreasing proportion of whites (table 3-23). In 1993, 84% of

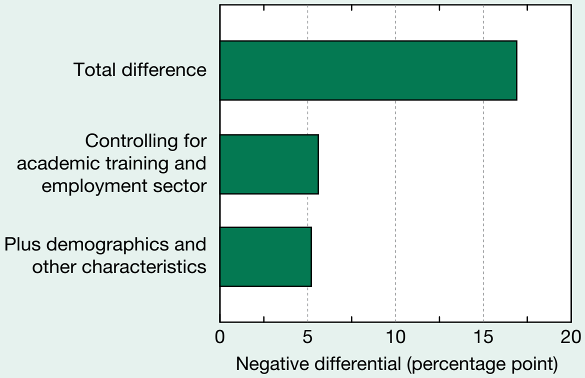
S&E Credentials and the Male-Female Gap in S&E Employment

Among college-educated individuals, a significantly higher proportion of men than women are employed in S&E occupations. For example, among S&E highest degree holders working full time, 26% of women, compared to 43% of men, hold positions with formal S&E jobs. This gender gap in S&E employment is found in all racial and ethnic groups. For example, among S&E highest degree holders working full time, S&E jobs are held by 43% of Asian women compared to 58% of Asian men, 22% of black women compared to 32% of black men, 19% of Hispanic women compared to 37% of Hispanic men, and 24% of white women compared to 41% of white men. The participation gap exists despite the trend that increasing proportions of women in all racial and ethnic groups are graduating from college. In most racial and ethnic groups, for example, a higher percentage of women than men have college degrees.

Field of degree, level of highest degree, employment sector, and other characteristics that are typically believed to be associated with occupational fields vary between men and women. As a result, it can be misleading to directly compare S&E employment rates by sex. Compared with men, women tend to have many characteristics—such as degrees in the life and social sciences, highest degrees at the bachelor's level, and employment in 2-year academic institutions and in the non-profit sector—that are associated with working outside S&E occupations. Statistical models can estimate the size of the male-female participation gap in S&E occupations when various occupation-related factors are taken into account. However, estimates of these differences vary somewhat depending on the assumptions that underlie the statistical model used.

After accounting for differences between men and women in field of degree, level of highest degree, and employment sector, the participation gap in S&E occupations declines significantly (from 17 to 6 percentage points) but does not attenuate completely (figure 3-C). Adding measures of personal and family characteristics that may affect S&E participation to academic and employment information further reduces the estimated participation gap marginally (from 6 to 5 percentage points). This suggests that although measurable differences between men and women explain a significant portion of the male-female participation gap in S&E occupations, they do not entirely explain the differing propensity of men and women to obtain S&E employment. As such, boosting college attendance alone is unlikely to equalize male-female participation in S&E employment as long as men and women study different fields and attain degrees at different levels.

Figure 3-C
Estimated differences in the proportions of women and of men with S&E highest degree employed in S&E occupations, controlling for selected characteristics: 2010



NOTE: Coefficients are estimated in a probit regression model using a binary (0–1) variable indicating employment in S&E occupations as the dependent variable.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (2010), http://sestat.nsf.gov.

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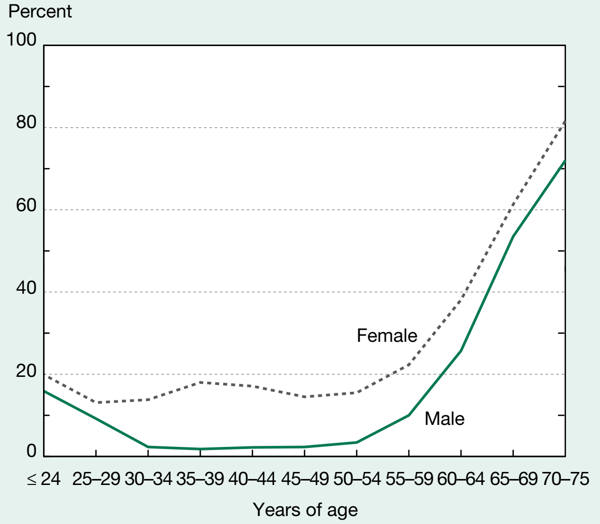
workers in S&E occupations reported their race as white. By 2010, this proportion declined to 70%. Most of the decline in the proportion of whites during this period was offset by an increase in the proportion of Asians and, to a lesser degree, by an increase in the proportion of some other groups, particularly Hispanics.

Figure 3-32
Highest degree holders in S&E not in the labor force, by sex and age: 2010



NOTE: Not in the labor force includes those not working nor looking for work in the 4 weeks prior to October 2010.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov

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Some of the changes by race may reflect changes to the way NSF workforce surveys collect information on this topic. After 2000, respondents were able to report two or more races rather than just one. Some of those who self-reported as white in the 1990s may have instead reported a multiracial identity after 2000 once they were given the option, which would decrease the estimated numbers of whites. However, because less than 2% of S&E workers reported a multiracial identity in years when that option was available, it is unlikely that this change contributed much to the decline in the proportion of whites between 1993 and 2010.

Racial and Ethnic Differences among S&E Degree Holders

Among employed S&E highest degree holders, racial and ethnic groups vary with respect to their proportions in different degree fields (table 3-24; appendix table 3-17). Differences in highest degree fields largely resemble the differences among S&E occupations. Asians have higher participation rates among engineering highest degree holders and among computer and mathematical sciences highest degree holders relative to other broad S&E degree fields. Blacks have higher participation rates in computer and mathematical sciences and in the social sciences. Hispanics have higher participation rates in engineering and in the social sciences. Whites represent a larger segment of life, physical, and social sciences highest degree holders than engineering or computer and mathematical sciences highest degree holders.

The demographic groups also differ in the level of their highest degree (table 3-25). For example, Asians account for a larger proportion of those whose highest degree is at the master's or doctoral level compared with those whose highest

Table 3-22
Racial and ethnic distribution of employed individuals in S&E occupations, and of S&E degree holders, college graduates, and U.S. residents: 2010
(Percent)

Race and ethnicity	S&E occupations	S&E highest degree holders	College degree holders	U.S. residential population[a]
Total (*n*)	5,398,000	11,385,000	40,623,000	221,319,000
American Indian or Alaska Native	0.2	0.2	0.3	0.6
Asian	18.5	13.9	7.9	4.9
Black	4.6	5.7	6.8	11.5
Hispanic	5.2	6.8	7.1	13.9
Native Hawaiian or Other Pacific Islander	0.2	0.3	0.3	0.1
White	69.9	71.5	76.2	67.5
More than one race	1.4	1.5	1.4	1.5

[a] Age 21 and over.

NOTES: Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

SOURCES: Census Bureau, American Community Survey (2010); National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), and National Survey of College Graduates (NSCG) (2010), http://sestat.nsf.gov.

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Table 3-23

Distribution of workers in S&E occupations, by race and ethnicity: 1993–2010

(Percent)

Race and ethnicity	1993	1995	1997	1999	2003	2006	2008	2010
American Indian or Alaska Native	0.2	0.3	0.3	0.3	0.3	0.4	0.3	0.2
Asian	9.1	9.6	10.4	11.0	14.2	16.1	16.9	18.5
Black	3.6	3.4	3.4	3.4	4.3	3.9	3.9	4.6
Hispanic	2.9	2.8	3.1	3.4	4.4	4.6	4.9	5.2
Native Hawaiian or Other Pacific Islander	NA	NA	NA	NA	0.3	0.5	0.4	0.2
White	84.1	83.9	82.9	81.8	75.2	73.2	71.8	69.9
More than one race	NA	NA	NA	NA	1.4	1.4	1.7	1.4

NA = not available.

NOTES: Before 2003, respondents could not classify themselves in more than one racial and ethnic category. Before 2003, Asian included Native Hawaiian and Other Pacific Islander. Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (1993–2010), http://sestat.nsf.gov.

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Table 3-24

Racial and ethnic distribution of employed individuals with S&E highest degree, by field of highest degree: 2010

(Percent)

Race and ethnicity	All S&E fields	Biological, agricultural, and environmental life sciences	Computer and mathematical sciences	Physical sciences	Social sciences	Engineering
Employed with highest degree in S&E (*n*)	11,385,000	1,764,000	1,886,000	693,000	4,363,000	2,679,000
American Indian or Alaska Native	0.2	0.3	0.2	0.3	0.3	0.2
Asian	13.9	12.0	22.7	15.2	6.5	20.6
Black	5.7	3.6	7.7	3.6	7.6	3.2
Hispanic	6.8	6.2	5.5	4.5	7.7	7.4
Native Hawaiian or Other Pacific Islander	0.3	S	0.2	0.1	0.3	0.4
White	71.5	75.7	62.6	75.3	75.8	66.9
More than one race	1.5	1.4	1.1	1.2	1.9	1.3

S = suppressed for reasons of confidentiality and/or reliability.

NOTES: Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Table 3-25

Racial and ethnic distribution of employed individuals with S&E highest degree, by level of highest degree: 2010

(Percent)

Race and ethnicity	Bachelor's	Master's	Doctorate
Employed with highest degree in S&E (*n*)	8,160,000	2,356,000	847,000
American Indian or Alaska Native	0.3	0.2	0.1
Asian	11.0	20.6	23.0
Black	6.1	5.6	2.8
Hispanic	7.5	5.7	3.8
Native Hawaiian or Other Pacific Islander	0.4	0.2	0.1
White	73.1	66.3	69.1
More than one race	1.6	1.4	1.1

NOTES: Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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degree is at the bachelor's level. Conversely, non-Asians represent a larger proportion of those whose highest degree is at the bachelor's and master's degree level compared with those whose highest degree is at the doctoral level.

Asian S&E highest degree holders are more likely than those in other racial and ethnic groups to work in S&E occupations and to work in the area in which they earned their degree (appendix table 3-15). Among blacks, Hispanics, and whites, about one-quarter or less of S&E highest degree holders work in their same broad field of highest degree. By comparison, nearly 40% of Asians work in the same broad field in which they received their highest degree.

Salary Differences for Women and Racial and Ethnic Minorities

Women and racial and ethnic minority groups generally receive less pay than their male and white counterparts (table 3-26). In 2010, among full-time workers with a highest degree in an S&E field, the median salary for women ($53,000) was about one-third lower than that for men ($80,000). Among S&E highest degree holders who work full-time in S&E occupations, the difference in median salary between men ($85,000) and women ($69,000) was smaller (19% less) (appendix table 3-18).

Table 3-26
Median annual salary among S&E highest degree holders working full time, by sex, race, and ethnicity: 1995, 2003, 2010
(Dollars)

Characteristic	1995	2003	2010
All	44,000	60,000	70,000
Sex			
Female	34,000	45,000	53,000
Male	49,000	68,000	80,000
Race and ethnicity			
American Indian or Alaska Native	S	48,000	59,000
Asian	45,000	64,000	75,000
Black	35,000	48,000	56,000
Hispanic	38,000	50,000	60,000
Native Hawaiian or Other Pacific Islander	NA	56,000	56,000
White	45,000	60,000	72,000
More than one race	NA	50,000	60,000

NA = not available; S = suppressed for reasons of confidentiality and/or reliability.

NOTES: Salaries are rounded to the nearest $1,000. Data for 1995 include some individuals with multiple races in each category. Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (1995, 2003, 2010), http://sestat.nsf.gov.

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Salary differences among racial and ethnic groups were somewhat smaller than salary differences between men and women (table 3-26; appendix table 3-19). Among S&E highest degree holders working full time, American Indians or Alaska Natives earned 18% less than whites, blacks earned 22% less than whites, and Hispanics earned 17% less than whites. Relative to Asians, American Indians or Alaska Natives earned 21% less, blacks earned 25% less, and Hispanics earned 20% less. These salary differences were generally more modest among those who worked in S&E occupations (appendix table 3-19).

Overall, salary differences between men and women and among racial and ethnic groups remained largely unchanged between 1995 and 2010 (table 3-26).

Differences in average age, work experience, academic training, sector and occupation of employment, and other characteristics can make direct comparison of salary statistics misleading. Statistical models can estimate the size of the salary difference between men and women, or the salary difference between racial and ethnic groups, when various salary-related factors are taken into account. Estimates of these differences vary somewhat depending on the assumptions that underlie the statistical model used. The remainder of this section presents estimated salary differences between men and women among individuals who are otherwise similar in age, work experience, field of highest degree, type of academic institution awarding highest degree (Carnegie classification and public/private status), occupational field and sector, and other relevant characteristics that are likely to influence salaries. Data bearing on salary differences between minorities (American Indians or Alaska Natives, blacks, Hispanics, Native Hawaiians or Other Pacific Islanders, and those reporting more than one race) relative to Asians and whites are also included.

Without accounting for any factors except level of degree, women working full time whose highest degree is at the bachelor's level in an S&E field earned 31% less than men (figure 3-33).[22] The salary difference is smaller, but nonetheless substantial, at both the master's level (29%) and the doctoral level (22%). The salary differences for non-Asian minorities relative to whites and Asians are narrower (figure 3-34). On average, minority salary levels are 22% lower than those of whites and Asians at the bachelor's level, 14% lower at the master's level, and 16% lower at the doctoral level.

Effects of Education, Employment, and Experience on Salary Differences

Salaries differ across degree field, occupational field and sector, and experience. For example, median salaries in 2010 were generally higher among individuals with highest degrees in engineering ($86,000), physical sciences ($68,000), or computer and mathematical sciences ($79,000) compared with those with highest degrees in life sciences ($50,000) or social sciences ($50,000). Degree areas with lower salaries generally have higher concentrations of women and of racial and ethnic minorities. Disproportionately larger proportions of degree holders in life sciences, and particularly in the social sciences, relative to other S&E degree fields, work in occupations not categorized as S&E, where salaries are generally lower than in S&E occupations (appendix table 3-18). As a result, differences in degree and occupational fields are likely to explain much of the salary differences by sex and by race and ethnicity.

Salaries also differ across employment sector. Academic and non-profit employers typically pay less for similar skills than employers in the private sector, and government compensation falls somewhere between these two groups. These differences are salient for understanding salary variations by sex and by race and ethnicity because men, Asians, and whites are more highly concentrated in the private for-profit sector.

Salaries also vary by indicators of experience, such as age or years since completing one's degree. Because of the rapid increase in female participation in S&E fields in recent years, female S&E highest degree holders employed full time are younger than their male counterparts (median age 40 years for women versus 44 years for men), which translates to fewer years of labor market experience for women relative to men. White S&E highest degree holders with similar characteristics are also older (44 years) compared with Asians (39 years) and most other racial and ethnic minorities (Hispanics: 39 years, blacks: 42 years, American Indians or Alaska Natives: 43 years, and Native Hawaiians or Other Pacific Islanders: 33 years).

After controlling for differences in field of highest degree, degree-granting institution, field of occupation, employment sector, and experience,[23] the estimated salary difference between men and women narrows by more than half (figure 3-33). However, among men and women in similar jobs, and with similar highest degree fields and levels of experience, women still earn 12% less than men among individuals whose highest degree is at the bachelor's level, 10% less than men among individuals whose highest degree is at

Figure 3-33
Estimated salary differences between women and men with highest degree in S&E employed full time, controlling for selected characteristics, by degree level: 2010

NOTES: Salary differences represent the estimated percentage difference in women's average full-time salary relative to men's average full-time salary. Coefficients are estimated in an ordinary least squares regression model using the natural log of full-time annual salary as dependent variable and then transformed into percentage difference.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (2010), http://sestat.nsf.gov.

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Figure 3-34
Estimated salary differences between minorities and whites and Asians with highest degree in S&E employed full time, controlling for selected characteristics, by degree level: 2010

NOTES: Salary differences represent the estimated percentage difference in the average full-time salary of minorities relative to the average full-time salary of whites and Asians. Coefficients are estimated in an ordinary least squares regression model using the natural log of full-time annual salary as dependent variable and then transformed into percentage difference. Minorities include American Indian or Alaska Natives, blacks, Hispanics (of any race), Native Hawaiian or Other Pacific Islanders, and those reporting more than one race.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (2010), http://sestat.nsf.gov.

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the master's level, and 9% less than men among individuals whose highest degree is at the doctoral level.

Compared with whites and Asians, other racial and ethnic groups with their highest degree at the bachelor's level also earn less (15%) after controlling for education, occupation, and experience (figure 3-34). Although the initial salary gap for racial and ethnic minorities is smaller than for women, less of this initial salary gap is explained by differences in education, occupation, and experience. Among those whose highest degree is at the bachelor's level, after controlling for education, occupation, and experience, more than half of the initial salary gap among racial and ethnic minorities persists, compared to less than half of the initial salary gap persisting among women. In comparison, among those with a master's or doctoral degree, the salary gap across racial and ethnic groups is significantly attenuated: after controlling for these factors, the salary gap is only 5% for those at the master's degree level and only 4% for those at the doctorate level.

Effects of Demographic and Other Factors on Salary Differences

Salaries vary by factors beyond education, occupation, and experience. For example, marital status, the presence of children, parental education, and other personal characteristics are often associated with salary differences. These differences reflect a wide range of issues, both voluntary and involuntary, including, but not limited to, factors affecting individual career- and education-related decisions, differences in how individuals balance family obligations and career aspirations, productivity and human capital differences among workers that surveys do not measure, and possible effects of employer prejudice or discrimination. Salaries also differ across regions, partly reflecting differences in the cost of living across geographic areas.

However, adding measures of personal and family characteristics that may affect compensation[24] to education, occupation, and experience results in only marginal changes in the estimated salary differences between men and women compared with estimates that account for education, occupation, and experience alone. Women who are similar to men along all of these dimensions receive salaries that are 11% (among bachelor's degree holders) to 8% (among doctoral degree holders) less than their male counterparts (figure 3-33). The salary difference among racial and ethnic groups largely disappears among advanced degree holders, but a significant amount of the difference remains among bachelor's degree holders (figure 3-34).

The analysis of salary differences suggests that attributes related to human capital (fields of education and occupation, employment sector, and experience) are much more important than socioeconomic and demographic attributes in explaining the salary differences observed among S&E highest degree holders by sex and across racial and ethnic groups. Nonetheless, the analysis also shows that measurable differences in human capital do not entirely explain income differences between demographic groups.[25]

Salary Differences among Recent Graduates

Salary differences among recent S&E graduates warrant particular attention. Employment metrics of recent graduates are important indicators of current conditions in the labor market, particularly for young people considering S&E careers. Salary differences among recent S&E graduates, particularly across racial and ethnic groups, are substantially narrower than in the population of S&E degree holders as a whole. This suggests that recent cohorts of S&E highest degree holders are much closer to earnings parity than their older counterparts. For example, in 2010, among recent graduates who attained their highest degree in or after 2005, minorities working full time earned 7% (among those whose S&E highest degree was at the bachelor's or doctorate level) to 8% (among those whose S&E highest degree was at the master's level) less than Asians and whites. These salary differences are substantially higher, ranging from 14% to 22%, among all S&E highest degree holders (regardless of graduation year) (figure 3-34). After accounting for differences in education, occupation, and experience, the salary differences for recently graduated minorities relative to whites and Asians are almost attenuated among bachelor's degree holders (a 3% salary gap remains) and completely attenuated among advanced degree holders. In contrast, when all S&E highest degree holders (regardless of graduation cohort) are included in the analysis, a significant amount of the salary gap remains unexplained by these human capital attributes, particularly among bachelor's degree holders (figure 3-34).

After controlling for differences in education, employment, demographic, and socioeconomic attributes, the gender salary gap among recent graduates is not completely attenuated, but it is lower. After controlling for these factors, women earn about 5% to 9% less than men among recent graduates, compared with about 8% to 11% less among all S&E highest degree holders (regardless of graduation cohort).

Immigration and the S&E Workforce

The industrialized nations of the world have long benefitted from the inflow of foreign-born scientists and engineers and the S&E skills and knowledge they bring. S&E skills are more easily transferrable across international borders than many other skills, and many countries have made it a national priority to attract international talent in S&E (NSB 2008). A large proportion of workers employed in S&E fields in the United States are foreign born. This section presents data on foreign-born scientists and engineers in the U.S. economy, including recent indicators of migration to the United States and the rate at which foreign-born recipients of U.S. doctoral degrees remain in the United States after earning their degree (stay rates). Data from various sources, including the Census Bureau, the U.S. Citizenship and Immigration Services (USCIS), and NSF (SESTAT and SED) are discussed to study the immigrant S&E workforce in the United

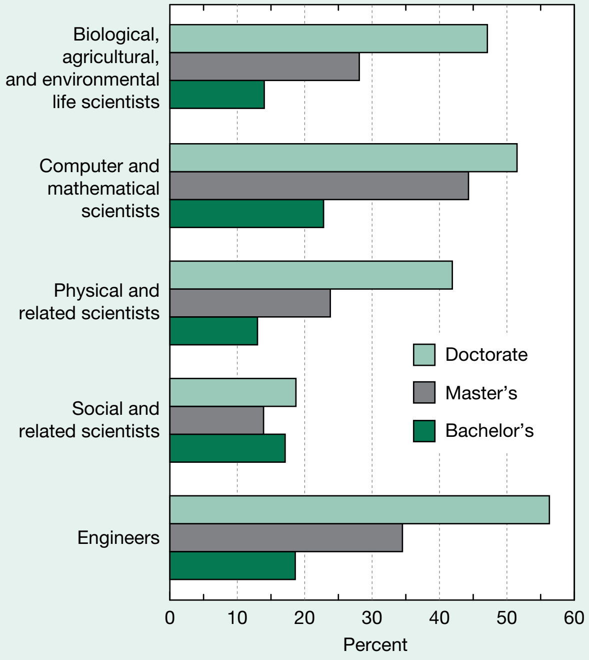
States. This section ends with a discussion of the global migration patterns of high-skill workers.

"Foreign-born" is a broad category, ranging from long-term U.S. residents with strong roots in the United States to recent immigrants who compete in global job markets and whose main social, educational, and economic ties are in their countries of origin. When interpreting data on foreign-born workers, the range of individuals in this category should be kept in mind. Both the number and proportion of foreign-born workers employed in S&E occupations in the United States have risen over time (table 3-27). Nationally representative survey data, such as SESTAT and ACS, although collected in different ways, yield broadly consistent estimates of the number of foreign-born scientists and engineers in the United States. In 2011, foreign-born individuals accounted for 21% of workers employed in nonacademic S&E occupations in the United States, which is higher than their representation in the overall population (13%). Among college-educated workers in nonacademic S&E occupations, the proportion of foreign-born individuals is higher: 26%, which is up from 22% in 2000 (table 3-27).

Characteristics of Foreign-Born Scientists and Engineers

Compared to the entire college-educated workforce, college graduates employed in S&E occupations are disproportionately foreign born. Among SESTAT respondents employed in S&E occupations in 2010, 27% were foreign born. Among all college-educated workers (regardless of occupational category) in 2010, 15% were foreign born. In general, foreign-born workers employed in S&E occupations tend to have higher levels of education than their U.S. native-born counterparts. Among individuals employed in S&E occupations, 19% of foreign-born scientists and engineers have a doctorate, compared to 10% of U.S. native-born scientists and engineers in these occupations. In most S&E occupations, the higher the degree level, the greater the proportion of the workforce who are foreign born (figure 3-35). This relationship is weakest among social scientists and strongest among computer and mathematical scientists and engineers. In 2010, at the bachelor's degree level, the

Figure 3-35
Foreign-born scientists and engineers employed in S&E occupations, by highest degree level and broad occupational category: 2010



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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Table 3-27
Foreign-born workers in S&E occupations, by education level: Selected years, 2000–11
(Percent)

Education	2000 Decennial census	2003 SESTAT	2003 ACS	2006 SESTAT	2006 ACS	2008 SESTAT	2008 ACS	2009 ACS	2010 SESTAT	2010 ACS	2011 ACS
All college educated[a]	22.4	22.6	24.2	23.8	25.3	24.6	24.9	25.2	27.4	26.5	26.2
Bachelor's	16.5	16.4	17.7	17.3	18.1	17.2	18.4	18.3	20.1	19.0	19.0
Master's	29.0	29.4	32.0	31.7	33.5	32.7	32.7	33.4	34.9	35.0	34.3
Doctorate	37.6	36.4	37.8	36.6	41.8	37.8	40.9	41.6	41.5	44.2	43.2

ACS = American Community Survey; SESTAT = Scientists and Engineers Statistical Data System.

[a] Includes professional degrees not broken out separately.

NOTES: The data from the ACS and the Decennial Census include all S&E occupations except postsecondary teachers because these occupations are not separately identifiable in the 2000 Census or ACS data files. SESTAT 2006 and 2008 data do not include foreign workers who arrived in the United States after the 2000 Decennial Census and also did not earn an S&E degree in the United States.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (2003–10), http://sestat.nsf.gov; Census Bureau, 2000 Decennial Census Public Use Microdata Sample (PUMS), and ACS (2003, 2006, 2008, 2009, 2010, 2011).

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proportion of foreign-born individuals in S&E occupations ranged from 13% (physical scientists) to 23% (computer and mathematical scientists). However, at the doctoral level, over 40% were foreign born in each S&E occupation except the social sciences.

Among SESTAT respondents employed in S&E occupations, foreign-born workers (median age 40 years) are younger than their native-born counterparts (median age 43). The distribution by sex is largely similar across foreign-born (26% female) and native-born (28% female) workers in S&E jobs. Asians account for the majority (60%) of foreign-born workers in S&E occupations but only a very small segment (3%) of U.S. native-born workers in these occupations (appendix table 3-20). In comparison, whites represent 27% of foreign-born workers in S&E jobs but 86% of native-born workers in these jobs. Nearly 90% of all Asians employed in S&E occupations are foreign-born.

In 2010, 56% of the foreign-born S&E highest degree holders in the United States were from Asia; 21% were from Europe. The remaining foreign-born workers came from North America, Central America, the Caribbean, South America, and Africa, each of which supplied 4% to 5% of the foreign-born S&E highest degree holders in the United States. In 2010, the leading country of origin among immigrants with a highest degree in S&E was India, which accounted for 19% of the foreign-born S&E highest degree holders (figure 3-36). With less than half the total for India, China was the second leading country with 8%. Source countries for the nearly 395,000 foreign-born holders of S&E doctorates are somewhat more concentrated, with China providing a higher proportion (23%) than India (13%). These patterns by source region and country for foreign-born S&E highest degree holders in the United States have been stable since 2003.

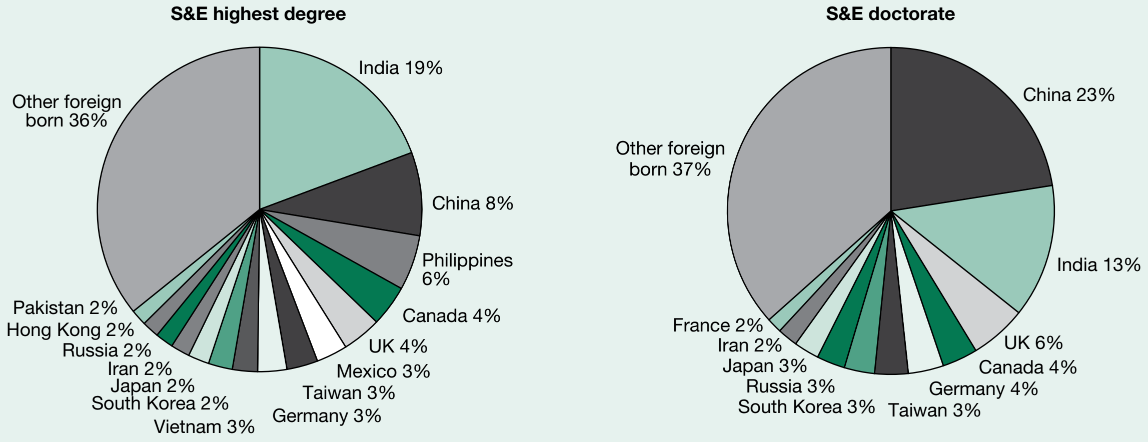
Source of Education

The SESTAT surveys ask respondents to provide information on where they received their postsecondary degrees. They also ask foreign-born respondents to provide information on why they came to the United States. Together, this information is helpful for understanding the educational and career paths of foreign-born scientists and engineers working in the United States and possible factors that influence these paths.

The majority of foreign-born scientists and engineers in the United States received their initial university training abroad. In 2010, there were about 4.3 million college-educated, foreign-born individuals employed in the United States with an S&E degree or in an S&E occupation; of these, 2.3 million received their first bachelor's degree abroad. Many of these individuals came to the United States for job or economic opportunities, educational opportunities, or family-related reasons.[26] Among employed foreign-born scientists and engineers, 54% of those whose highest degree is at the bachelor's level received their initial university degree from a foreign institution. The proportion is similar among foreign-born scientists and engineers with advanced degrees (53%), although SESTAT lacks information for a small proportion of individuals in this group.[27]

Many foreign-born scientists and engineers in the United States appear to come here for further higher education after receiving their initial university training abroad. Of the 2.1 million foreign-born scientists and engineers who are employed in the United States and hold an advanced degree,

Figure 3-36
Foreign-born individuals with highest degree in S&E living in the United States, by place of birth: 2010



UK = United Kingdom.

NOTE: Percentages may not add to 100% because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2010), http://sestat.nsf.gov.

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two-thirds completed their highest degree in the United States, divided almost evenly between those who received their first bachelor's degree abroad (671,000) and those who received their first bachelor's degree in the United States (647,000). Almost one-fourth of foreign-born scientists and engineers with an advanced degree (472,000) received both their initial university degree and advanced (highest) degree abroad. In contrast, only a small number of foreign-born scientists and engineers (35,000) received their first bachelor's degree in the United States and their highest degree abroad.

The information provided by foreign-born scientists and engineers on factors that influenced their migration to the United States reinforces the patterns seen in the migration data. Among those who obtained their initial university degree abroad but their highest degree in the United States, the most commonly cited reason for coming to the United States was educational opportunities (27%). Family-related reasons (9%) and job/economic opportunities (7%) were cited by much smaller proportions. In comparison, among those who received both degrees abroad, the most commonly cited reasons for coming to the United States were job/economic opportunities (29%) and family-related reasons (23%), followed by scientific or professional infrastructure (11%), and educational opportunities (10%).

Among the foreign-born doctorate holders employed in the United States, 58% received this degree from a U.S. institution and 83% (of those for whom SESTAT contains information on first bachelor's degree) received their initial university degree from a foreign institution.

New Foreign-Born Workers

During the 2007–09 economic downturn, two indicators—the number of temporary work visas issued by the U.S. government in visa classes for high-skill workers and the stay rates of foreign-born U.S. doctorate recipients—showed evidence that the volume of new foreign-born workers entering the U.S. S&E workforce might be declining. Recent data, however, indicate that this period of decline may be temporary. In addition to these two indicators, this section discusses characteristics of workers with temporary work visas and country profiles of new foreign-born workers.

Temporary Visas

The number of temporary work visas issued for high-skill workers provides an indication of new immigrant workers entering the U.S. labor force.[28] After several years of growth, the largest classes of these temporary visas declined during the recent economic downturn (figure 3-37). Data since the downturn, however, suggest that growth has resumed in recent years. Despite the increases in the issuance of temporary visas since fiscal year (FY) 2009, the numbers have not yet reached the recent highs seen in FY 2007, before the beginning of the economic downturn (figure 3-37). A decline in the issuance of these visas, particularly H-1B visas, also occurred around the more mild recession in 2001.

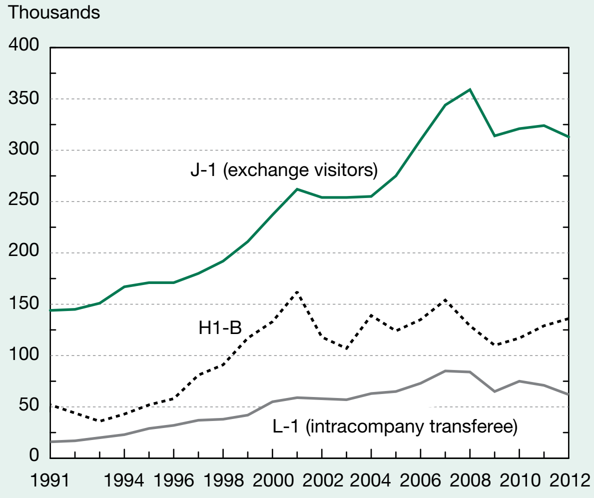
H-1B visas account for a significant proportion of foreign-born high-skill workers employed by U.S. firms on temporary visas. This type of visa is issued to individuals who seek temporary entry into the United States in a specialty occupation that requires professional skills. It is issued for up to 3 years with the possibility of an extension to 6 years. In 2012, the United States issued nearly 136,000 H-1B visas, up 23% from the recent low in 2009 (110,000) but still down from the recent peak of about 154,000 issued in 2007 (figure 3-37).

Issuance of visas in other temporary work categories that usually contain large numbers of high-skill workers also rose since 2009; however, the H-1B visa category has shown continued increase since 2009, unlike the J-1 and L-1 categories (figure 3-37).

Characteristics of H-1B Visa Recipients

Although H-1B visas are not issued exclusively for scientists and engineers, the majority of H-1B visa recipients work in S&E or S&E-related occupations (appendix table 3-21). However, precise counts of H-1B visas issued to individuals in these occupations cannot be obtained because USCIS does not classify occupations with the same taxonomy used by NSF. In 2011, workers in computer-related occupations as classified by USCIS were the most common recipients of H-1B visas, accounting for almost half (48%) of new H-1B visas issued. The total number of newly initiated H-1B visas for workers in computer-related fields increased significantly between 2010 and 2011, following a steep decline between 2008 and 2009 during the economic downturn. The

Figure 3-37
Temporary work visas issued in categories with many high-skilled workers: FYs 1991–2012



NOTE: J-1 exchange visitor visa is used for many different skill levels.

SOURCE: U.S. Department of State, Nonimmigrant Visa Issuances by Visa Class and by Nationality and Nonimmigrant Visas by Individual Class of Admission, http://www.travel.state.gov/visa/statistics/nivstats/nivstats_4582.html (accessed 12 April 2013).

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proportion of H-1B recipients who worked in computer sciences was considerably lower in the earlier part of the 2000s. For example, in 2002, only 25% of H-1B visa recipients worked in computer-related fields (NSB 2012).

H-1B visa recipients tend to possess advanced degrees. In FY 2011, 55% of new H-1B visa recipients had an advanced degree, including 39% with master's degrees, 5% with professional degrees, and 12% with doctorates (DHS USCIS 2012). The degree distribution differs by occupations. In FY 2009, for example, the vast majority of mathematical and physical scientists (83%) and life scientists (87%) with H-1B visas held advanced degrees; 44% of mathematical and physical scientists and 61% of life scientists with H-1B visas had doctorates (NSB 2012).

In 2011, 53% of new H-1B visa recipients were from India, and another 10% were from China (DHS USCIS 2012). H-1B visa recipients are relatively young. In 2011, 46% of new H-1B visa recipients were between the ages of 25 and 29, and another 25% were between the ages of 30 and 34 (DHS USCIS 2012).

Table 3-28 shows salaries paid to new recipients of H-1B visas by occupation group. These starting salaries, taken from final visa application forms sent to USCIS, are different from H-1B salaries that firms report on their applications to the Department of Labor, which are filed much earlier in the H-1B process. The relatively low median salaries for workers in life sciences may reflect the common use of H-1B visas to hire individuals for relatively low-paying postdoc positions.

Table 3-28
Annual salaries for new H-1B visa recipients, by occupation: FY 2011
(Dollars)

Occupation	Median	Mean
Administrative specializations	55,000	67,000
Architecture, engineering, and surveying	72,000	79,000
Art	45,000	54,000
Computer-related occupations	64,000	70,000
Education	46,000	56,000
Entertainment and recreation	35,000	43,000
Law and jurisprudence	85,000	106,000
Life sciences	47,000	56,000
Managers and officials nec	81,000	103,000
Mathematics and physical sciences	70,000	74,000
Medicine and health	57,000	93,000
Miscellaneous professional, technical, and managerial	70,000	82,000
Museum, library, and archival sciences	48,000	58,000
Religion and theology	36,000	41,000
Social sciences	65,000	78,000
Writing	43,000	51,000

nec = not elsewhere classified.

SOURCE: Department of Homeland Security (DHS), U.S. Citizenship and Immigration Services; *Characteristics of H-1B Specialty Occupation Workers, Fiscal Year 2011 Annual Report to Congress*, http://www.uscis.gov/USCIS/Resources/Reports%20and%20Studies/H-1B/h1b-fy-11-characteristics.pdf, accessed 20 December 2012.

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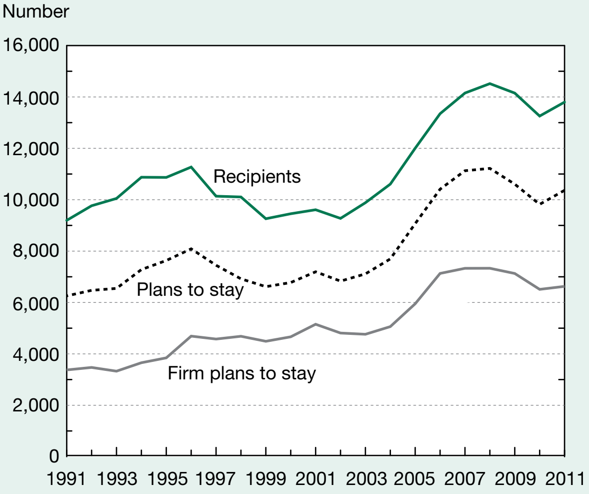
Short-Term Stay Rates for U.S. S&E Doctorate Recipients

Among doctorate recipients, the period immediately after earning their doctorate is a pivotal point that can substantially affect long-term career trajectories. During this period, foreign-born doctorate recipients who remain in the United States may set themselves on a path to long-term residency.

At the time they receive their doctorates, foreign-born students at U.S. universities report whether they intend to stay in the United States and whether they have a firm offer to work in the United States (either a postdoc or a job) the following year.[29] These responses provide estimates of short-term stay rates.[30]

Most foreign-born noncitizen recipients of U.S. S&E doctorates plan to stay in the United States after graduation. At the time of doctorate receipt, 75% of foreign-born recipients of U.S. S&E doctorates, including those on both temporary and permanent visas, plan to stay in the United States, and 48% have either accepted an offer of postdoc study or employment or are continuing employment in the United States (figure 3-38). The proportion of foreign-born S&E doctorate recipients planning to stay in the United States has risen over time. In 1991, 68% of foreign students who earned S&E doctorates at U.S. universities reported that they planned to stay in the United States after graduation,

Figure 3-38
Plans of foreign recipients of U.S. S&E doctoral degrees at graduation to stay in the United States, by year of doctorate: 1991–2011



NOTE: Data include doctorate recipients on temporary and permanent visas.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Survey of Earned Doctorates (SED) (1991–2011).

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and 37% said that they had firm offers for postdoc study or employment. Throughout the 1980s, these proportions were about 50% and 33%, respectively (NSB 2012).

During the latter part of the decade 2000–09, a period marked by the economic downturn and financial crisis, both the percentage of foreign-born S&E doctorate recipients reporting plans to stay in the United States and the percentage of those reporting firm offers to stay declined slightly (figure 3-38). The overall number of foreign-born S&E doctorate recipients also declined in 2009 and 2010. Although the numbers have since risen in 2011, the levels remain below the recent peaks seen in 2008.

Overall, S&E short-term stay rates reflect the high short-term stay rates in computer and mathematical sciences, the biological and related sciences, the physical sciences, and engineering (appendix table 3-22). Between 2008 and 2011, the short-term stay rates in these four fields ranged from 77% to 83%, as measured by reports of intentions to stay in the United States. However, the short-term stay rates for foreign-born U.S. S&E doctorate recipients in health fields (71%) were somewhat lower, and those in the social sciences (57%) were substantially lower.

Stay rates vary by place of origin. Between 2008 and 2011, the vast majority of U.S. S&E doctorate recipients from China (86%) and from India (87%) reported plans to stay in the United States, and close to 60% of these individuals reported accepting firm offers for employment or postdoc research in the United States (appendix table 3-22). U.S. S&E doctorate recipients from Japan, South Korea, and Taiwan were less likely than those from China and India to stay in the United States (figure 3-39). About half of U.S. S&E doctorate recipients from Europe had firm plans to stay in the United States after graduation (appendix table 3-22). In North America, the percentage of U.S. S&E doctorate recipients who had definite plans to stay in the United States was higher for those from Canada than for those from Mexico (appendix table 3-22).

Among U.S. S&E doctorate recipients from the two top countries of origin, China and India, the proportions reporting plans to stay in the United States have declined since the early part of the decade of the 2000s (appendix table 3-22).

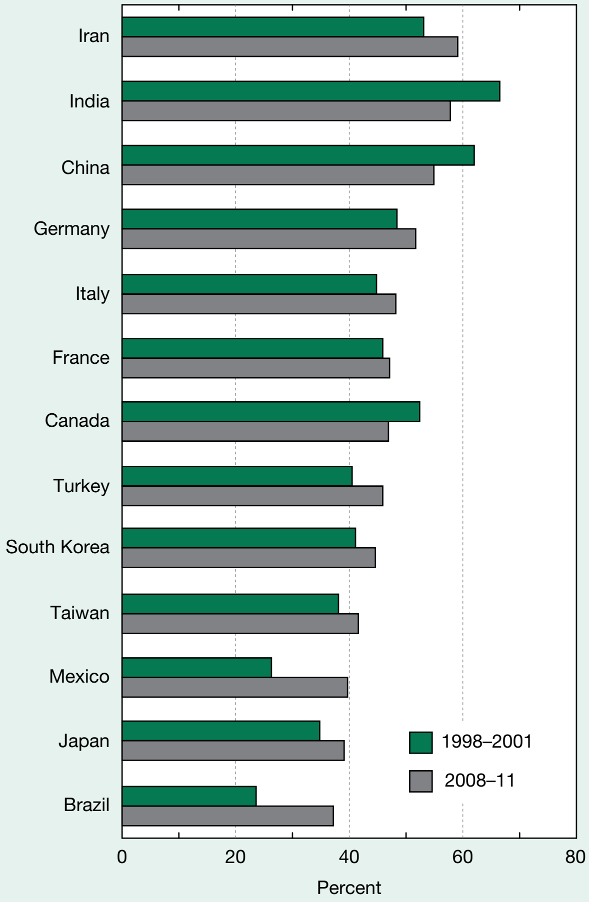
Long-Term Stay Rates for U.S. S&E Doctorate Recipients

Long-term stay rates indicate the degree to which foreign-born recipients of U.S. S&E doctorates enter and remain in the U.S. labor force to pursue their careers. For a particular cohort of foreign-born noncitizen S&E doctorate recipients, the proportion of that cohort that pays federal taxes a given number of years after receiving their degrees is an indicator of the cohort's long-term stay rate.[31] Estimates of short-term stay rates are derived from data on reported intentions to stay in the United States within the year after graduation. Stay rates over the short term can be compared with those over a longer duration to analyze how stated intentions for the period immediately after graduation compare with actual behavior some years later.

Stay rate data include foreign-born noncitizen recipients of U.S. S&E doctorates who were on either a permanent or a temporary visa at the time they received their doctorates. For the 2001 and 2006 graduating cohorts, stay rate data are available separately for permanent and temporary visa holders. Within these cohorts, stay rates are particularly stable over time among individuals who received their doctorates while on a permanent visa (figure 3-40). Temporary residents, who account for the vast majority of noncitizen recipients of U.S. S&E doctorates, have lower stay rates than do permanent residents, and their stay rates decline with additional years

Figure 3-39

Plans of foreign recipients of U.S. S&E doctoral degrees at graduation to stay in the United States, by place of origin and year of doctorate: 1998–2001 and 2008–11



NOTES: Data reflect proportions of each group reporting firm commitment to postgraduation employment in the United States. Data include doctorate recipients on temporary and permanent visas. Data for China include Hong Kong.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of Survey of Earned Doctorates (SED).

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since degree. For example, among foreign-born U.S. S&E doctorate recipients from the 2001 cohort, those who were on a temporary visa at the time they earned their degree had a 2-year stay rate in 2003 that was 16 percentage points lower than those with a permanent visa. This difference grew wider over time, reaching almost 26 percentage points by 2011, as stay rates for temporary visa holders fell while stay rates for permanent residents changed little.

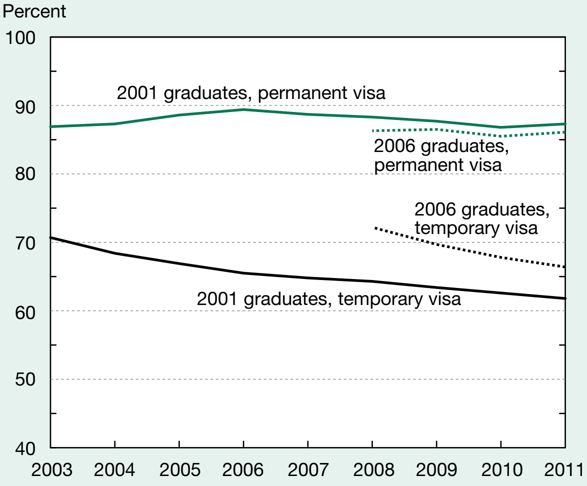
The stay rates within the entire 2001 and 2006 cohorts of foreign-born noncitizen recipients of U.S. S&E doctorates fell with additional years since graduation (Finn 2014); this was a result of the declining stay rates among temporary visa holders, who accounted for nearly 90% of all noncitizen U.S. S&E doctorate recipients in these cohorts. The 2001 cohort had a stay rate after 2 years of 73%; after 10 years, this rate declined by 8 percentage points. The 2006 cohort had a 2-year stay rate of 74%, which declined to 68% after 5 years. In comparison, among the cohort of foreign-born U.S. S&E doctorate recipients who earned their degrees in 1995, stay rates were relatively stable as additional years passed since graduation. The 1995 cohort had a 2-year stay rate of 65%, which dropped to 61% after 16 years (Finn 2014). Stay rate data for the 1995 cohort, however, are not separately available for permanent and temporary residents. Data from earlier and subsequent years suggest that temporary visa holders accounted for the vast majority of foreign-born noncitizen recipients of U.S. S&E doctorates in 1995 (Finn 2012); as a result, temporary residents likely played an important role in the overall stability of the stay rate within this cohort.

In recent years, long-term stay rates have fluctuated within a fairly narrow range, neither increasing nor declining consistently (table 3-29). Among U.S. S&E doctorate recipients with a temporary visa at graduation, 5-year stay rates rose in the latter part of the decade of the 2000s after declining for several years around the 2007–09 economic downturn. While figure 3-40 shows the stay rate data annually for fixed cohorts (2001 and 2006 graduating cohorts), table 3-29 presents data on 5-year stay rates during the 2001–11 period. Data for each year reflect the stay rate in that year for the cohort that received their doctorates 5 years earlier. The 5-year stay rate rose to 66% in 2011, close to the recent high level seen in 2005 (67%).

The trends in the 5-year stay rates vary across source countries (table 3-29). Among foreign-born recipients from China (the largest source country) who were temporary residents at the time they received their U.S. S&E doctorates,

Figure 3-40

Stay rates for U.S. S&E doctorate recipients with permanent or temporary visas at graduation, by selected year of doctorate: 2003–11



SOURCE: Finn M. 2014 (forthcoming). *Stay Rates of Foreign Doctoral Recipients from U.S. Universities: 2011*. Oak Ridge, TN: Oak Ridge Institute for Science and Education.

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Table 3-29

Five-year stay rates for U.S. S&E doctorate recipients with temporary visas at graduation, by selected country/region/economy: 2001–11

(Percent)

Country/region/economy	2001	2003	2005	2007	2009	2011
All countries/regions/economies	58	64	67	63	62	66
China	98	93	95	94	89	85
India	89	90	89	83	79	82
Europe	53	63	67	67	60	62
Canada	66	63	60	56	53	55
South Korea	22	36	44	42	42	42
Japan	24	39	41	33	40	38
Taiwan	41	48	52	43	37	38
Mexico	31	22	32	33	35	39
Brazil	26	26	31	32	33	37

NOTE: Data for each year reflect the stay rate in that year for the cohort that received their doctoral degrees 5 years earlier.

SOURCE: Finn M. 2014 (forthcoming). *Stay Rates of Foreign Doctoral Recipients from U.S. Universities: 2011.* Oak Ridge, TN: Oak Ridge Institute for Science and Education.

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the 5-year stay rate declined in 2011, continuing the trend since before the economic downturn. However, even with this decline, rates remain higher than those of other major locations. Foreign-born U.S. S&E doctorate recipients from other major source countries/economies, like India and Taiwan, saw slight increases in the 5-year stay rate between 2009 and 2011, although their stay rate overall declined between 2001 and 2011. Among foreign-born recipients of U.S. S&E doctorates from South Korea who were on a temporary visa at the time they received their doctorate, stay rates remained stable between 2007 and 2011 after doubling during the first half of the decade.

Data from the 2006 cohort suggest that among temporary visa holders receiving U.S. S&E doctorates, stated intentions to stay in the United States (short-term stay rates) are reasonable indicators of stay rates some years later (Finn 2014). Among temporary residents who received their U.S. S&E doctorate in 2006 and reported definite plans to stay in the United States within the year after graduation, 94% were in the United States 1 year later and 80% remained 5 years later. Among the 2006 cohort of temporary residents who reported plans to stay in the United States (as opposed to firm employment offers), 86% were in the United States 1 year later and 72% remained 5 years later. A number of factors are likely to affect how precisely short-term intentions to stay in the United States predict actual behavior some years later. Among these are overall economic conditions and job opportunities in the United States, comparable conditions in the doctorate recipient's country of origin, and family-related and other personal considerations.

High-Skill Migration Worldwide

No worldwide or internationally comparable data exist on the migration of workers in S&E occupations or with college-level S&E degrees. Docquier and Rapoport (2012) compiled and analyzed data on international migration to OECD countries by educational attainment in 1990 and 2000 (see also Docquier, Lowell, and Marfouk 2009; Docquier and Marfouk 2006). They defined high-skill migrants as the total number of foreign-born individuals, age 25 and over, with some postsecondary education living in an OECD country. They gathered data for nearly 200 source countries (which included OECD and non-OECD countries), all but a handful of which are independent nations. More recent and comprehensive data on global high-skill migration patterns are not currently available. However, the flow of migration historically has been from developing to developed nations, and the OECD data for the 1990 to 2000 period confirm this pattern. As R&D activity expands in developing countries, press reports suggest increased movement in the opposite direction; however, systematic and recent data do not exist to address that pattern.

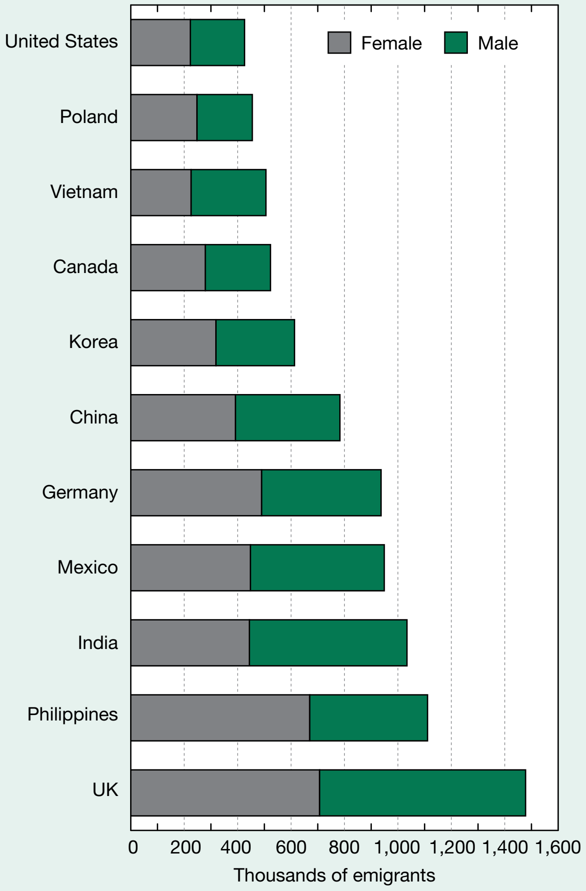
The data on migration to OECD countries indicate several patterns in international migration of individuals age 25 and older:

- Between 1990 and 2000, the total number of immigrants (regardless of skill level) in OECD countries increased from about 42 million to about 59 million.
- Globally, OECD countries account for the vast majority of high-skill immigrants. The migration rate among high-skill individuals to the OECD nations changed only slightly between 1990 and 2000 (rising from 5.1% to 5.5%). Nonetheless, because worldwide education levels are rising, the proportion of high-skill individuals among those who immigrated to OECD countries rose during this period, from 30% to 35%.
- Rates of legal emigration were much greater among high-skill individuals (5.5% in 2000) than among those with less education (1.3% in 2000).
- In countries that the World Bank classifies as low income, the gap in emigration rates between high- and low-skill groups (7.6% and 0.3%, respectively, in 2000) was especially large. In comparison, the rates of high- and low-skill emigration rates were similar in countries that the World Bank classifies as high income (3.9% and 3.6%, respectively, in 2000).
- Between 1990 and 2000, the proportion of women among high-skill migrants rose, partly because of the worldwide increase in the proportion of individuals with some postsecondary education who are women.
- In 2000, the countries estimated to have the largest number of high-skill emigrants living in OECD countries were the United Kingdom (1.5 million), the Philippines (1.1 million), India (1.0 million), Mexico (0.9 million), and Germany (0.9 million) (figure 3-41). The proportion of high-skill emigrants who are women varied considerably across source countries (figure 3-41; see also Docquier, Lowell, and Marfouk 2009).

In a more limited study covering six major destination countries (United States, Canada, Australia, Germany, United Kingdom, and France), Defoort (2008) concluded that worldwide emigration rates for high-skill persons between 1975 and 2000 were stable in a large number of countries. Stable rates of emigration, however, would produce an increase in the total number of high-skill emigrants due to rising levels of worldwide education and skill.

Regarding high-skill migration to the United States, college-educated foreign-born workers in the United States are disproportionately found in S&E occupations and disproportionately have advanced degrees (see "Characteristics of the Foreign-Born Scientists and Engineers"). However, current international data do not enable researchers to assess whether and how migration rates globally or to OECD countries vary among different categories of high-skill workers.

Figure 3-41
Top countries of origin of foreign-born persons residing in OECD countries and having at least a tertiary education, age 25 years or more, by sex: 2000



OECD = Organisation for Economic Co-operation and Development; UK = United Kingdom.

NOTE: Tertiary education is roughly equivalent in U.S. terms to individuals who have earned at least technical school or associate's degrees and includes all degrees up to the doctorate.

SOURCE: Docquier F, Lowell B, Marfouk A. 2009. A gendered assessment of highly skilled emigration. *Population and Development Review* 35(2):297–321, http://onlinelibrary.wiley.com/doi/10.1111/j.1728-4457.2009.00277.x/abstract (accessed 22 January 2013).

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Global S&E Labor Force

The rising emphasis on developing S&E expertise and technical capabilities has been a global phenomenon. S&E work is not limited to developed economies; it occurs throughout the world. Such work, however, is concentrated in developed nations, where a significant portion of R&D also takes place. The availability of a suitable labor force is an important determinant of where businesses choose to locate S&E work (Davis and Hart 2010), and concentrations of existing S&E work, in turn, spawn new employment opportunities for workers with relevant S&E knowledge and skills. As a result, governments in many countries have made increased investments in S&E-related postsecondary education a high priority. At the same time, high-skill workers, such as those educated or employed in S&E fields, are increasingly mobile, and the number that leave their native countries to pursue education and career goals is growing. In recent years, many nations, recognizing the value of high-skill workers for the economy as a whole, have changed their laws to make it easier for such workers to immigrate. These changes indicate an accelerating competition for globally mobile talent (Shachar 2006).

Data on the global S&E workforce, however, are very limited, which makes it difficult to analyze the precise size and characteristics of this specialized workforce. Unfortunately, the internationally comparable data that exist are limited to establishment surveys that provide only basic information about workers in S&E occupations or with training in S&E disciplines. In contrast, SESTAT includes far more data on members of the U.S. S&E labor force than is available in other national statistical systems. In addition, although surveys that collect workforce data are conducted in many OECD member countries, they do not cover several countries—including Brazil, India, and Israel—that have high and rising levels of science and technology capability, and they do not provide fully comparable data for China.

This section provides information about the size and growth of workforce segments whose jobs involve R&D in nations for which relevant data exist.

Size and Growth of the Global S&E Labor Force

Although comprehensive data on the worldwide S&E workforce do not exist, OECD data covering significant, internationally comparable segments of the S&E workforce provide strong evidence of widespread, though uneven, growth in the world's developed nations. OECD countries, which include most of the world's highly developed nations, compile data on researchers from establishment surveys in member and selected non-member countries. These surveys generally use a standardized occupational classification that defines researchers as "professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned" (OECD 2002:93). Because this definition can be applied differently when different nations conduct surveys, international comparisons should be made with caution. OECD also reports data on a broader measure of all personnel employed directly in R&D. In addition to researchers, the data on total R&D personnel include those who provide direct services to R&D such as clerical and administrative staff employed in R&D organizations.

OECD reports an estimated increase in the number of researchers in its member countries from 2.8 million in 1995 to 4.2 million in 2007. OECD also publishes estimates for seven non-member economies, including China and Russia; adding these to the OECD member total for

2007 yields a worldwide estimate of 6.3 million researchers. However, numerous uncertainties affect this estimate, including, but not limited to, lack of coverage of countries with significant R&D enterprise, as well as methodological inconsistencies over time and across countries. For example, some non-member countries that engage in large and growing amounts of research (e.g., India, Brazil) are omitted entirely from these totals. In addition, for some countries and regions, including the United States and the European Union (EU; see glossary for member countries), OECD estimates are derived from multiple national data sources and not from a uniform or standardized data collection procedure. For example, China's data after 2008 are collected in accordance with OECD definitions and standards; compared to China's estimate for 2008, these data yield estimates of about 440,000, 382,000, and 274,000 fewer researchers in 2009, 2010, and 2011, respectively.

Despite these limitations for making worldwide estimates of the number of researchers, the OECD data are a reasonable starting point for estimating the rate of worldwide growth. For most economies with large numbers of researchers, growth since the mid-1990s has been substantial (figure 3-42). China, whose pre-2009 data did not entirely correspond to the OECD definition, reported about triple the number of researchers in 2008 compared with 1995. South Korea doubled its number of researchers between 1995 and 2006 and continued to grow strongly between 2007 and 2011. The United States and the EU experienced steady growth but at a lower rate; the number of researchers grew 36% in the United States between 1995 and 2007 and 65% in the EU between 1995 and 2010. Exceptions to the overall worldwide trend included Japan (which experienced little change) and Russia (which experienced a decline, especially early in the period; see also Gokhberg and Nekipelova 2002). Trends in full-time equivalent R&D personnel were generally parallel to those for researchers in those cases for which both kinds of data are available (appendix table 3-23).

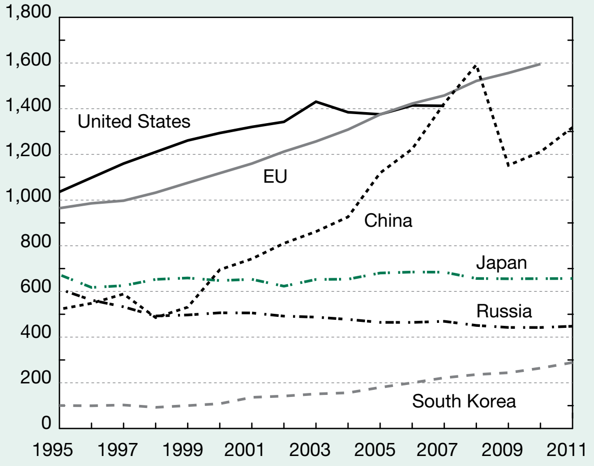
OECD also estimates the proportion of researchers in the workforce. In OECD's most recent estimates, small economies in Scandinavia (Denmark, Finland, Norway, Sweden) report that between 1% and 2% of their employed workforce are researchers; small economies in East Asia (Singapore, Taiwan) report that about 1% of their workforce are researchers (appendix table 3-24). Among economies with more than 200,000 researchers, OECD's latest estimates are that researchers make up the highest proportions of the workforce in Japan (1.0%), South Korea (1.2%), and the United States (0.95%). Although China reports a large number of researchers, they are a much smaller percentage of its workforce (0.17%) than in OECD member countries.

Several Asian economies have shown marked and continuous increases in the percentage of their workforce employed as researchers. These include China, South Korea, Singapore, and Taiwan (appendix table 3-24). In the United States and Japan, where growth occurred at all, it took place mostly between the mid-1990s and the early 2000s (figure 3-43). Patterns and trends in the proportion of the workforce

Figure 3-42

Estimated number of researchers in selected countries/regions: 1995–2011

Thousands



EU = European Union.

NOTES: Data are not available for all countries/regions for all years. Researchers are full-time equivalents. Before 2009, counts for China were not consistent with Organisation for Economic Co-operation and Development (OECD) standards.

SOURCE: OECD, *Main Science and Technology Indicators* (2013/1 and earlier years), http://www.oecd.org/sti/msti.htm.

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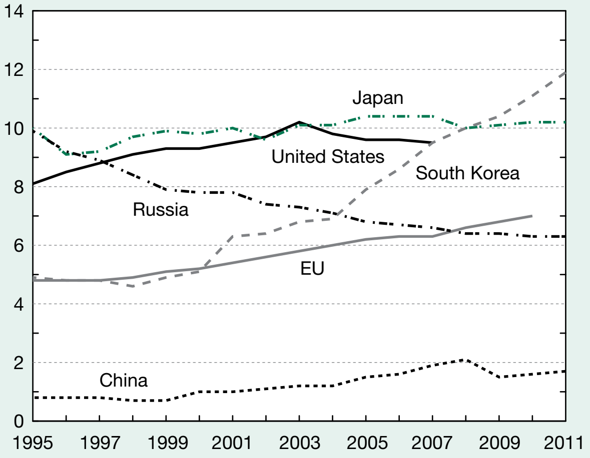
Figure 3-43

Researchers as a share of total employment in selected countries/regions: 1995–2011

Per thousand



EU = European Union.

NOTES: Data are not available for all countries/regions for all years. Researchers are full-time equivalents per thousand total employment. Before 2009, counts for China were not consistent with Organisation for Economic Co-operation and Development (OECD) standards.

SOURCE: OECD, *Main Science and Technology Indicators* (2013/1 and earlier years), http://www.oecd.org/sti/msti.htm.

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classified as R&D personnel are generally similar to those for researchers.

The proportion of female researchers varies considerably across OECD economies. According to the most recent estimates for the selected OECD countries for which data by sex are available, Japan (14% women) and South Korea (17% women) have a significant imbalance among researchers. By comparison, Turkey, Sweden, Spain, and Poland are more balanced with women representing between 35% and 40% of researchers.

R&D Employment Abroad by U.S. Companies

R&D jobs located abroad in U.S.-owned companies are an indicator of global engagement by U.S. companies in the world's S&E workforce. Data from NSF's Business R&D and Innovation Survey (BRDIS) provide an overview of R&D employment in the business sector and enable comparisons between domestic and foreign R&D employment in companies located in the United States (both U.S.- and foreign-owned) that have R&D activity. These data identify employment as either domestic or foreign on the basis of the job's location and not on the basis of the company's ownership, the employee's citizenship, or the employee's place of birth. Chapter 4 includes a detailed analysis of BRDIS data on R&D employment abroad by U.S. companies.

Conclusion

The S&E labor force may be defined in a variety of ways. At its core are individuals in S&E occupations, but those with S&E degrees who are employed in a variety of other jobs also play a role. Many more individuals hold S&E degrees than work in S&E occupations. Indicative of a knowledge-based economy, many of those in non-S&E occupations report that their work nonetheless requires at least a bachelor's degree level of S&E knowledge and skills. This suggests that the application of S&E knowledge and technical expertise is widespread across the U.S. economy and not just limited to S&E occupations.

In both the United States and the rest of the world, the S&E workforce has experienced strong growth over time. During the 2007–09 economic downturn, S&E employment remained more resilient in the United States than overall employment. Policymakers with otherwise divergent perspectives agree that jobs involving S&E are good for workers and good for the economy as a whole. These jobs pay more, even when compared to jobs requiring similar levels of education and comparably specialized skills. Although S&E workers are not totally exempt from joblessness, workers with S&E training or in S&E occupations are less often exposed to periods of unemployment.

Innovation based on S&E R&D is globally recognized as an important vehicle for a nation's economic growth and competitive advantage. As such, it is not surprising that growing numbers of workers worldwide are engaged in research. Growth has been especially marked in rapidly developing economies, such as China and South Korea, that have either recently joined the ranks of the world's developed economies or are poised to do so. Mature developed economies in North America and Europe have maintained slower growth whereas the number of researchers in the struggling Japanese economy has been stagnant.

The demographic composition of the S&E workforce in the United States is changing. The baby boom portion of the S&E workforce continues to age into retirement. However, increasing proportions of scientists and engineers are postponing retirement to somewhat later ages. At the same time, members of historically underrepresented groups (e.g., women, blacks, Hispanics) have played an increasing role in the U.S. S&E labor force, although this has been more the case in some fields (e.g., life sciences and social sciences) than in others (e.g., computer and mathematical sciences, physical sciences, and engineering). Despite the recent increases in S&E participation by women and by racial and ethnic minorities, both groups remain underrepresented in the U.S. S&E workforce compared to their overall labor force participation. For example, women account for slightly more than one-fourth of all workers employed in S&E occupations in the United States despite representing half of the college-educated workforce.

The United States has remained an attractive destination for foreign students and workers with advanced S&E training. In the wake of the 2001 recession, there were increases in both temporary work visas and stay rates of foreign recipients of S&E doctorates. Although declines occurred during the 2007–09 economic downturn—a period marked by rising unemployment in the United States among workers in S&E as well as in other occupations—growth has since resumed.

In today's dynamic marketplace, where information flows rapidly and technology is always evolving, labor market conditions change fast. Numerous factors—such as global competition, demographic trends, aggregate economic activities, and S&E training pathways and career opportunities—will affect the availability of workers equipped with S&E expertise as well as the kinds of jobs that the U.S. economy generates in the future. As a result, comprehensive and timely analysis of current labor force and demographic trends will play a critical role in providing the information needed to understand the dynamic S&E landscape both in the United States and globally.

Notes

1. The standard definition of the term *labor force* is a subset of the population that includes both those who are employed and those who are not working but seeking work (unemployed); other individuals are not considered to be in the labor force. When data refer only to employed persons, the term *workforce* is used. For data on unemployment rates by occupation, calculations assume that unemployed individuals are seeking further employment in their most recent occupation.

2. The SOC is used by federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, and disseminating data. Detailed information on the SOC is available at http://www.bls.gov/SOC/.

3. Despite the limitations of this subjective measure, variations among occupations in the proportions of workers who say that they need this level of S&E technical expertise are in accordance with common sense. For example, among postsecondary teachers of physics, 95% said that their job required at least a bachelor's degree level of knowledge in engineering, computer sciences, mathematics, or the natural sciences. Among postsecondary teachers of business commerce or marketing, 83% said that their job required at least this level of expertise in other fields such as health, business, or education. Among the SESTAT population whose occupation is secretary/receptionist/typist, fewer than 10% said that their job required bachelor's level S&E expertise of any kind, and 12% said that their job required at least this level of expertise in other fields such as health, business, or education.

4. Estimates of the size of the S&E workforce vary across the example surveys because of differences in the scope of the data collection (SESTAT surveys collect data from individuals with at least a bachelor's degree); because of the type of survey respondent (SESTAT surveys collect data from individuals, OES collects data from establishments, and ACS collects data from households); or because of the level of detail collected on an occupation, which aids in classifying a reported occupation into a standard occupational category. All of these differences can affect the estimates. For example, the SESTAT estimate of the number of workers in S&E occupations includes postsecondary teachers of S&E fields; however, postsecondary teachers in ACS are grouped under a single occupation code regardless of field and are therefore not included in the ACS estimate of the number of workers in S&E occupations.

5. Among those with doctorates in an S&E field, life sciences and social sciences were the most common fields, followed by physical sciences, engineering, and computer and mathematical sciences.

6. The data on S&E employment level for 1960 are calculated using the Census Bureau's 1960 Decennial Census microdata, adjusted by the Integrated Public Use Microdata Series (IPUMS) from the University of Minnesota's Minnesota Population Center (http://www.ipums.org). The data for 2011 are calculated using the 2011 American Community Survey (ACS) public use microdata sample (PUMS) files from the Census Bureau (http://www.census.gov/acs/www/data_documentation/public_use_microdata_sample/). S&E employment levels for 1960 and 2011 include workers at all education levels and do not include S&E postsecondary teachers. Although the 1960 Decennial Census data allow for separate identification of S&E postsecondary teachers, the 2011 ACS data aggregate all postsecondary teachers into one occupation code and therefore do not allow for separate identification of S&E postsecondary teachers. For 1960, including S&E postsecondary teachers would increase the number of workers employed in S&E occupations to nearly 1.2 million. See appendix table 3-1 for a list of S&E occupations in the 1960 Decennial Census and 2011 ACS.

7. Many comparisons using Census Bureau data on occupations are limited to looking at all S&E occupations except postsecondary teachers (i.e., nonacademic S&E occupations) because the Census Bureau aggregates all postsecondary teachers into one occupation code. NSF surveys of scientists and engineers and some BLS surveys collect data on postsecondary teachers by field.

8. The data on self-employment from SESTAT include those who report being self-employed or employed by a business owner in either an unincorporated or incorporated business, professional practice, or farm. As a result, the data may capture both self-employed individuals in their own businesses as well as those whose principal employer is a business owner. This is a major reason why the SESTAT estimate of self-employed workers in S&E occupations is higher than those from other surveys (e.g., the Census Bureau's ACS).

9. Employment in the federal government is largely limited to those with U.S. citizenship. In the competitive civil service, only U.S. citizens and nationals may be appointed; however, in the excepted service or the Senior Executive Service, certain noncitizens who meet specific employability requirements may be employed. Many federal workers with S&E employment are in occupations that, nationwide, include relatively large concentrations of foreign-born persons, some of whom are not U.S. citizens, rendering them ineligible for many federal jobs.

10. This list does not include the National Institutes of Health, which is a part of the Department of Health and Human Services (DHHS). DHHS accounted for 5% of total federal S&E employment in 2012.

11. The other 10 activities are used to define four additional broad categories of primary/secondary work activities, including teaching; management and administration; computer applications; and professional services, production workers, or other work activities not specified.

12. Social scientists were exceptions. In 2010, the difference in R&D activity rates between social scientists with doctorates and social scientists with bachelor's degrees was not statistically significant.

13. The patent activity rate is the proportion who reported having been named as an inventor on a patent application in the previous 5 years.

14. Although SESTAT respondents were allowed to provide more than one reason for participating in work-related training, the data presented in this section are on the most important reason for participating in such training.

15. The Business Cycle Dating Committee of the National Bureau of Economic Research is generally the source for determining the beginning and end of recessions or expansions in the U.S. economy. See http://www.nber.org/cycles/recessions.html for additional information.

16. The Bureau of Labor Statistics civilian unemployment rate for persons 16 years and over, not seasonally adjusted, is available at http://data.bls.gov/timeseries/LNU04000000 (accessed 4 December 2012).

17. Social scientists were exceptions. The change in the unemployment rate from 2006 to 2010 among social scientists was not statistically significant.

18. The CPS is the source of the official unemployment rate.

19. Although the formal job title is often *postdoc fellowship* or *research associate*, titles vary among organizations. This chapter generally uses the shorter, more commonly used, and best understood name, *postdoc*. A postdoc is generally considered a temporary position that individuals take primarily for additional training—a period of advanced professional apprenticeship—after completion of a doctorate.

20. NSF is currently developing a data collection strategy as part of its Early Career Doctorates Project (ECDP) to gather in-depth information about postdoc researchers and other early career doctorates. The ECDP will collect information related to educational achievement, professional activities, employer demographics, professional and personal life balance, mentoring, training and research opportunities, and career paths and plans for individuals who earned their doctorate in the past 10 years and are employed in an academic institution or a research facility.

21. In this chapter, American Indian or Alaska Native, Asian, black, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin. Hispanics may be any race.

22. Salary differences represent estimated percentage differences in women's reported full-time annual salary relative to men's reported full-time annual salary as of October 2010. Coefficients are estimated in an ordinary least squares regression model using natural log of full-time annual salary as the dependent variable. This estimated percentage difference in earnings differs slightly from the observed difference in median earnings by sex because the former addresses differences in mean earnings rather than median.

23. Included are 20 SESTAT field of degree categories (out of 21 S&E fields), 38 SESTAT occupational categories (out of 39 categories), 6 SESTAT employment sector categories (out of 7), years since highest degree, years since highest degree squared, Carnegie classification of school awarding highest degree, and private/public status of postsecondary institution awarding highest degree.

24. In addition to the education- and employment-related variables, the following indicators are included: nativity and citizenship, marital status, disability, number of children living in the household, geographic region (classified into nine U.S. Census divisions), and whether either parent holds a bachelor's or higher level degree. The sex regression controls for racial and ethnic minority status, and the race and ethnicity regression controls for sex.

25. The regression analysis addresses major factors that affect differences in earnings but does not attempt to cover all possible sources of difference. For a more detailed discussion on the topic, see Blau and Kahn (2007), Mincer (1974), Polachek (2008), and Xie and Shauman (2003).

26. When asked about the most important reason for coming to the United States, many foreign-born scientists and engineers who obtained their initial university degree abroad cited family-related reasons (24%), job or economic opportunities (23%), and educational opportunities (14%).

27. For an additional 15% (about 321,000) of foreign-born employed SESTAT respondents who hold an advanced degree, SESTAT lacks information on first bachelor's degree, including the country in which they received their bachelor's degree. Nearly three-fourths of these individuals received their highest degree from a foreign institution. The vast majority of foreign-born advanced degree holders for whom SESTAT contains information on first bachelor's degree and who received their advanced degree abroad also received their initial university education abroad. It is therefore highly likely that a significant portion of the group for whom SESTAT is missing first bachelor's degree information also received this degree abroad.

28. For all types of temporary work visas, the actual number of individuals using them is less than the number issued. For example, some individuals may have job offers from employers in more than one country and may choose not to foreclose any options until a visa is certain.

29. This question is part of the Survey of Earned Doctorates (SED), which is administered to individuals receiving research doctoral degrees from all accredited U.S. institutions. For information on the SED, see http://www.nsf.gov/statistics/srvydoctorates/. The information on plan to stay or definite commitment to stay reflects intentions within the year after graduation as reported by the doctorate recipient around the graduation date. As such, any changes in intentions after survey completion are not captured.

30. Many foreign recipients of U.S. doctorates who report that they plan to stay in the United States the year after graduation may do so using their student (F-1) visa and never obtain a new visa that would permit a longer stay. Student visas permit an additional 12-month stay in the United States after graduation if a student applies for optional practical training (OPT). OPT refers to paid or unpaid work that is performed at least 20 hours a week and that is related to a student's field of study. Starting in April 2008,

those earning a degree in science, technology, engineering, and mathematical (STEM) fields could apply for an extension of their OPT to a total of 29 months. Data from the Department of Homeland Security's Student and Exchange Visitor Information System show that 75.6% of students with F-1 visas completing a doctorate in any field between 2004 and 2009 had applied for OPT.

31. Tax data that are used for estimating stay rates are reported by tax authorities in aggregate forms for groups of individuals in order to protect confidentiality of individual tax payers.

Glossary

European Union (EU): As of June 2013, the EU comprised 27 member nations: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Croatia joined the EU in July 2013. Unless otherwise noted, OECD data on the EU include all 28 members; data on the EU from other sources are limited to the 27 nations that were members as of June 2013.

Involuntarily out of field (IOF) employment: Employment in a job not related to the field of one's highest degree because a job in that field was not available. The IOF rate is the proportion of all employed individuals that report IOF employment.

Labor force: A subset of the population that includes both those who are employed and those who are not working but seeking work (unemployed); other individuals are not considered to be in the labor force.

Organisation for Economic Co-operation and Development (OECD): An international organization of 34 countries headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Estonia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected non-member countries.

Postdoc: A temporary position awarded in academia, industry, government, or a non-profit organization, primarily for gaining additional education and training in research after completion of a doctorate.

Scientists and Engineers Statistical Data System (SESTAT): A system of three surveys conducted by the National Science Foundation that measure the educational, occupational, and demographic characteristics of the S&E workforce. The three surveys are the National Survey of College Graduates (NSCG), the Survey of Doctorate Recipients (SDR), and the National Survey of Recent College Graduates (NSRCG).

Stay rate: The proportion of foreign recipients of U.S. S&E doctoral degrees who stay in the United States after receiving their doctorate.

Tertiary education: Roughly equivalent in U.S. terms to individuals who have earned at least technical school or associate's degrees, including all degrees up to the doctorate.

Workforce: A subset of the labor force that includes only employed individuals.

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Chapter 4

Research and Development: National Trends and International Comparisons

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Highlights

Trends in U.S. R&D Performance

The total of U.S. research and development performance returned to current dollar growth in 2010 and 2011. On a constant dollar basis, however, U.S. total R&D in 2011 remains slightly below that for 2008, and the 2009 and 2010 levels are noticeably below the 2008 level.

- Overall R&D performed in the United States totaled $406.7 billion (current dollars) in 2010, roughly the same as the 2009 level of $404.7 billion. U.S. R&D in 2011 totaled $424.4 billion, an increase of $17.7 billion.
- This growth in U.S. R&D expenditures in 2011 followed a 2-year period of stagnation (2009 and 2010). This resulted chiefly from a drop in business R&D in the face of the national and international financial crisis and economic downturn that started in late 2008.
- This seeming return to growth in 2011 is less apparent, however, when the U.S. R&D data are adjusted for inflation. On a constant dollar basis, the U.S. total R&D in 2011 is essentially equal to the 2008 level.

The business sector continues to account for most of U.S. R&D performance and U.S. R&D funding.

- The business sector performed $294 billion of R&D in 2011, or 69% of the U.S. total, drawing on business, federal sources, and other sources of R&D support. The business sector itself provided $267 billion of funding for R&D in 2011, or 63% of the U.S. total, most all of which supported R&D performed by business.
- Even with the declining levels of R&D expenditures in both 2009 and 2010, business R&D performance has accounted for most of the nation's R&D growth over the last 5 years.
- The academic sector is the second-largest performer of U.S. R&D, accounting for an estimated $63 billion in 2011, or about 15% of the national total.
- The federal government is the second-largest funder of U.S. R&D, accounting for an estimated $126 billion, or 30% of U.S. total R&D performance in 2011.

Most of U.S. basic research is conducted at universities and colleges and funded by the federal government. However, the largest share of U.S. total R&D is development, which is largely performed by the business sector. The business sector also performs the majority of applied research.

- In 2011, basic research was about 18% ($75 billion) of total U.S. R&D performance, applied research was about 19% ($82 billion), and development was about 63% ($267 billion).
- Universities and colleges historically have been the main performers of U.S. basic research, and they accounted for about 55% of all U.S. basic research in 2011. The federal government remains the primary source of basic research funding, accounting for about 55% of all such funding in 2011.
- The business sector is the predominant performer of applied research, accounting for 57% of all U.S. applied research in 2011. Business is also the largest source of funding for applied research, providing 53% in 2011.
- Development is by far the largest component of U.S. R&D. Funding for development comes primarily from the business sector (78% in 2011); nearly all of the rest comes from the federal government.

International Comparisons of R&D Performance

The top three R&D-performing countries—United States, China, and Japan—accounted for over half of the estimated $1.435 trillion in global R&D in 2011.

- The United States, the largest single R&D-performing country, accounted for just under 30% of the 2011 global total, down from 37% in 2001.
- The economies of East/Southeast and South Asia—including China, India, Japan, Malaysia, Singapore, South Korea, and Taiwan—represented 25% of the global R&D total in 2001 but accounted for 34% in 2011. China (15%) and Japan (10%) were the largest R&D performers in this group.
- The pace of real growth over the past 10 years in China's overall R&D remains exceptionally high at about 18% annually, adjusted for inflation.
- The European Union accounted for 22% total global R&D in 2011, down from 26% in 2001.

High-income countries, which tend to emphasize production of high-technology goods and services, devote larger shares of their GDP to R&D.

- The U.S. R&D/gross domestic product (GDP) ratio (or R&D intensity) was just over 2.8% in 2011 and has fluctuated between 2.6% and 2.9% during the past 10 years, largely reflecting changes in business R&D spending.
- In 2011, the United States ranked 10th in R&D intensity—surpassed by Israel, South Korea, Finland, Japan, Sweden, Denmark, Taiwan, Germany, and Switzerland. However, all of these economies performed much less R&D annually than the United States.
- Among the top European R&D-performing countries, Germany reported a 2.9% R&D/GDP ratio in 2011, France reported 2.2%, and the United Kingdom reported 1.8%.

- South Korea's R&D/GDP ratio moved upward to 4.0% in 2011. Japan's ratio was 3.4%. China's ratio remains comparatively low, somewhat above 1.8%, but has more than doubled from just under 1.0% in 2001.

U.S. Business R&D

In 2011, business R&D performance reached $294 billion, a record in current dollars but still below the 2008 peak when measured in inflation-adjusted dollars.

- Total U.S. business R&D performance increased from 2010 to 2011 by 5%. However, when measured in inflation-adjusted dollars, 2011 business R&D performance of $259.4 billion is still below the 2008 peak of $267.7 billion, at the beginning of the most recent recession.
- Funding from business and other nonfederal sources increased 5.1% in constant dollars in 2011, the first such increase since 2008. On the other hand, federally funded business R&D as reported by performers dropped 10% in constant dollars in 2011 after a 15% decline in 2010.

R&D by Multinational Companies

The majority of R&D by U.S. multinational companies (MNCs) is still performed in the United States (84.1% of their $252 billion in R&D globally in 2010). Europe hosts the largest expenditures of R&D performed by majority-owned foreign affiliates (MOFAs) of U.S. MNCs, but affiliates in other regions, especially in Asia, are increasing their shares.

- Parent companies of U.S. MNCs performed $212.5 billion of R&D in the United States, according to preliminary 2010 data. Their MOFAs performed $39.5 billion, so that U.S. MNCs as a whole performed $252.0 billion in R&D globally in 2010, up 2.2% from the $246.5 billion performed in 2009.
- European host countries accounted for 62% of U.S. MOFA R&D in 2010. Asia-Pacific was the second-largest host region for U.S. MOFA R&D with 21.1%, including 4.8% in Japan and a record high of 16.3% in the rest of the region. The Middle East and Latin America each accounted for about 5% in 2010, up from 3.0% and 3.4%, respectively, in 2007.
- Europe, Canada, and Japan have long hosted the majority of R&D by U.S. MOFAs. Seven of 13 countries with at least $1 billion in U.S. MOFA R&D in 2010 are in Europe. However, rapid growth in reported R&D by U.S. MOFAs in China, India, Brazil, and Israel has put these locations in the billion-dollar-plus category.
- U.S.-owned MOFA R&D in China more than doubled from 2005 to 2008, with year-to-year double-digit increases to a record $1.7 billion in 2008, although it declined to $1.5 billion by 2010. U.S. MOFA R&D tripled in India and more than doubled in Brazil from 2007 to 2010, growing much faster than U.S. MOFA production activity in those countries, according to preliminary 2010 statistics. Brazil's and India's U.S. MOFA R&D expenditures are now on par with affiliates in China.

Federal R&D Performance and Funding

Federal spending on R&D increased annually on both current and constant dollar bases from the late 1990s through FY 2010. Funding dropped in FY 2011, which was a noticeable departure from the recent trend.

- Federal obligations for the total of R&D and R&D plant were $136 billion in FY 2011 ($132 billion for R&D and an additional $4 billion for R&D plant). The corresponding data for FYs 2009 and 2010 were higher: $145 billion and $147 billion, respectively.
- Defense continues to account for more than half of annual federal R&D spending. Health-related R&D accounts for the majority of federal nondefense R&D. Over the last two decades, the greatest change in federal R&D priorities has been the rise in health-related R&D.
- Fifteen federal departments and 12 other agencies engage in and/or fund R&D in the United States. Nine of these departments/agencies reported R&D spending in FY 2011 in excess of $1 billion, and the nine together accounted for 97% of all federal obligations for R&D that year: the Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Homeland Security, and Transportation; the National Science Foundation; and the National Aeronautics and Space Administration.

Federal Programs to Promote Technology Transfer and the Commercialization of Federal R&D

The federal government has been active since the early 1980s in establishing policies and programs to better transfer and economically exploit the results of federally funded R&D.

- The latest statistics suggest that the federal departments/agencies accounting for the largest portion of federal R&D continue to be active in their use of the technology transfer authorities provided by the Technology Innovation Act of 1980 (Stevenson-Wydler Act) and subsequent legislation.
- The levels of funding going to small, entrepreneurial companies engaged in R&D with eventual commercialization objectives, through the Small Business Innovation Research and Small Business Technology Transfer programs, are now vastly larger than when these programs were first initiated in, respectively, the early 1980s and the mid-1990s.

Introduction

Chapter Overview

This chapter discusses how different economic sectors—including business, the federal government, and universities and colleges—contributed to recent trends in research and development funding and performance. It emphasizes R&D in the business and federal sectors (chapter 5 covers academic R&D in detail).

The importance of these trends to national welfare is highlighted by the recent change in the U.S. gross domestic product (GDP) and related National Income and Product Accounts treating R&D as investment. The change recognizes R&D as a long-term contributor to GDP growth (see sidebar, "R&D in the U.S. National Income and Product Accounts").

In addition to U.S. R&D trends, this chapter presents international R&D comparisons at the national and economic sector levels. One major trend highlighted here is the particularly rapid expansion of R&D performance in Asia. The chapter also details the distribution of R&D performed by foreign affiliates of U.S. multinational companies (MNCs).

Chapter Organization

This chapter is organized in eight sections covering national R&D totals, business activity, and government efforts in the United States and internationally. The first two sections cover U.S. and international comparisons in national R&D performance and funding.

The next three sections detail business sector R&D from the perspective of U.S. domestic activity, MNCs owned by U.S. parent companies or located in the United States, and cross-national industry R&D comparisons. The last three sections provide further detail on the R&D performed and/or funded by the U.S. federal government, compare the national government R&D priorities of the United States and the other major R&D-performing countries, and discuss several U.S. federal programs to promote technology transfer and commercialization.

Trends in U.S. R&D Performance

The U.S. R&D system consists of a variety of performers and sources of funding. These include businesses, the federal government, universities and colleges, other government (nonfederal) agencies, and nonprofit organizations. Organizations that perform R&D often receive significant levels of outside funding; those that fund R&D may also be significant performers. This section discusses the current levels and notable recent trends in overall U.S. R&D performance and funding. (Definitions for key terms in this section appear in this chapter's glossary. The sidebar "Measured and Unmeasured R&D" discusses the main data sources that provide the basis for this analysis. Appendix tables 4-1–4-9 provide additional core data on U.S. R&D funding and performance.)

R&D in the U.S. National Income and Product Accounts

The most recent comprehensive revision of the U.S. GDP and related National Income and Product Accounts (NIPA), released July 2013 by the U.S. Bureau of Economic Analysis (BEA), includes a change to treat R&D as a fixed investment with long-term benefits. Prior to the change, NIPA considered R&D as an expense or as an intermediate input cost in the business sector and as consumption in the government and nonprofit sectors (BEA 2013). This update is one of several NIPA changes aimed at capturing the role of intangible assets in economic growth. Intangibles or intellectual property products include software, R&D, and entertainment, literary, and artistic originals. (For background on the July 2013 release, see http://www.bea.gov/national/an1.htm; for full, revised NIPA statistics, see http://www.bea.gov/national/index.htm#gdp.) The National Science Foundation's surveys serve as the primary data source for the R&D component of these revisions. For further details, see the forthcoming InfoBrief on incorporating R&D as investment in GDP statistics at http://www.nsf.gov/statistics.

U.S. Total R&D and R&D Intensity

R&D performed in the United States totaled $424.4 billion (current dollars) in 2011, an increase of $17.7 billion over the previous year (table 4-1). The comparable total in 2008 was $406.6 billion, having increased $26.9 billion over the previous year. However, 2009 and 2010 were more difficult years for what has, over the longer term, been a mainly expanding U.S. R&D enterprise (figure 4-1). In 2009 and 2010, total U.S. R&D fluctuated narrowly around the 2008 level, showing little expansion ($404.7 billion in 2009; $406.7 billion in 2010). These circumstances resulted chiefly from a lowered level of business R&D in the face of the national and international financial crisis and economic downturn that started in late 2008 (figure 4-2).

The challenging path for U.S. R&D performance over the last several years is more apparent when the R&D expenditure figures are adjusted for inflation.[1] On a constant dollar basis, U.S. total R&D in 2010 was below the 2008 level (table 4-1). Furthermore, the 2011 level only barely returns to the 2008 level. Much the same is true for R&D performance by the business sector (which accounts for around two-thirds of all U.S. R&D performance), although even in 2011 this sector's R&D remains well below the 2008 level in inflation-adjusted terms (table 4-1).

U.S. total R&D grew by 4.4% in 2011, compared with a 3.9% expansion of GDP that year (table 4-2).[2] These relative changes better mirror what has been the “historical” pattern of R&D and GDP growth than the experiences of 2009 or 2010. As a matter of longer-term averages, the growth of U.S. total R&D has outpaced that of the nation’s GDP—whether the averaging period is the past 5, 10, or 20 years (table 4-2). But, again, 2009 and 2010 were notably different experiences. U.S. total R&D dropped by 0.5% in 2009 mainly because of the hefty decline in R&D performed by the business sector (figure 4-2). GDP declined even more sharply that year, by 2.5%. GDP rebounded in 2010, growing by 4.2% over the 2009 level. R&D, however, did not match this pace, growing by only 0.5% over the 2009 level—held back by another year of decline in business sector R&D expenditures (figure 4-2). R&D’s return to a more familiar pace of growth in 2011 owes much to the return of a relatively high rate of expansion of business sector R&D (table 4-2; figure 4-2). (Preliminary data for 2012, available too late to incorporate in this chapter’s charts and tables, put the U.S. R&D total at $452.6 billion that year, an increase of 5.7% over the prior year, well ahead of the 4.0% pace of

Measured and Unmeasured R&D

The statistics on U.S. R&D discussed in this section reflect the National Science Foundation’s (NSF’s) periodic National Patterns of R&D Resources reports and data series, which provide a comprehensive account of total U.S. R&D performance. The National Patterns data, in turn, derive from five major NSF surveys of the organizations that perform the bulk of U.S. R&D:

- Business R&D and Innovation Survey
- Higher Education R&D Survey
- Survey of Federal Funds for R&D
- Survey of R&D Expenditures at Federally Funded R&D Centers
- Survey of R&D Funding and Performance by Nonprofit Organizations

The National Patterns analysis integrates R&D spending and funding data from these separate surveys into U.S. R&D performance totals, which are then reported on a calendar-year basis and for the main performing sectors and funding sources.

Because of practical constraints in the surveys, some elements of R&D performance are omitted from the U.S. totals. In evaluating R&D performance trends over time and in international comparisons, it is important to be aware of these omissions.

The U.S. business R&D estimates are derived from a survey of R&D-performing companies with five or more employees. No estimates of R&D performance currently are available for companies with fewer than five employees. (NSF is in the process of designing and implementing a Microbusiness Innovation and Science and Technology Survey, which will collect data from companies with fewer than five employees.)

Until recently, the U.S. statistics for business R&D did not include social science R&D, and, likewise, R&D in the humanities and other non-S&E fields (such as law) was excluded from the U.S. academic R&D statistics. Other countries include both of these R&D components in their national statistics, making their national R&D expenditures relatively larger when compared with those of the United States. Both of these shortfalls are now addressed in the U.S. statistics. NSF’s Business R&D and Innovation Survey—which replaced the previous Survey of Industrial R&D, starting with the 2008 data year—includes social science R&D. Also, the Higher Education R&D Survey—which replaced the previous Survey of R&D Expenditures at Universities and Colleges, starting with the 2010 academic fiscal year—directly includes non-S&E R&D expenditures in the reported academic R&D totals. (The academic R&D totals reported by the National Patterns statistics have been revised back to 2003 to include the non-S&E R&D expenditures.)

The statistics for academic R&D track research expenditures that are separately accounted for in both sponsored research and institutionally funded research. U.S. universities do not report funds for research that are not separately accounted for, such as estimates of faculty time spent on research. This can be a limitation in international R&D comparisons because such estimates are often included in the national statistics of other countries.

Likewise, the activity of individuals performing R&D on their own time and not under the auspices of a corporation, university, or other organization is omitted from official U.S. R&D statistics.

Statistics on R&D performed by state governments are collected in a biennial NSF/U.S. Census Bureau survey, but these amounts (typically totaling only several hundred million dollars annually) are not yet regularly included in the National Patterns totals. Moreover, NSF has not fielded a full survey on R&D performance by nonprofit organizations since 1998—the National Patterns performance figures for this sector in the national R&D totals are estimated.

The National Center for Science and Engineering Statistics commissioned the National Research Council’s Committee on National Statistics to review the methodologies used in preparing the National Patterns data. The review panel began work in mid-2011 and provided its report in early 2013.

GDP growth, and mainly again the result of increased business R&D. This continuation in 2012 of the strong pace of R&D growth in 2011 suggests a return to the longer-term trend of R&D expansion in the wake of the 2008–09 domestic and international economic downturns [Boroush 2013].)

A consequence of these shifting growth rates is that the R&D intensity of the national economy (the ratio of R&D expenditures to GDP) exhibited a noticeable decline in 2010 and 2011, compared with the earlier years (figure 4-3). (The ratio of total national R&D expenditures to GDP is often reported as a measure of the intensity of a nation's overall R&D effort and is widely used as an international benchmark for comparing countries' R&D systems.)

U.S. expenditures on R&D totaled 2.80% of GDP in 2010 and 2.81% in 2011. Both of these figures are lower than the 2.90% ratio that prevailed in 2009 (figure 4-3). Over the 10-year period from 2001 to 2011, the ratio has fluctuated to some degree year to year, between a low of 2.57% in 2004 and a high of 2.90% in 2009. The ratio had been rising since

Table 4-1

U.S. R&D expenditures, by performing sector and source of funding: 2006–11

Sector	2006	2007	2008	2009	2010	2011
	Current $millions					
All performing sectors	352,567	379,681	406,610	404,697	406,708	424,413
Business	247,669	269,267	290,681	282,393	278,977	294,093
Federal government	41,611	44,133	45,649	47,363	48,939	49,394
Federal intramural[a]	28,240	29,859	29,839	30,560	31,217	31,505
FFRDCs	13,371	14,274	15,810	16,804	17,985	17,889
Industry administered[b]	3,122	5,165	6,346	6,646	7,214	7,037
U&C administered[b]	7,306	5,567	4,766	5,052	5,315	5,294
Nonprofit administered	2,943	3,543	4,698	5,106	5,457	5,558
Universities and colleges	48,951	51,149	53,917	56,939	60,235	63,102
Other nonprofit organizations	14,336	15,132	16,363	18,002	18,294	17,825
All funding sectors	352,567	379,681	406,610	404,697	406,708	424,413
Business	227,110	246,741	258,691	247,274	249,182	267,290
Federal government	101,558	106,858	119,423	127,467	126,962	125,686
Universities and colleges	10,076	10,833	11,640	11,884	11,990	12,488
Nonfederal government	3,182	3,438	3,706	3,808	3,782	3,832
Other nonprofit organizations	10,641	11,810	13,151	14,264	14,793	15,117
	Constant 2005 $millions					
All performing sectors	341,532	357,426	374,472	368,815	366,434	374,394
Business	239,917	253,484	267,706	257,355	251,351	259,433
Federal government	40,308	41,546	42,041	43,164	44,330	43,572
Federal intramural[a]	27,356	28,109	27,480	27,850	28,126	27,792
FFRDCs	12,953	13,438	14,560	15,314	16,204	15,780
Industry administered[b]	3,024	4,862	5,844	6,057	6,499	6,207
U&C administered[b]	7,078	5,241	4,389	4,604	4,789	4,670
Nonprofit administered	2,851	3,335	4,327	4,653	4,916	4,903
Universities and colleges	47,419	48,151	49,656	51,891	54,270	55,665
Other nonprofit organizations	13,888	14,245	15,070	16,406	16,482	15,724
All funding sectors	341,532	357,426	374,472	368,815	366,434	374,394
Business	220,002	232,278	238,244	225,349	224,506	235,788
Federal government	98,379	100,595	109,984	116,165	114,390	110,873
Universities and colleges	9,760	10,198	10,720	10,831	10,802	11,016
Nonfederal government	3,083	3,237	3,413	3,471	3,408	3,381
Other nonprofit organizations	10,308	11,118	12,111	12,999	13,328	13,335

FFRDC = federally funded R&D center; U&C = university and college.

[a] Includes expenditures of federal intramural R&D and costs associated with administering extramural R&D.

[b] Los Alamos National Laboratory (some $2 billion in annual R&D expenditures in recent years) became industry administered in June 2006; previously, it was U&C administered. Lawrence Livermore National Laboratory (more than $1 billion in annual R&D expenditures in recent years) became industry administered in October 2007; previously, it was U&C administered. These shifts in administration category are a main reason for the changes apparent in the R&D performer figures across 2006, 2007, and 2008.

NOTES: Data are based on annual reports by performers except for the nonprofit sector. Expenditure levels for academic and federal government performers are calendar-year approximations based on fiscal-year data. For federal government expenditures, the approximation is equal to 75% of the amount reported in same fiscal year plus 25% of the amount reported in the subsequent fiscal year. For academic expenditures, the respective percentages are 50% and 50%, because those fiscal years generally begin on 1 July instead of 1 October.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

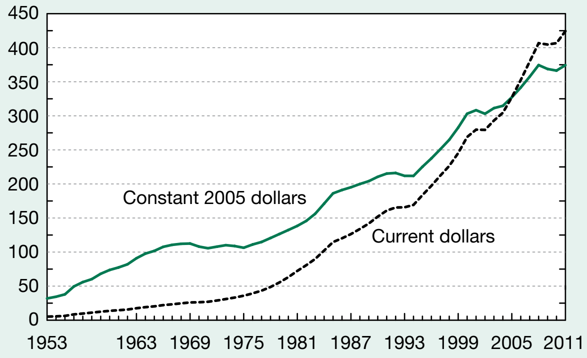
Science and Engineering Indicators 2014

2004 (figure 4-3). The lower levels in 2010 and 2011 represent a noticeable reversal.

Most of the rise of the R&D/GDP ratio over the past several decades has come from the increase of nonfederal spending on R&D, particularly that by the business sector (figure 4-3). This reflects the growing role of business R&D in the national R&D system and, in turn, the growing prominence of R&D-derived goods and services in the national and global economies. By contrast, the ratio of federal R&D spending to GDP declined from the mid-1980s to the late 1990s, notably from cuts in defense-related R&D. There had been a gradual uptick through 2009, the result of increased federal spending on biomedical and national security R&D and the one-time incremental funding for R&D provided by the American Recovery and Reinvestment Act of 2009 (ARRA).

Figure 4-1
U.S. total R&D expenditures: 1953–2011

Billions of dollars



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix table 4-2.

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Performers of R&D

The National Science Foundation (NSF) tracks the R&D spending patterns of all the major performers in the overall U.S. R&D system: businesses, the intramural R&D activities of federal agencies, federally funded research and development centers (FFRDCs), universities and colleges, and other nonprofit organizations.

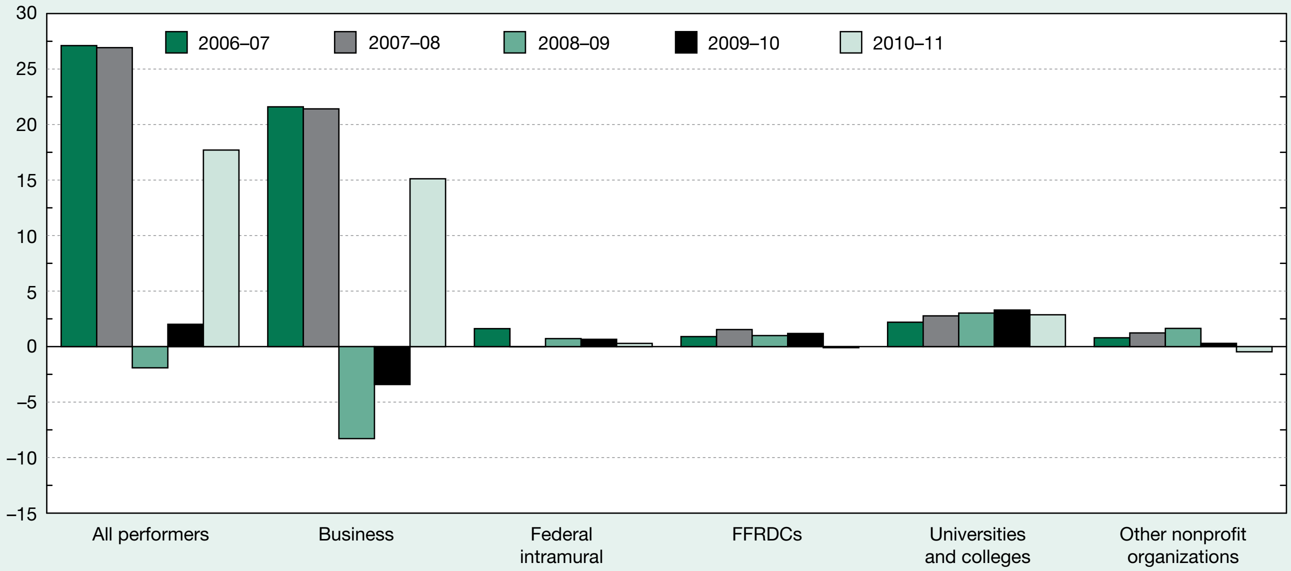
Business Sector

In 2011, the business sector continued to be the largest performer of U.S. R&D, conducting $294.1 billion, or 69%, of the national total (table 4-1; figure 4-4). The 2011 level of business R&D performance rose over the 2010 level ($279.0 billion) and reversed apparent declines in 2009 and 2010. Over the 5-year period of 2006–11, business R&D performance grew an average of 3.5% annually, although somewhat behind the 3.8% rate of growth of overall U.S. R&D (table 4-2).

The business sector's predominance in the composition of national R&D has long been the case, with its annual

Figure 4-2
Year-to-year changes in U.S. R&D expenditures, by performing sector: 2006–11

Billions of current dollars



FFRDC = federally funded R&D center.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

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share ranging between 68% and 74% over the 20-year period of 1991–2011 (figure 4-5).

Universities and Colleges

Academia is the second-largest performer of U.S. R&D. Universities and colleges performed $63.1 billion,[3] or 15%, of U.S. R&D in 2011 (table 4-1; figure 4-4). The total of academic R&D performance has increased by several billion dollars each year since 2006. Annual growth of R&D in this sector has averaged 5.2% over the period of 2006–11, well ahead of the rate of total national R&D (table 4-2).

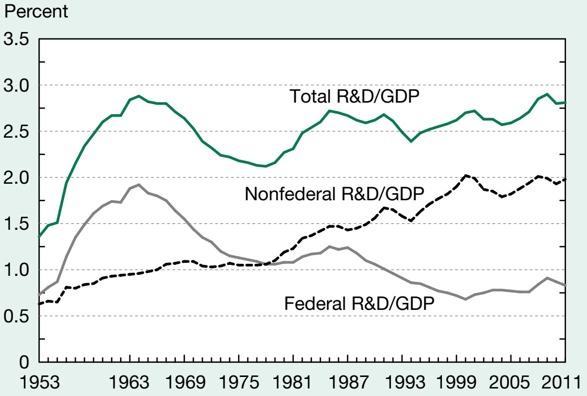
Over the 20-year period of 1991–2011, the academic sector's share in U.S. R&D has ranged between 11% and 15% annually. Furthermore, as discussed below, universities and colleges have a special niche in the nation's R&D system: they performed more than half (55%) of the nation's basic research in 2011.

Federal Agencies and FFRDCs

R&D performed by the federal government includes the activities of agency intramural laboratories and that of the FFRDCs. Federal intramural R&D performance includes the spending for both agency laboratory R&D and for agency activities to plan and administer intramural and extramural R&D projects. FFRDCs are R&D-performing organizations

Figure 4-3

Ratio of U.S. R&D to gross domestic product, by federal and nonfederal funding for R&D: 1953–2011



GDP = gross domestic product.

NOTE: Federal R&D/GDP ratios represent the federal government as a funder of R&D by all performers; the nonfederal ratios reflect all other sources of R&D funding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

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Table 4-2

Annual rates of growth in U.S. R&D expenditures, total and by performing sectors: 1991–2011

(Percent)

	Longer-term trend			Most recent years		
Expenditures and gross domestic product	1991–2011	2001–11	2006–11	2008–09	2009–10	2010–11
	Current dollars					
Total R&D, all performers	5.0	4.3	3.8	-0.5	0.5	4.4
Business	4.8	3.8	3.5	-2.9	-1.2	5.4
Federal government	3.8	4.2	3.5	3.8	3.9	0.4
Federal intramural[a]	3.7	3.5	2.2	2.4	2.2	0.9
FFRDCs	4.0	5.5	6.0	6.3	7.0	-0.5
Universities and colleges	6.4	6.5	5.2	5.6	5.8	4.8
Other nonprofit organizations	6.9	4.8	4.5	10.0	1.6	-2.6
Gross domestic product	4.7	3.9	2.4	-2.5	4.2	3.9
	Constant 2005 dollars					
Total R&D, all performers	2.8	2.0	1.9	-1.5	-0.6	2.2
Business	2.7	1.5	1.6	-3.9	-2.3	3.2
Federal government	1.7	1.9	1.6	2.7	2.7	-1.7
Federal intramural[a]	1.6	1.2	0.3	1.3	1.0	-1.2
FFRDCs	1.9	3.2	4.0	5.2	5.8	-2.6
Universities and colleges	4.2	4.1	3.3	4.5	4.6	2.6
Other nonprofit organizations	4.7	2.5	2.5	8.9	0.5	-4.6
Gross domestic product	2.6	1.6	0.5	-3.5	3.0	1.7

FFRDC = federally funded R&D center.

[a] Includes expenditures of federal intramural R&D and costs associated with administering extramural R&D.

NOTE: Longer-term trend rates are calculated as compound annual growth rates.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

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that are exclusively or substantially financed by the federal government. An FFRDC is operated to provide R&D capability to serve agency mission objectives or, in some cases, to provide major facilities at universities for research and associated training purposes. (There were 40 FFRDCs in 2011; see appendix table 4-10). Each FFRDC is administered by an industrial firm, a university, a nonprofit institution, or a consortium.

The federal government conducted $49.4 billion, or 12%, of U.S. R&D in 2011 (table 4-1; figure 4-4). Of this amount, $31.5 billion (7% of the U.S. total) was intramural R&D performed by federal agencies in their own research facilities, and $17.9 billion (4%) was R&D performed by the 40 FFRDCs.

The federal total was up only barely in 2011 (an increase of $0.5 billion over the prior year). Over the 2006–11 period more generally, however, it has increased from $1 billion to $2 billion annually (table 4-1). In 1991, the federal performance share was 15%, but it gradually declined in the years since 2006, ranging annually between 11% and 12%.

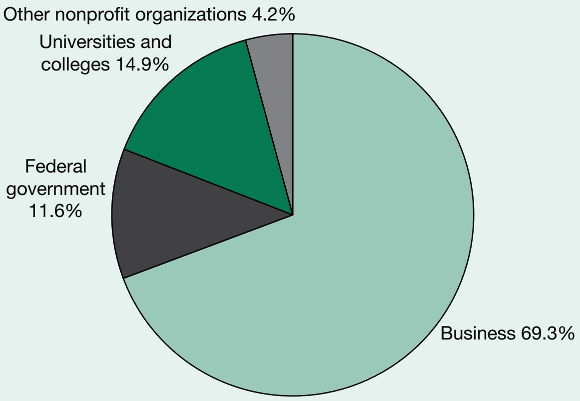
The volume of the federal government's R&D performance is relatively small compared with that of the U.S. business sector. Even so, the $49.4 billion performance total in 2011 exceeded the total national R&D expenditures of every country except China, Japan, Germany, South Korea, and France.[4]

Other Nonprofit Organizations

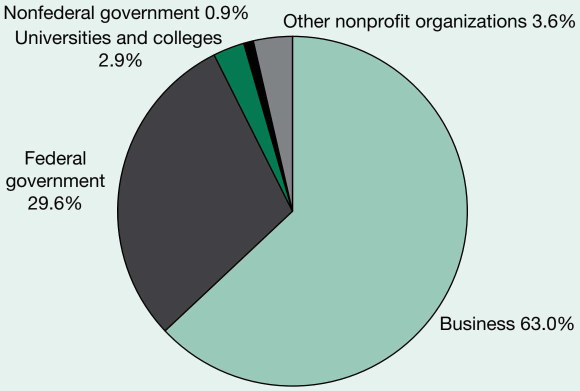
R&D performed in the United States by nonprofit organizations other than universities and certain FFRDCs was estimated at $17.8 billion in 2011 (table 4-1). This was 4%

Figure 4-4
Shares of U.S. total R&D expenditures, by performing sector and funding source: 2011

Performing sector



Funding source



NOTES: National R&D expenditures are estimated to be $424.4 billion in 2011. Federal performing sector includes federal agencies and federally funded R&D centers. State and local government support to business is included in business support for business performance.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-2 and 4-6.

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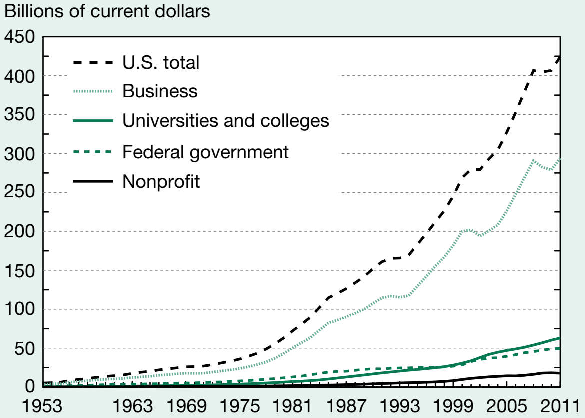
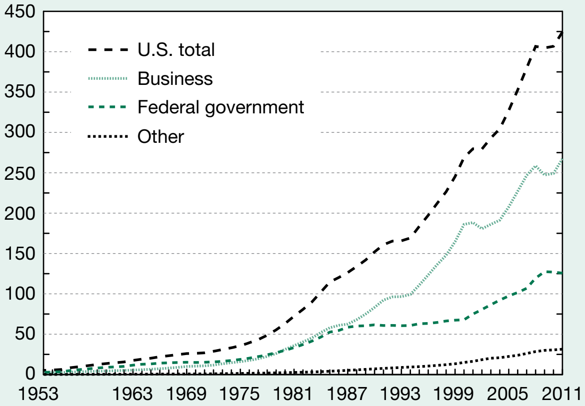
Figure 4-5
U.S. R&D, by performing and funding sectors: 1953–2011

Performing sector



Funding sector



NOTES: Federal performers of R&D include federal agencies and federally funded R&D centers. Other funding includes support from universities and colleges, nonfederal government, and nonprofit organizations. State and local government funding to businesses is included in business support for business R&D performance.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-2 and 4-6.

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of U.S. R&D in 2011, a share that has been largely the same since 2000 (figure 4-4).

Geographic Location of R&D

The sidebar "Location of R&D Performance, by State," summarizes the leading geographic locations of U.S. R&D performance. For additional R&D indicators at the state level, see chapter 8.

Sources of R&D Funding

Funds that support the conduct of R&D in the United States come from a variety of sources, including businesses, federal and nonfederal government agencies, academic institutions, and other nonprofit organizations. The mix of funding sources varies by performer.

R&D Funding by Business

The business sector is the predominant source of funding for the R&D performed in the United States. In 2011, business sector funding accounted for $267.3 billion, or 63% of the $424.4 billion of total U.S. R&D performance (table 4-1; figure 4-4).

Nearly all of the business sector's funding for R&D (98%) is directed toward business R&D performance (table 4-3).[5] The small remainder goes to academic and other nonprofit performers.

The business sector's predominant role in the nation's R&D funding began in the early 1980s, when the support it provided started to exceed 50% of all U.S. R&D funding (figure 4-6). This business sector share moved up annually until reaching 69% in 2000. However, this share has declined somewhat in the years since, amid rising federal R&D funding, to 64% in 2006 and 63% in 2011.

Location of R&D Performance, by State

Distribution of R&D expenditures among the U.S. states

In 2010, the 10 states with the largest R&D expenditure levels accounted for about 62% of U.S. R&D expenditures that can be allocated to the states: California, Massachusetts, Texas, Maryland, New Jersey, New York, Washington, Illinois, Michigan, and Pennsylvania (table 4-A).[*] California alone accounted for 22% of the U.S. total, almost 4 times as much as Massachusetts, the next highest state. The top 20 states accounted for 84% of the R&D total; the 20 lowest-ranking states accounted for around 5% (appendix tables 4-11 and 4-12).

The states with the biggest R&D expenditures are not necessarily those with the greatest intensity of R&D. Among those with the highest R&D/GDP ratios in 2010 were New Mexico, Maryland, Massachusetts,

Table 4-A
Top 10 U.S. states in R&D performance, by sector and intensity: 2010

	All R&D[a]		Sector ranking			R&D intensity (R&D/GDP ratio)		
Rank	State	Amount (current $millions)	Business	Universities and colleges	Federal intramural and FFRDCs[b]	State	R&D/GDP (%)	GDP (current $billions)
1	California	81,005	California	California	Maryland	New Mexico	8.07	77.1
2	Massachusetts	20,657	New Jersey	New York	California	Maryland	6.28	293.3
3	Texas	19,504	Texas	Texas	New Mexico	Massachusetts	5.47	377.8
4	Maryland	18,429	Massachusetts	Maryland	Virginia	Washington	4.91	339.8
5	New Jersey	17,876	Washington	Pennsylvania	District of Columbia	California	4.31	1,877.6
6	New York	17,141	Illinois	Massachusetts	Massachusetts	Michigan	3.99	368.4
7	Washington	16,685	Michigan	North Carolina	Tennessee	Missouri	3.80	243.4
8	Illinois	15,820	New York	Illinois	Alabama	New Jersey	3.72	480.4
9	Michigan	14,702	Pennsylvania	Ohio	Washington	Delaware	3.64	64.0
10	Pennsylvania	13,074	Missouri	Michigan	Illinois	New Hampshire	3.50	61.6

FFRDC = federally funded R&D center; GDP = gross domestic product.

[a] Includes in-state total R&D performance of business sector, universities and colleges, federal agencies, FFRDCs, and federally financed nonprofit R&D.
[b] Includes costs associated with the administration of intramural and extramural programs by federal personnel and actual intramural R&D performance.

NOTES: Small differences in parameters for state rankings may not be significant. Rankings do not account for the margin of error of the estimates from sample surveys.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). State GDP data are from the U.S. Bureau of Economic Analysis. See appendix tables 4-11 and 4-12.

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R&D Funding by the Federal Government

The federal government is the second-largest source of overall funding for U.S. R&D. It is a major source for most U.S. performer sectors except private businesses, where the federal role, while not negligible, is substantially overshadowed by the business sector's own funds.

Funds from the federal government accounted for $125.7 billion, or 30%, of U.S. total R&D in 2011 (table 4-1; figure 4-4). This funding was mainly directed to federal, business, and academic performers, but other nonprofit organizations were also recipients (table 4-3).

Federal funding accounted for all of the $31.5 billion of federal intramural R&D performance in 2011 and nearly all of the $17.9 billion of R&D performed by FFRDCs. (Nonfederal support for FFRDC R&D has been around $0.4 billion in recent years, or less than 1% of total support; see appendix table 4-10.)

Federal funding to the business sector accounted for $31.3 billion of business R&D performance in 2011, or 11% of the sector's R&D total that year (table 4-3). Federal funds to academia supported $38.7 billion (61%) of the $63.1 billion spent on academic R&D in 2011. For the R&D performed by other nonprofit organizations, $6.3 billion (about 35%) of this sector's $17.8 billion of performance was supported by federal funds.

The federal government was once the leading sponsor of the nation's R&D, funding some 67% of all U.S. R&D in 1964 (figure 4-6). The federal share decreased in subsequent years to 49% in 1979, on down to a historical low of 25% in 2000. However, changing business conditions and expanded federal funding for health, defense, and counterterrorism R&D pushed the federal funding share above 30% in 2009 and 2010 and to nearly 30% in 2011. Similarly, through the early 1960s, more than half of the nation's business-performed R&D had been funded by the federal government. This share then declined in subsequent years to below 10% in 2000, but it increased again to 11% by 2011 (appendix table 4-2).

Location of R&D Performance, by State—continued

and Washington (table 4-A). New Mexico is the location of a number of major government research facilities. Maryland is the site of many government research facilities and growing research universities. Massachusetts benefits from both leading research universities and thriving high-technology industries. Washington State is home to government research facilities, leading research universities, and high-technology industries. California has relatively high R&D intensity and benefits from the presence of Silicon Valley, other high-technology industries, federal R&D, and leading research universities, but it is still fifth on this list.

U.S. R&D performance, by sector and state

The proportion of R&D performed by each of the main R&D-performing sectors (business, universities and colleges, federal intramural R&D facilities, and FFRDCs) varies across the states, but the states that lead in total R&D also tend to be well represented in each of these sectors (table 4-A).

In 2010, R&D performed by the business sector accounted for about 69% of the U.S. total R&D that could be allocated to specific states. Of the top 10 states in total R&D performance, 9 are also in the top 10 in industry R&D. Missouri, 10th in business sector R&D, surpasses Maryland in the business R&D ranking.

University-performed R&D accounts for 16% of the allocable U.S. total and mirrors the distribution of overall R&D performance. Only New Jersey and Washington fall out of the top 10 total R&D states, replaced by North Carolina and Ohio.

Federal R&D performance (including both intramural R&D facilities and FFRDCs)—about 13% of the U.S. total—is more concentrated geographically than that in other sectors. Only five jurisdictions—Maryland, California, New Mexico, Virginia, and the District of Columbia—account for 63% of all federal R&D performance.[†] This figure rises to 80% when the other 5 of the top 10 performers—Massachusetts, Tennessee, Alabama, Washington, and Illinois—are included.

Federal R&D accounts for the bulk of total R&D in several states, including New Mexico (84%), which is home to the nation's two largest FFRDCs (Los Alamos and Sandia National Laboratories), and Tennessee (42%), which is home to Oak Ridge National Laboratory. The high figures for Maryland (58%), the District of Columbia (72%), and Virginia (45%) reflect the concentration of federal facilities and federal R&D administrative offices in the national capital area.

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[*] The latest data available on the distribution of U.S. R&D performance by state are for 2010 (appendix table 4-11). Total U.S. R&D expenditures that year are estimated at $406.7 billion. Of this total, $377.0 billion could be attributed to one of the 50 states or the District of Columbia. This state-attributed total differs from the U.S. total for a number of reasons: some business R&D expenditures cannot be allocated to any of the 50 states or the District of Columbia because respondents did not answer the question related to location, nonfederal sources of nonprofit R&D expenditures (an estimated $11.3 billion in 2010) could not be allocated by state, state-level university R&D data have not been adjusted for double-counting of R&D passed from one academic institution to another, and state-level university and federal R&D performance data are not converted from fiscal to calendar years.

[†] Federal intramural R&D includes costs associated with the administration of intramural and extramural programs by federal personnel, as well as actual intramural R&D performance. This is a main reason for the large amount of federal intramural R&D in the District of Columbia.

Table 4-3

U.S. R&D expenditures, by performing sector, source of funds, and character of work: 2011

	Source of funds ($millions)						
Performing sector and character of work	Total	Business	Federal government	Universities and colleges	Nonfederal government	Other nonprofit organizations	Total expenditures (% distribution)
R&D	424,413	267,290	125,686	12,488	3,832	15,117	100.0
Business	294,093	262,784	31,309	*	*	*	69.3
Federal government	49,394	*	49,394	*	*	*	11.6
Federal intramural	31,505	*	31,505	*	*	*	7.4
FFRDCs	17,889	*	17,889	*	*	*	4.2
Industry administered	7,037	*	7,037	*	*	*	1.7
U&C administered	5,294	*	5,294	*	*	*	1.2
Nonprofit administered	5,558	*	5,558	*	*	*	1.3
Universities and colleges	63,102	3,173	38,710	12,488	3,832	4,899	14.9
Other nonprofit organizations	17,825	1,333	6,274	*	*	10,218	4.2
Percent distribution by source	100.0	63.0	29.6	2.9	0.9	3.6	na
Basic research	74,961	15,072	40,913	7,828	2,402	8,744	100.0
Business	13,020	12,343	677	*	*	*	17.4
Federal government	11,467	*	11,467	*	*	*	15.3
Federal intramural	4,875	*	4,875	*	*	*	6.5
FFRDCs	6,592	*	6,592	*	*	*	8.8
Industry administered	2,761	*	2,761	*	*	*	3.7
U&C administered	2,212	*	2,212	*	*	*	3.0
Nonprofit administered	1,619	*	1,619	*	*	*	2.2
Universities and colleges	40,952	1,989	25,662	7,828	2,402	3,071	54.6
Other nonprofit organizations	9,521	740	3,108	*	*	5,673	12.7
Percent distribution by source	100.0	20.1	54.6	10.4	3.2	11.7	na
Applied research	82,379	43,947	30,311	3,255	999	3,866	100.0
Business	47,186	42,782	4,404	*	*	*	57.3
Federal government	12,885	*	12,885	*	*	*	15.6
Federal intramural	7,747	*	7,747	*	*	*	9.4
FFRDCs	5,138	*	5,138	*	*	*	6.2
Industry administered	2,223	*	2,223	*	*	*	2.7
U&C administered	1,314	*	1,314	*	*	*	1.6
Nonprofit administered	1,602	*	1,602	*	*	*	1.9
Universities and colleges	16,614	827	10,256	3,255	999	1,277	20.2
Other nonprofit organizations	5,693	338	2,766	*	*	2,590	6.9
Percent distribution by source	100.0	53.3	36.8	4.0	1.2	4.7	na
Development	267,074	208,271	54,461	1,405	431	2,506	100.0
Business	233,887	207,659	26,228	*	*	*	87.6
Federal government	25,041	*	25,041	*	*	*	9.4
Federal intramural	18,884	*	18,884	*	*	*	7.1
FFRDCs	6,158	*	6,158	*	*	*	2.3
Industry administered	2,053	*	2,053	*	*	*	0.8
U&C administered	1,768	*	1,768	*	*	*	0.7
Nonprofit administered	2,336	*	2,336	*	*	*	0.9
Universities and colleges	5,536	357	2,792	1,405	431	551	2.1
Other nonprofit organizations	2,610	255	400	*	*	1,955	1.0
Percent distribution by source	100.0	78.0	20.4	0.5	0.2	0.9	na

* = small to negligible amount, included as part of the funding provided by other sectors; na = not applicable.

FFRDC = federally funded R&D center; U&C = university and college.

NOTES: Funding for FFRDC performance is chiefly federal, but any nonfederal support is included in the federal figures. State and local government support to business is included in business support for business performance.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

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R&D Funding from Other Sources

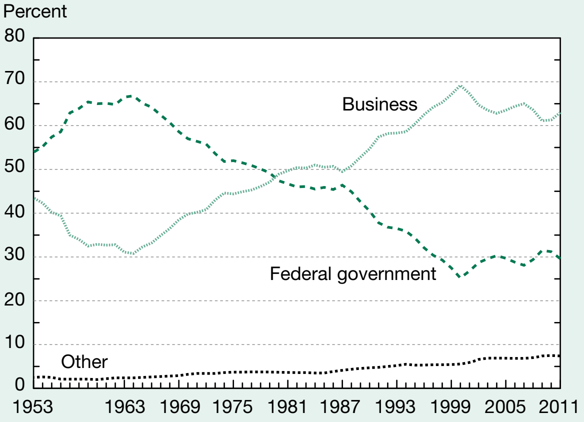
The balance of R&D funding from other sources is small: $31.4 billion in 2011, or about 7% of all U.S. R&D performance that year. Of this amount, $12.5 billion (3%) was academia's own institutional funds, all of which remain in the academic sector; $3.8 billion (1%) was from state and local governments, primarily supporting academic research; and $15.1 billion (4%) was from other nonprofit organizations, the majority of which funds this sector's own R&D. In addition, some funds from the nonprofit sector support academic R&D.

The share of R&D funding from these sources has been gradually increasing over the 2006–11 period (figure 4-6). In 2006, these other sources accounted for just under 7% of U.S. total R&D.

R&D, by Character of Work

R&D encompasses a wide range of activities: from research yielding fundamental knowledge in the physical, life, and social sciences; to research addressing national defense needs and such critical societal issues as global climate change, energy efficiency, and health care; to the development of platform or general-purpose technologies that can enable the creation and commercial application of new and improved goods and services. The most widely applied classification of these activities characterizes R&D as "basic research," "applied research," or "(experimental) development" (OMB 2012b; OECD 2002; NSF 2006). (For definitions of these terms, see this chapter's glossary.) These categories have been criticized as reinforcing the idea that creating new knowledge and innovation is a linear process beginning with basic research, followed by applied research and development, and ending with the production and diffusion of new technology. However, alternative classifications that involve measureable distinctions and capture major differences in types of R&D have yet to emerge. Despite the recognized limitations of the basic research-applied research-development classification framework, it remains useful in providing indications of differences in the motivation, expected time horizons, outputs, and types of investments associated with R&D projects.

Figure 4-6
U.S. total R&D expenditures, by source of funds: 1953–2011



NOTE: Other includes universities and colleges, state and local government, and other nonprofit organizations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix table 4-6.

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The most recent character-of-work cross-section in NSF's R&D expenditures and funding data covers 2011.[6] Basic research activities accounted for 18% ($75.0 billion) of the $424.4 billion of total U.S. R&D that year. Applied research was 19% ($82.4 billion); development was 63% ($267.1 billion) (table 4-3; figure 4-7).

Basic Research

Universities and colleges remain the primary performers of U.S. basic research, accounting for 55% of the $75.0 billion in 2011 (table 4-3). The business sector performed about 17%; the federal government (agency intramural labs and FFRDCs) performed 15%; and other nonprofit organizations performed 13%.

The federal government continues as the prime source of funding for basic research, accounting for about 55% of all such funding in 2011 (table 4-3). The business sector was the second-largest performer at 20%, but although its $15.1 billion of funding for basic research is small compared to its $267.3 billion of funding for all R&D that year, the contribution is particularly significant to the national R&D as a whole. Universities and colleges themselves provide about 10% of basic research funding. Other nonprofit organizations provide 12%.

In choosing whether to perform basic research, businesses consider various factors, such as the extent of appropriability of results, the commercialization risks involved, and the uncertainties of investment returns over business-acceptable time horizons. Despite the risks and uncertainties involved, many companies believe that company engagement in basic research can help them develop human capital, attract and retain talent, absorb external knowledge, and strengthen innovation capacity. Businesses that invest most heavily in basic research tend to be in industries that are most directly tied to ongoing scientific and technological advances, such as the pharmaceuticals and scientific R&D service industries.

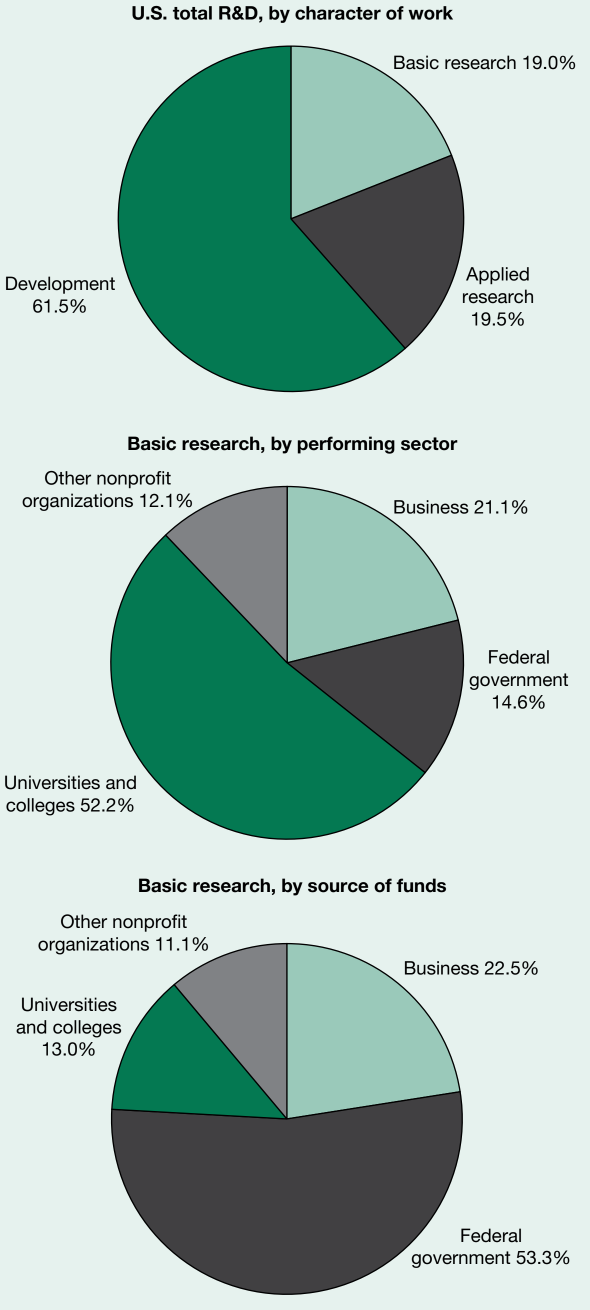
Applied Research

The business sector performed 57% of the $82.4 billion of applied research in 2011 (table 4-3). Universities and colleges accounted for 20%; the federal government (federal agency intramural labs and FFRDCs) accounted for 16%; and nonprofit organizations accounted for 7%.

Businesses provided the bulk of funding (53%) for applied research in 2011. The federal government provided 37%. Academia, nonfederal governments, and other nonprofit organizations contributed 4%, 1%, and 5%, respectively.

Industries that perform relatively large amounts of applied research include chemicals and aerospace. Federal funding for applied research is spread broadly across all the

Figure 4-7
U.S. R&D by character of work, basic research by performing sector, and basic research by source of funds: 2011



U.S. total R&D, by character of work

Basic research, by performing sector

Basic research, by source of funds

NOTES: National R&D expenditures were estimated at $424.4 billion in 2011. National basic research expenditures were estimated at $75.0 billion in 2011. Federal performers include federal agencies and federally funded R&D centers. State and local government support to industry is included in industry support for industry performance. State and local government support to universities and colleges is included in universities and colleges support of performance by universities and colleges.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3–4-5 and 4-7.

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performers, with the largest amounts (in 2011) going to universities and colleges, federal intramural labs, the business sector, and FFRDCs (table 4-3).

Development

The business sector dominates in development, performing 88% of the $267.1 billion that the United States devoted to development in 2011 (table 4-3).[7] The federal government (agency intramural labs, FFRDCs) accounted for another 9%—much of it was defense related, with the federal government being the main consumer. By contrast, academia and other nonprofit organizations perform very little development, respectively 2% and 1% of the total in 2011.

The business sector provided about three-quarters (78%) of development funding ($208.3 billion) in 2011, nearly all of it in support of development activities by businesses (table 4-3). The federal government provided 20% ($54.5 billion) of the funding, with more than half going to the business sector—especially in defense-related industries—and most of the remainder going to federal intramural labs and FFRDCs. Universities and colleges, other nonprofit organizations, and nonfederal government agencies provided small amounts of funding to support performance of development activities.

International Comparisons of R&D Performance

Data on R&D expenditures by country and region provide a broad picture of the changing distribution of R&D capabilities and activities around the world. R&D data available from the Organisation for Economic Co-operation and Development (OECD) cover the organization's 34 member countries and 7 nonmembers (OECD 2013). The United Nations Educational, Scientific and Cultural Organization's (UNESCO's) Institute for Statistics provides data on additional countries (UNESCO 2013). The discussion in this section draws on both of these data sets.

Cross-national comparisons of R&D expenditures and funding necessarily involve currency conversions. The analysis in this section uses the international convention of converting foreign currencies into U.S. dollars via purchasing power parity (PPP) exchange rates (for a discussion of this methodology, see the sidebar, "Comparing International R&D Expenditures").

Global Pattern of R&D Expenditures

Worldwide R&D expenditures totaled an estimated $1,435 billion (current PPP dollars) in 2011.[8] The corresponding estimate for 5 years earlier in 2006 is $1,051 billion. Ten years earlier, in 2001, it was $753 billion. By these figures, growth in total global R&D has been rapid, averaging 6.4% annually over the 5-year period and 6.7% annually over the 10-year period.

Overall, global R&D performance remains highly concentrated in three geographic regions: North America, Asia, and Europe (figure 4-8). North America (United States, Canada, Mexico) accounted for 32% ($462 billion) of worldwide R&D performance in 2011; the combination of East/Southeast and South Asia (including China, Taiwan, Japan, India, South Korea) accounted for 34% ($492 billion); and Europe, including (but not limited to) European Union (EU; see "Glossary" for member countries) countries accounted for 24% ($345 billion). The remainder, around 10%, reflects the R&D of countries in the regions of Central and South America, Central Asia, the Middle East, Australia/Oceania, and Africa.

The geographic concentration of R&D is more apparent when looking at specific countries (table 4-4). Three countries account for more than half of global R&D. The United States is by far the largest R&D performer ($429 billion in 2011), accounting for just under 30% of the global total, but down from 37% in 2001. China was the second-largest performer ($208 billion) in 2011, accounting for about 15% of the global total. Japan is third at 10% ($147 billion). The largest EU performers spend comparatively less: Germany ($93 billion, 7%), France ($52 billion, 4%), and the United Kingdom ($40 billion, 3%). R&D spending by South Korea has also been rising in recent years and accounted for 4% ($60 billion) of the global total in 2011. Taken together, these top seven countries account for about 72% of total global R&D. The Russian Federation, Taiwan, Brazil, Italy, Canada, India, Australia, and Spain make up the next tier of performers, with total R&D expenditures ranging from $20 billion to $35 billion. The top seven countries, along with the second group of eight economies, together account for 84% of current global R&D.

The generally vigorous pace at which total global R&D continues to grow is certainly one of the prominent developments, a reflection of the growing knowledge-intensiveness of the economic competition among the world's nations. The other major trend is the particularly rapid expansion of R&D performance in the regions of East/Southeast and South Asia, including economies such as China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand. The R&D performed in these two Asian regions represented only 25% of total global R&D in 2001 but increased to 34% in 2011, including China (15%) and Japan (10%).

China continues to exhibit the world's most dramatic R&D growth pattern (figure 4-9; appendix table 4-13). The World Bank revised China's PPP exchange rate in late 2007, significantly lowering the dollar value of its R&D expenditures. Nonetheless, the pace of growth over the past 10 years (2001–11) in China's overall R&D remains exceptionally high at 20.7% annually (still very high, at 18.1% per year, when adjusted for inflation).

The rate of growth in South Korea's R&D has also been quite high, averaging 10.9% annually over the same 10-year

Comparing International R&D Expenditures

Comparisons of international R&D statistics are hampered by the lack of R&D-specific exchange rates. Two approaches are commonly used: (1) express national R&D expenditures as a percentage of gross domestic product (GDP), or (2) convert all expenditures to a single currency. The first method is straightforward but permits only gross comparisons of R&D intensity. The second method permits absolute level-of-effort comparisons and finer-grain analyses but entails selecting an appropriate method of currency conversion. The choice is between market exchange rates (MERs) and purchasing power parities (PPPs), both of which are available for a large number of countries over an extended period.

MERs represent the relative value of currencies for cross-border trade of goods and services but may not accurately reflect the cost of nontraded goods and services. They are also subject to currency speculation, political events, wars or boycotts, and official currency intervention. PPPs were developed to overcome these shortcomings (Ward 1985). They take into account the cost differences of buying a similar market basket of goods and services covering tradables and nontradables. The PPP basket is assumed to be representative of total GDP across countries. PPPs are the preferred international standard for calculating cross-country R&D comparisons and are used in all official R&D tabulations of the OECD.*

Because MERs tend to understate the domestic purchasing power of developing countries' currencies, PPPs can produce substantially larger R&D estimates than MERs for these countries. For example, China's R&D expenditures in 2010 (as reported to the OECD) are $178 billion in PPP terms but only $104 billion using MERs.

However, PPPs for large developing countries such as China and India are often rough approximations and have other shortcomings. For example, structural differences and income disparities between developing and developed countries may result in PPPs based on markedly different sets of goods and services. In addition, the resulting PPPs may have very different relationships to the cost of R&D in different countries.

R&D performance in developing countries often is concentrated geographically in the most advanced cities and regions in terms of infrastructure and level of educated workforce. The costs of goods and services in these areas can be substantially greater than for the country as a whole.

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* Recent research raises some unresolved questions about the use of GDP PPPs for deflating R&D expenditures. In analyzing the manufacturing R&D inputs and outputs of six industrialized OECD countries, Dougherty et al. (2007:312) concluded that "the use of an R&D PPP will yield comparative costs and R&D intensities that vary substantially from the current practice of using GDP PPPs, likely increasing the real R&D performance of the comparison countries relative to the United States."

period. The growth in Japan's R&D has been much slower, at an annual average rate of 3.5%.

By comparison, while the United States remains atop the list of the world's R&D-performing nations, its pace of growth in R&D performance has averaged 4.4% over the same 2001–11 period, and its share of global R&D has declined from 37% to 30%. Total R&D by EU nations has been growing over the same 10 years at an annual average rate of 5.0%. The pace of growth during the same period for Germany (5.5%), France (3.8%), and the United Kingdom (3.1%) has been somewhat slower. The EU countries accounted for 22% of total global R&D in 2011, down from 26% in 2001.[9]

Comparison of Country R&D Intensities

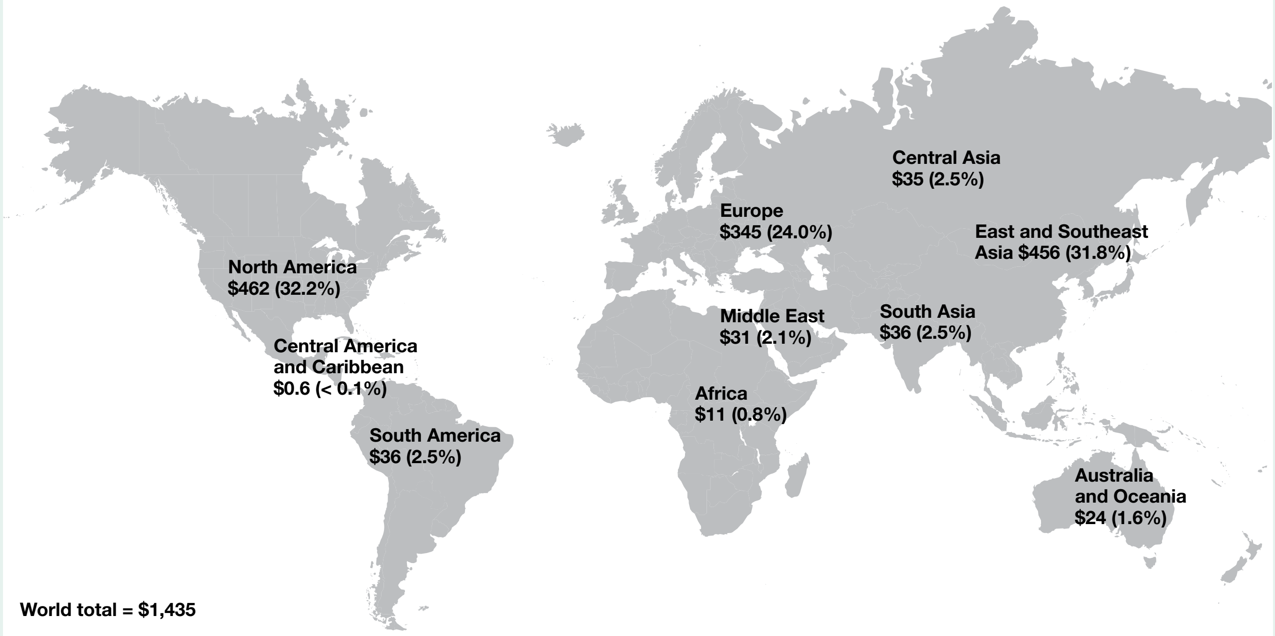
R&D intensity provides another basis for international comparisons of R&D performance. This metric does not require conversion of a country's currency to a standard international benchmark (dollars), but it does provide a means to adjust for differences in the sizes of national economies.

The U.S. R&D/GDP ratio was somewhat over 2.8% in 2011 (table 4-4). At this level, the United States is 10th among the economies tracked by the OECD and UNESCO. Israel continues to have the highest ratio at 4.4%. South Korea is now second at 4.0%, and Finland is third at 3.8%. Japan and Sweden are both around 3.4%. Denmark is at 3.1%, and Taiwan is at 3.0%. Germany and Switzerland, both at 2.9%, are slightly ahead of the United States. By way of comparison, the United States was eighth in R&D intensity in the data for 2007; it has been gradually slipping in the world rank for this indicator in recent years.

The R&D/GDP ratio in the United States has ranged from 1.4% in 1953 to well above 2.8% in 1963–67 to a historical high of 2.9% in 2009. Over the 10-year period from 2001 to 2011, the ratio fluctuated between a low of 2.6% in 2004 to a high of 2.9% in 2009 (figure 4-10; appendix table 4-13). The ratio has generally been rising since 2004, but the drop in 2010 to 2.8% is a noticeable departure.

Most of the growth over time in the U.S. R&D/GDP ratio can be attributed to increases in nonfederal R&D spending, primarily that financed by business. Nonfederally financed R&D increased from about 0.6% of GDP in 1953 to 2.0% of GDP in 2011. This increase in the nonfederal R&D/GDP ratio reflects the growing role of business R&D in the national R&D system and, more broadly, the growing prominence of R&D-derived products and services in the national and global economies.

Figure 4-8
Global R&D expenditures, by region: 2011
Billions of U.S. PPP dollars



PPP = purchasing power parity.

NOTES: Foreign currencies are converted to U.S. dollars through PPPs. Some country figures are estimated. Countries are grouped according to the regions described by *The World Factbook*, available at www.cia.gov/library/publications/the-world-factbook/index.html.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, estimates (August 2013). Based on data from the Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1); and the United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed 2 August 2013.

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Table 4-4
International comparisons of gross domestic expenditures on R&D and R&D share of gross domestic product, by region/country/economy: 2011 or most recent year

Region/country/economy	GERD (PPP $millions)	GERD/GDP (%)
North America		
United States (2011)[a]	429,143.0	2.85
Canada (2011)	24,289.3	1.74
Mexico (2011)	8,209.4	0.43
South America		
Brazil (2010)	25,340.2	1.16
Argentina (2011)	4,640.6	0.65
Chile (2010)	1,331.4	0.42
Colombia (2010)	856.7	0.16
Europe		
Germany (2011)	93,055.5	2.88
France (2011)	51,891.0	2.24
United Kingdom (2011)	39,627.1	1.77
Italy (2011)	24,812.1	1.25
Spain (2011)	19,763.1	1.33
Netherlands (2011)	14,581.5	2.04
Sweden (2011)	13,216.2	3.37
Switzerland (2008)	10,525.2	2.87
Austria (2011)	9,761.9	2.75
Belgium (2011)	8,719.4	2.04
Finland (2011)	7,634.8	3.78
Denmark (2011)	7,052.4	3.09
Poland (2011)	6,227.9	0.76
Czech Republic (2011)	5,086.5	1.85
Norway (2011)	5,006.7	1.66
Portugal (2011)	4,037.6	1.49
Ireland (2011)	3,223.0	1.70
Hungary (2011)	2,581.9	1.21
Ukraine (2011)	2,400.0	0.73
Greece (2007)	1,866.8	0.60
Romania (2011)	1,648.5	0.50
Slovenia (2011)	1,387.8	2.47
Belarus (2011)	1,074.1	0.76
Slovak Republic (2011)	882.3	0.68
Luxembourg (2011)	656.2	1.43
Croatia (2011)	642.9	0.75
Serbia (2011)	633.9	0.73
Bulgaria (2011)	632.6	0.57
Middle East		
Turkey (2011)	10,826.9	0.86
Israel (2011)	9,822.7	4.38
Iran (2008)	6,432.2	0.79
Africa		
South Africa (2009)	4,416.2	0.87
Egypt (2011)	2,230.6	0.43
Morocco (2010)	1,115.6	0.73
Tunisia (2009)	1,055.9	1.10
Central Asia		
Russian Federation (2011)	35,045.1	1.09
South Asia		
India (2007)	24,305.9	0.76
Pakistan (2011)	1,618.5	0.33
East and Southeast Asia		
China (2011)	208,171.8	1.84
Japan (2011)	146,537.3	3.39
South Korea (2011)	59,890.0	4.03
Taiwan (2011)	26,493.1	3.02
Singapore (2011)	7,060.2	2.23
Malaysia (2011)	4,953.4	1.07
Thailand (2009)	1,355.8	0.25
Indonesia (2009)	802.3	0.08
Australia, Oceania		
Australia (2010)	20,578.1	2.20
New Zealand (2011)	1,772.1	1.30
Selected country groups		
European Union (2011)	320,455.9	1.94
OECD (2011)	1,034,024.3	2.37
G20 (2011)	1,323,147.2	2.02

G20 = Group of Twenty; GDP = gross domestic product; GERD = gross expenditures (domestic) on R&D; OECD = Organisation for Economic Co-operation and Development; PPP = purchasing power parity.

[a] Figures for the United States in this table may differ slightly from those cited earlier in the chapter. Data here reflect international standards for calculating GERD, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D.

NOTES: The table includes countries with annual GERD of $500 million or more. Year of data is listed in parentheses. Foreign currencies are converted to dollars through PPPs. Countries are grouped according to the regions described by *The World Factbook*, www.cia.gov/library/publications/the-world-factbook/index.html. No countries in the Central American and Caribbean region had annual GERD of $500 million or more. Data for Israel are civilian R&D only. See sources below for GERD statistics on additional countries.

SOURCES: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed August 2013.

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Among the other top seven R&D-performing countries, most had increasing R&D/GDP ratios over the 2000–11 period (figure 4-10). However, for some, the rise was modest at best, and for others, it was quite large. France exhibited only a bare increase over this period: from 2.2% in 2001 to somewhat over 2.2% in 2011. The United Kingdom's ratio was also rather flat over the same period, around 1.8%. For Germany, the ratio increased from 2.5% in 2001 to 2.9% in 2011. Japan was also in the modest increase category: from 3.1% in 2001 to 3.4% in 2011. (Japan's rising ratio reflects in part the confluence of declining GDP and largely flat R&D spending.) The high-risers were China and South Korea. China's ratio doubled over the period: from just under 1.0% in 2001 to somewhat above 1.8% in 2011. South Korea's ratio increased from 2.5% in 2001 to 4.0% in 2011.

In addition to the United States, countries in Nordic and Western Europe and the most advanced areas of Asia have R&D/GDP ratios above 1.5%. This pattern broadly reflects the global distribution of wealth and level of economic development. Countries with high incomes tend to emphasize the production of high-technology goods and services and are also those that invest heavily in R&D activities. Private sectors in low-income countries often have a low concentration of high-technology industries, resulting in low overall R&D spending and, therefore, low R&D/GDP ratios.

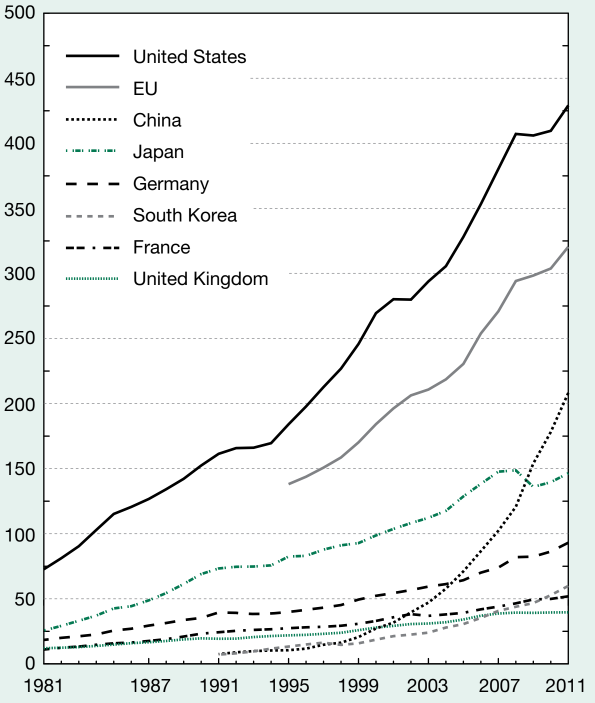
Comparative Composition of Country R&D Performance

The business sector is the predominant R&D performer for the top seven R&D-performing nations (table 4-5; appendix table 4-14). For the United States, the business sector accounted for 69% of gross expenditures on R&D in 2011. Japan's business sector was the highest, accounting for 77% of the country's overall R&D performance. China (76%) and South Korea (77%) were also well above the U.S. level. Germany, at 67%, was close to the level of the United States. France and the United Kingdom were somewhat lower, at, respectively, 63% and 62%.

Figure 4-9

Gross domestic expenditures on R&D by the United States, EU, and selected other countries: 1981–2011

Billions of current PPP dollars



EU = European Union; PPP = purchasing power parity.

NOTES: Data are not available for all countries in all years. Data for the United States in this figure reflect international standards for calculating gross expenditures on R&D, which vary slightly from the National Science Foundation's approach to tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data because of changes in methodology. EU data for all years are based on the current 27 EU member countries.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1). See appendix table 4-13.

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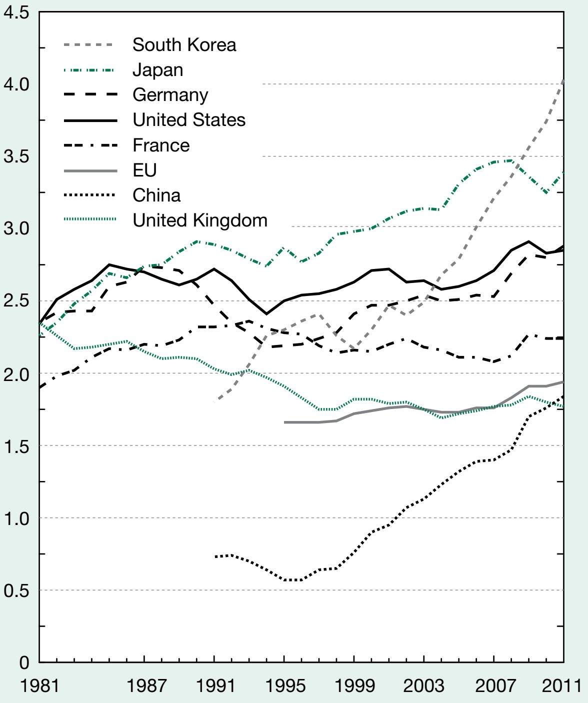
Figure 4-10

Gross expenditures on R&D as share of GDP, for the United States, EU, and selected other countries: 1981–2011

Percent



EU = European Union; GDP = gross domestic product.

NOTES: Data are not available for all countries in all years. The table includes the top seven R&D-performing countries. Figures for the United States reflect international standards for calculating gross expenditures on R&D, which differ slightly from the National Science Foundation's protocol for tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data because of changes in methodology.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1). See appendix table 4-13.

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The R&D performed by the government ranges over 8%–16% of total national R&D for the leading seven countries. Japan (8%) and the United Kingdom (9%) are on the lower end of this range. China (16%), Germany (15%), and France (14%) are at the high end. The United States and South Korea lie in between.

Academic R&D ranges from 8% to 27% of total national R&D performance for these countries. China has the lowest ratio, at 8%. The United Kingdom has the highest, at 27%. The United States (15%), Japan (13%), and South Korea (10%) have lower shares; Germany (18%) and France (21%) have higher shares.

With regard to the funding of R&D, the business sector is again the predominant source for the top seven R&D-performing nations (table 4-5). In 2011, funding for about 77% of Japan's total national R&D came from the business sector. The corresponding figures for South Korea, China, and Germany are also high, in the 66%–74% range. R&D funding from business is lower, but still predominant, in the United States (59%) and France (54%). The corresponding figure for the United Kingdom (45%) is notably lower.

Government is the second major source of R&D funding for these seven countries. France is the highest, at 37%. The lowest is Japan, at 16%. The United States (31%), the United Kingdom (32%), and Germany (30%) are on the higher side. South Korea (25%) and China (22%) are in between.

Funding from abroad refers to funding from businesses, universities, governments, and other organizations located outside of the country. Among the top seven R&D-performing countries, the United Kingdom is the most notable in this category, with 17% of R&D funding coming from abroad. France is also comparatively high, at nearly 8%. Germany and the United States are both around 4%, and the rest are much lower. (For the United States, the funding from abroad reflects foreign funding for domestic R&D performance by the business and higher education sectors.)

Another dimension in which to compare countries is the extent of total national R&D performance directed to basic research. None of the other top seven R&D-performing countries come close to the United States in its $74 billion of support for basic research in 2011 (table 4-6). The next closest is Japan, at $18 billion, and then France, at $13 billion. The U.S. basic research share (17%) is also high among this group, although it is exceeded by France (25%). China has the lowest share of basic research (5%) in this group of countries.

Table 4-5

Gross expenditures on R&D for selected countries, by performing sector and funding sources: 2011 or most recent year

Country	GERD PPP ($billions)	Share of total (%)			
		Business	Government	Higher education	Private nonprofit
		R&D performance			
United States (2011)[a]	429.1	68.5	12.7	14.6	4.3
China (2011)	208.2	75.7	16.3	7.9	0.0
Japan (2011)	146.5	77.0	8.4	13.2	1.5
Germany (2011)	93.1	67.3	14.7	18.0	**
South Korea (2011)	59.9	76.5	11.7	10.1	1.6
France (2011)	51.9	63.4	14.1	21.2	1.2
United Kingdom (2011)	39.6	61.5	9.3	26.9	2.4
		R&D funding sources			
United States (2011)[a, b]	429.1	58.6	31.2	6.4	3.8
China (2011)	208.2	73.9	21.7	NA	1.3
Japan (2011)	146.5	76.5	16.4	6.6	0.5
Germany (2010)	93.1	65.6	30.3	0.2	3.9
South Korea (2011)	59.9	73.7	24.9	1.2	0.2
France (2010)	51.9	53.5	37.0	1.8	7.6
United Kingdom (2011)	39.6	44.6	32.2	6.2	17.0

** = included in data for other performing sectors; NA = not available.

GERD = gross expenditures on R&D; PPP = purchasing power parity.

[a] Figures for the United States in this table reflect international standards for calculating GERD, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D.

[b] The data for U.S. funding from abroad include foreign funding for business R&D and higher education R&D.

NOTES: The table includes the top seven R&D-performing countries. Percentages may not add to 100 due to rounding. Data years are listed in parentheses.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1).

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Table 4-6
Basic research as a share of gross expenditures on R&D, for selected countries: 2011

Country	GERD PPP ($billions)	Basic research PPP ($billions)	Basic research Share (%)
United States[a]	429.1	74.3	17.3
China	208.2	9.9	4.7
Japan	146.5	18.0	12.3
Germany	93.1	NA	NA
South Korea	59.9	10.8	18.1
France	51.9	13.1	25.3
United Kingdom	39.6	4.3	10.8

NA = not available.

GERD = gross expenditures on R&D; PPP = purchasing power parity.

[a] Figures for the United States in this table reflect international standards for calculating gross expenditures on R&D, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D.

NOTES: The table includes the top seven R&D-performing countries. Percentages may not add to 100 due to rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1).

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U.S. Business R&D

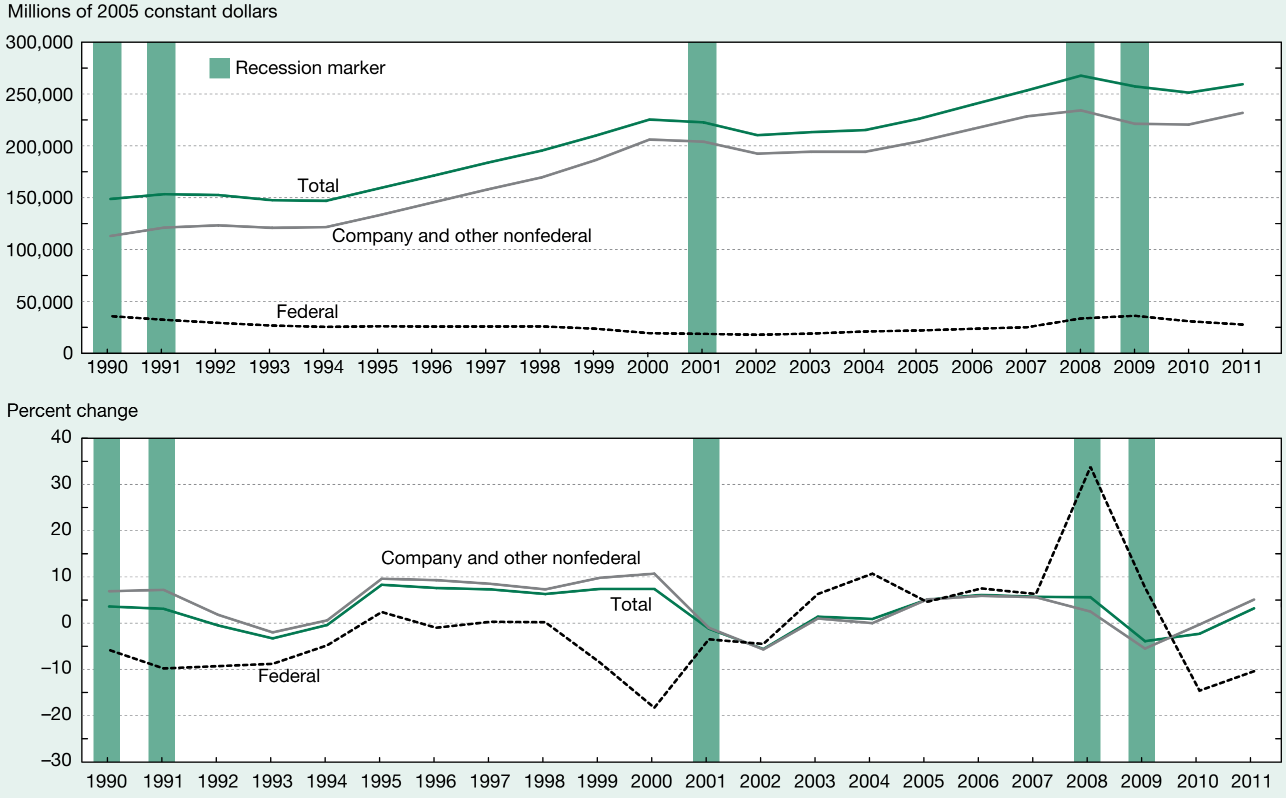
Total U.S. business R&D performance reached a record $294.1 billion in 2011, a 5% increase from 2010 according to statistics from the Business R&D and Innovation Survey (BRDIS). However, measured in inflation-adjusted dollars, the 2011 business R&D performance of $259.4 billion (up 3% from 2010) is still below the 2008 peak of $267.7 billion, at the beginning of the most recent recession.[10] Over the past two decades, constant dollar U.S. business R&D performance follows peaks and troughs timed close to business cycle changes, short-term up-and-down movements in constant dollar GDP (figure 4-11).[11]

The company size distribution of U.S. business R&D performance has changed little since 2008. In 2011, large companies (those with 25,000 domestic employees or more) performed 35% of U.S. business R&D. Companies with 5 to 499 employees performed about 20% (appendix table 4-15).[12]

Business and other nonfederal funding sources increased 5.1% in constant dollars in 2011, the first such increase since 2008. On the other hand, federally funded business R&D as reported by performers dropped 10% in constant dollars in 2011 after a 15% decline in 2010, following increases in 2008 and 2009.

The rest of this section focuses on recent industry-level data measured in current dollars. See appendix tables 4-15–4-22.

Figure 4-11
U.S. business R&D, by major source of funds: 1990–2011



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Survey of Industrial R&D and Business R&D and Innovation Survey (annual series).

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Recent Trends in Domestic Business R&D

Trends in U.S. business R&D performance are driven by five industries (called "top industries" below) that together accounted for $239.0 billion, or 81%, of domestic business R&D performance in 2011: computer and electronic product manufacturing, chemicals manufacturing (including pharmaceuticals), transportation equipment (including aerospace), information (including software publishers), and professional, scientific, and technical (PST) services.

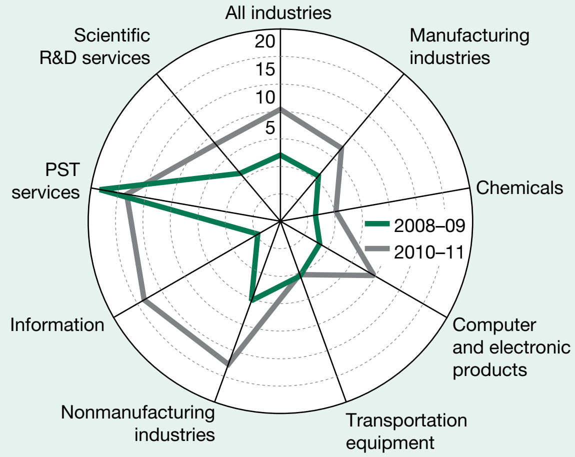
Manufacturing industries historically account for the largest share of U.S. business R&D performance (68% in 2011). However, between 2010 and 2011, nonmanufacturing industries' R&D grew faster (12.7%) than manufacturing R&D (2.4%). Indeed, the largest growth in domestic R&D performance among the top five industries in 2011 occurred in information services (13.6%) and PST services (13.4%). Computer and electronic product manufacturing increased by 4.7%. The other two top industries posted drops in R&D expenditures: chemicals (4.7% decrease, including 7.0% decline in pharmaceuticals) and transportation equipment (4.7% decrease) (figure 4-12; appendix table 4-15).

Overall, domestic R&D performance bounced back by 5.4% from 2010 to 2011 after declining 2.9% during the recession years from 2008 to 2009. Company and other nonfederal funding sources increased 7.4% in 2010–11 after declining 4.5% in 2008–09. In contrast, federal sources decreased 8.5% in 2010–11.

At the same time, federal funding accounted for only 10.6% of domestic business R&D in 2011, down from 12.3% in 2010. This funding source is also highly concentrated in some industries, based on 2010 detailed statistics. The highest shares of federal funding for domestic business R&D are in transportation equipment manufacturing (47%), which includes aerospace (63%); in PST services (20.3%), which includes scientific R&D services and architectural, engineering, and related services; and in computer and electronic products manufacturing (9.9%) (figure 4-13).

Apart from direct funding for R&D in the form of contracts and grants to businesses, the U.S. government offers indirect R&D support via fiscal incentives such as tax credits (see sidebar, "Federal R&E Tax Credit").

Figure 4-12
Percentage change in U.S. domestic business R&D performance: 2008–09 and 2010–11



PST = professional, scientific, and technical.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (annual series).

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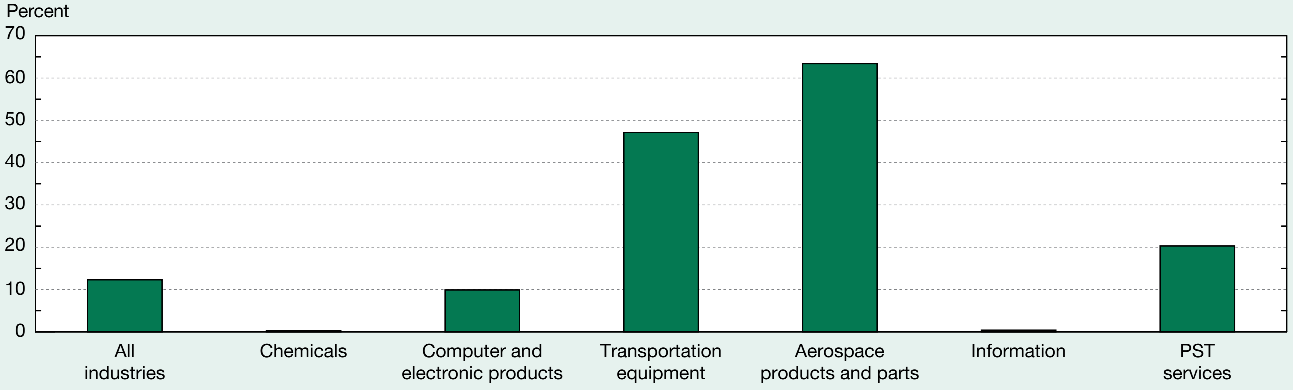
Figure 4-13
Share of U.S. business R&D performance funded by the federal government: 2010



PST = professional, scientific, and technical.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2010).

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Domestic and International Funding Sources, by Type of Source

Funding for domestic business R&D may be classified by the geographic location of funding sources, by ownership, and by a combination of these categories according to new details available from BRDIS. Most domestic R&D is funded from domestic sources (regardless of ownership) and by company-owned units (regardless of their location). In 2011, $238.8 billion (81.2% of $294.1 billion of domestic R&D performance) was funded internally (company-owned units regardless of location), including $3.3 billion by subsidiaries located abroad (table 4-7; see also appendix tables 4-15–4-19).

Federal R&E Tax Credit

The United States and other OECD countries offer fiscal incentives for business R&D at the national and subnational levels (Thomson 2012). For businesses, tax credits reduce after-tax costs of R&D activities. For governments, tax credits are forgone revenue, known as tax expenditures. Public incentives for R&D are generally justified by the inability of private performers to fully capture benefits from these activities, given the intangible nature of knowledge and information.

The U.S. research and experimentation (R&E) tax credit was originally established by the Economic Recovery Tax Act of 1981 on a temporary basis. It has been extended and modified several times and was last renewed through 31 December 2013 by the American Taxpayer Relief Act of 2012.[*] The credit is designed to apply to incremental amounts beyond recent research activity by a business. In particular, the regular research tax credit applies to 20% of qualified research expenses beyond a base.[†] The efficiency of the credit, how much a dollar worth of credit generates research activities beyond what otherwise would occur, depends on the effective credit (after limitations in overall business credits and other adjustments to the statutory credit are taken into account for a given taxpayer) and how sensitive R&D is to business costs. For an overview and methodologies to estimate the effectiveness of the R&E credit, see Guenther (2013) and Hall (1995).

Research tax credit claims fell 6.4% to $7.8 billion in 2009 from $8.3 billion in 2008, whereas corporate tax returns claiming the credit dropped 3% to 12,359 filers (appendix tables 4-21 and 4-22), based on estimates from Statistics of Income/Internal Revenue Service (IRS). The reported reduction in credit activity is consistent with the 3.3% decline in company-funded domestic R&D over the same period (appendix table 4-15). R&E credit claims relative to company-funded domestic R&D have fluctuated rather narrowly between 3.0% and 3.5% since 2001 (3.5% in 2009).

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[*] See Internal Revenue Code (IRC) Section 41(a)(1). P.L. 112-240, Section 301. The 2012 Act retroactively extended the research tax credit from 1 January 2012 through 31 December 2013.

[†] For the regular credit, the base amount is a multiyear average of research intensity (research relative to gross receipts) up to a maximum of 50% of current research spending. Variations include the alternative simplified credit and the alternative incremental R&E tax credit (AIRC; IRC Section 41(c)(4)), in place for 1996–2008 tax years (Guenther 2013). See also IRS form 6765 at http://www.irs.gov/pub/irs-pdf/f6765.pdf.

More generally, the $294.1 billion in 2011 U.S. business R&D performance can be partitioned in four major funding and location sources (table 4-7). The largest of these four components, $235.4 billion (80% percent), was funded by U.S.-located, within-company sources. Domestic external sources funded another $43.1 billion (15%). The bottom left row in figure 4-14 shows the distribution of these external domestic sources, the largest of which is the federal government. Overall, $278.6 billion (95%) of domestic business R&D performance was funded by U.S.-located sources in 2011, as summarized in the left panels of figure 4-14.

The remainder, $15.5 billion (5%), was funded by sources from abroad as shown in the right panels of figure 4-14. These sources may be classified by ownership or affiliation, namely, subsidiaries abroad owned by U.S.-located companies, foreign parents of U.S.-located companies, or independent foreign sources (primarily companies).

Table 4-8 provides further detail on 2011 funding from abroad for selected industries by affiliation and type of organization (for-profit companies, foreign governments, and others, including foreign universities). Virtually all of the $15.5 billion in funding from abroad for domestic business R&D performance came from other companies. About half (48%) came from foreign parent companies, 29% came from foreign independent companies, and 22% came from company-owned units abroad (see also appendix tables 4-17 and 4-19).

The top five industries received $12.4 billion, or 80%, of total funding from abroad in 2011, about the same share of these industries in total domestic performance (81%). However, chemicals (including its pharmaceuticals and

Table 4-7
Funding sources for domestic business R&D performed: 2011
(Millions of U.S. dollars)

Geographic source	Within company	Outside company	All sources
All locations	238,768	55,324	294,093
United States	235,427	43,123	278,550
Outside United States	3,342	12,199	15,543

NOTE: Detail may not add to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2011).

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medicines component) and PST services (including its scientific R&D services component) accounted for a larger share in funding from abroad compared with their share in total domestic R&D performance.

At the same time, sources of funding from abroad differ considerably for pharmaceuticals and scientific R&D services. Over half ($1.0 billion or 55%) of funding from abroad for scientific R&D services companies came from foreign independent companies, with the balance coming almost exclusively from foreign parents ($809 million or 43%) (table 4-8). For pharmaceuticals, affiliated sources dominated funding from abroad (26% from subsidiaries located abroad and 39% from foreign parents), based on BRDIS statistics, consistent with the high level of outward and inward foreign direct investment (FDI) in R&D in this industry discussed later in this chapter. Foreign independent companies accounted for a third (34%) of funding from abroad for this industry.

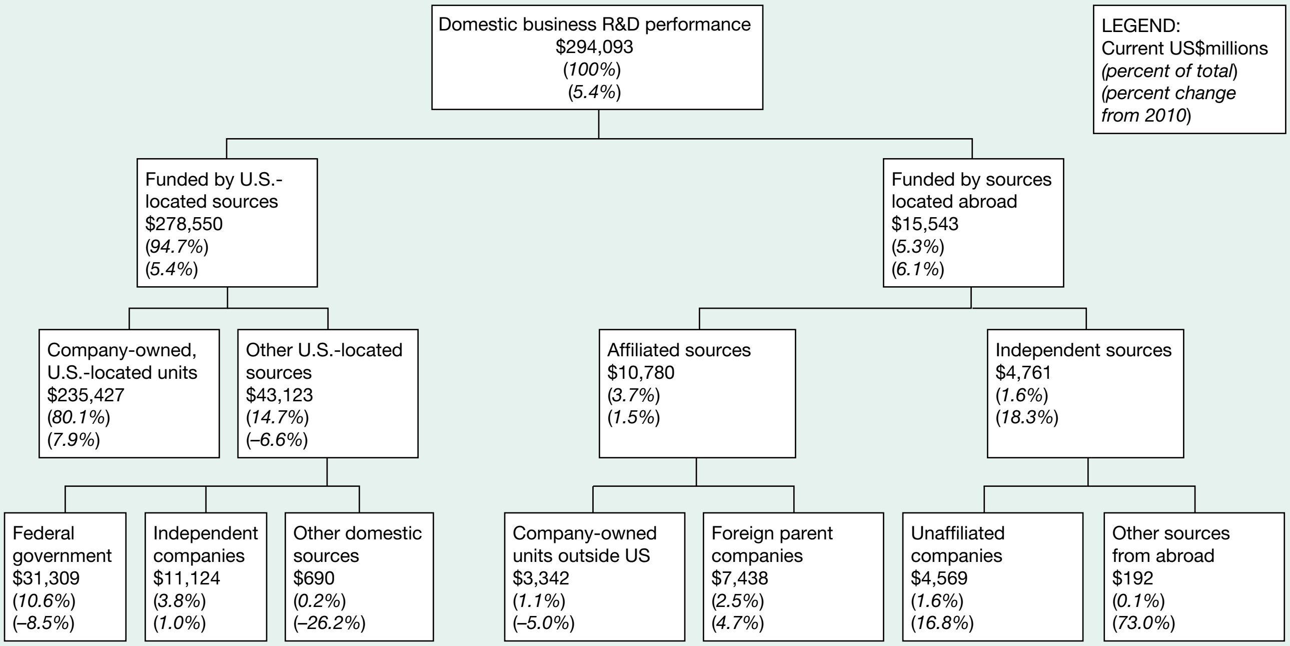
Business Activities for Domestic R&D

Data at the industry level presented above are obtained by classifying a company's total R&D into a single industry, even if R&D activities occur in multiple lines of business. For example, if a company has $100 million in R&D expenses—$80 million in pharmaceuticals and $20 million in medical devices—the total R&D expense of $100 million will be assigned to the pharmaceuticals industry because this is the largest component of its R&D expense (Shackelford 2012). In addition to collecting data by the main industry classification, BRDIS collects data by lines of business most closely related to R&D expense. Codes for line of business are collected at a rather fine level of detail, as indicated in appendix table 4-20. However, most companies performed R&D in only one business activity area. In 2010, 86% of companies reported domestic R&D performed by and paid for by the company related to only one business activity. See Shackelford (2012) for an in-depth analysis of the relationship between business codes and industry codes.

R&D by Multinational Companies

The spread of R&D by MNCs reflects a number of trends in international production and innovation. Among these are the need to strengthen or complement internal technological capabilities, increased complexity of global supply-chains in R&D-intensive sectors, and improved scientific and technological resources across the globe (Moncada-Paternò-Castello, Vivarelli, and Voigt 2011; OECD 2008). R&D associated with FDI, the ownership or control of a business (affiliate) in another country, represents another dimension of the international character of knowledge creation and exploitation. Direct investment is defined as ownership or control of 10% or more of the voting securities of a business

Figure 4-14
Domestic and international funding sources for U.S. business R&D performance, by type of source: 2011



NOTE: Detail may not add to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D Innovation Survey (2010 and 2011).

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(affiliate) in another country. This section covers statistics collected by BEA on R&D performed by majority-owned affiliates (those owned more than 50% by their parent companies) of foreign MNCs located in the United States and on R&D performed by U.S. MNCs and their majority-owned foreign affiliates.[13]

Between 2000 and 2010, U.S. R&D performed by members of MNCs grew faster than R&D in the U.S. business sector as a whole. Over this period, R&D performed by all U.S.-located businesses grew at an average annual rate of 1.1% in constant dollars. R&D performed in the United States by affiliates of foreign MNCs grew at an average annual rate of 2.3% in constant dollars. R&D performed in the United States by parents of U.S. MNCs also grew at an average annual rate of 2.3% in constant dollars over the same 2000–10 period.[14]

In 2010, parent companies performed $212.5 billion ($191.5 billion in constant dollars) or 76% of U.S. business R&D—higher than their 68% share in 2000. U.S. affiliates of foreign MNCs performed about 15% of U.S. business R&D in 2010, compared with 11% in 2000.[15] The rest of this section looks at changes in recent years (in current dollars) See appendix tables 4-23–4-30.

U.S. Affiliates of Foreign Companies

Affiliates of foreign MNCs located in the United States (U.S. affiliates) performed $41.3 billion of R&D in 2010, up 2.1% after little change in 2009 and 2008 (appendix table 4-23). R&D by these companies has accounted for 14%–15% of U.S. business R&D performance since 2007, according to BEA and NSF statistics. Year-to-year movements in U.S. affiliates' R&D activity reflect a combination of changes in foreign ownership of existing U.S.-located firms, the establishment of new R&D-performing companies by foreign investors, and variations in R&D strategies and resources by firms that are foreign owned in consecutive years.

In 2010, three-fourths of R&D by U.S. affiliates of foreign MNCs was performed by firms owned by parent companies based in five countries: Switzerland (22.0%), the United Kingdom (14.5%), Germany (13.8%), France (12.7%), and Japan (12.4%) (table 4-9; appendix table 4-23).

Table 4-8

Domestic business R&D performance and funding from abroad for selected industries: 2011

(Millions of U.S. dollars)

	Domestic business R&D performance		Funding from abroad							Funding from abroad as share of domestic business R&D (%)
Industry	Total	Percent	Total	Percent	Subsidiaries[a]	Foreign parent companies	Unaffiliated companies	Foreign governments	All other funding from abroad	
All industries	294,093	100.0	15,543	100.0	3,342	7,438	4,569	63	129	5.3
Manufacturing industries	201,361	68.5	11,497	74.0	2,527	5,871	2,999	46	54	5.7
Chemicals	55,324	18.8	5,229	33.6	1,354	2,209	1,658	0	8	9.5
Pharmaceuticals and medicines	45,949	15.6	4,717	30.3	1,235	1,848	1,626	0	8	10.3
Computer and electronic products	62,704	21.3	3,291	21.2	521	1,735	991	D	D	5.2
Transportation equipment	40,880	13.9	857	5.5	D	D	D	D	7	2.1
Nonmanufacturing industries	92,731	31.5	4,046	26.0	815	1,568	1,570	17	76	4.4
Information	41,865	14.2	565	3.6	D	D	D	D	*	1.3
PST services	38,219	13.0	2,489	16.0	201	1,038	1,175	17	58	6.5
Scientific R&D services	15,301	5.2	1,862	12.0	0	809	1,024	2	27	12.2

* = less than $500,000; D = data withheld to avoid disclosing operations of individual companies.

PST = professional, scientific, and technical.

[a] In the table, subsidiaries are company-owned units located outside the United States. Although all estimates include an adjustment to the weight to account for unit nonresponse, the estimates for domestic R&D paid by subsidiaries abroad do not include item imputation. Caution should be used when comparing the subsidiaries' estimates to other estimates presented in the table.

NOTES: Detail may not add to total due to rounding. Industry classification is based on the dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used for sampling was assigned. Statistics pertain to companies located in the United States that performed or funded R&D.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2011).

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Manufacturing U.S. affiliates performed 70% or more of U.S. affiliates R&D since 2006 (appendix tables 4-24 and 4-25). The R&D intensity (R&D divided by value added) of manufacturing U.S. affiliates was 6.4% in 2010—little changed since 2007.[16] R&D by affiliates classified in pharmaceuticals increased by 4% to $15.1 billion in 2010. This industry has accounted for at least a third of U.S. affiliates R&D since 2006 and has the highest R&D intensity (32.2% in 2010) among the largest R&D-performing industries within U.S. affiliates. Other manufacturing industries posting increases in R&D performance include computers and electronic products (8.7%) and electrical equipment, appliances, and components (8.9%). On the other hand, transportation equipment R&D was flat in 2010 after double-digit declines in 2009 and 2008, in part associated with changes in foreign ownership within the industry. Within nonmanufacturing industries, affiliates in information services increased R&D performance by 11.2% in 2010, whereas PST services R&D declined by 6.8%.

U.S. MNCs' Parent Companies and Their Foreign Affiliates

Parent companies of U.S. MNCs performed $212.5 billion of R&D in the United States, based on preliminary 2010 data from BEA (appendix table 4-30).[17] Their majority-owned foreign affiliates (MOFAs) performed $39.5 billion (appendix table 4-26). (The latter was essentially flat after declining 6.0% in 2009, the first such decline since 2001). Thus, U.S. MNCs (U.S. parent companies and their MOFAs) performed $252.0 billion in R&D globally in 2010. From 2000 to 2010, global R&D by U.S. MNCs grew at an average annual rate of 2.6% in constant dollars. R&D performed overseas by MOFAs grew at a 4.4% annual rate in constant dollars, compared with a 2.3% annual rate by U.S. parents on the same basis. However, parent companies still perform over 80% of U.S. MNCs R&D in the United States (84% in 2010 compared with 88% in 2000). The rest of this section focuses on recent trends in geographic and industrial focus of MOFA R&D in current dollars (see appendix tables 4-26–4-28).

European host countries accounted for 62% of U.S. MOFA R&D in 2010, down from 66% in 2007 (table 4-10; appendix table 4-26). At the same time, Germany and the United Kingdom remain by far the largest hosts of U.S.-owned R&D with at least $6 billion each. Another 5 of the 13 countries with at least $1 billion in U.S. MOFA R&D in 2010 are in Europe (table 4-11). The shares of R&D performed by U.S. MOFAs in Canada and Japan—traditional locations for U.S. FDI and R&D along with Europe—have declined from 7.9% to 7.0% and from 5.6% to 4.8%, respectively, from 2007 to 2010.

On the other hand, the shares of R&D activities by affiliates in other regions are increasing. The region of Asia-Pacific, excluding Japan, accounted for a record 16.3% of U.S. MOFA R&D in 2010. The Middle East and Latin America each accounted for about 5% in 2010, up from 3.0% and 3.4%, respectively, in 2007. Within these emerging regions for U.S.-owned R&D, China, India, Brazil, and Israel accounted for the largest shares.

U.S. MOFA R&D performance in China more than doubled in current dollars from 2005 to 2008, with year-to-year double-digit increases to a record $1.7 billion in 2008.

Table 4-9

R&D performed by majority-owned affiliates of foreign companies in the United States, by selected industry of affiliate and investor country: 2010

(Millions of current U.S. dollars)

		Manufacturing						Nonmanufacturing		
Country	All industries	Total	Chemicals	Machinery	Computer, electronic products	Electrical equipment, appliances, components	Transportation equipment	Wholesale trade	Information	Professional, scientific, technical services
All countries	41,272	29,894	16,638	2,509	4,731	621	2,306	6,035	1,870	2,843
Canada	575	314	1	9	D	1	211	106	49	84
France	5,248	4,064	1,360	D	1,891	225	71	145	D	74
Germany	5,679	4,731	2,099	D	106	18	907	338	D	79
Japan	5,112	1,842	713	117	479	47	287	2,302	194	669
Netherlands	1,910	1,592	169	D	D	5	D	D	3	26
Switzerland	9,086	7,676	7,103	40	D	D	6	D	2	1,019
United Kingdom	5,975	5,621	4,046	45	282	D	425	102	111	137
Other	7,687	4,054	1,146	633	957	193	D	2,546	134	755

D = suppressed to avoid disclosure of confidential information.

NOTES: Preliminary 2010 estimates are for majority-owned (> 50%) affiliates of foreign companies by country of ultimate beneficial owner and industry of affiliate. Includes R&D conducted by foreign affiliates, whether for themselves or others under contract; excludes R&D conducted by others for affiliates.

SOURCE: Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States (annual series), http://www.bea.gov/international, accessed January 2013.

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Table 4-10

R&D performed abroad by majority-owned foreign affiliates of U.S. parent companies, by selected industry of affiliate and host region/country/economy: 2010

(Millions of current U.S. dollars)

Region/country/ economy	All industries	Total	Chemicals	Machinery	Computer, electronic products	Electrical equipment, appliances, components	Transportation equipment	Wholesale trade	Information	Professional, scientific, technical services
All countries	39,470	27,571	8,532	1,448	6,030	703	7,584	1,975	2,018	7,759
Canada	2,749	1,449	434	26	286	D	535	174	311	806
Europe	24,406	18,208	6,351	963	2,997	376	5,047	1,379	865	3,855
Austria	277	D	21	111	8	23	4	6	0	D
Belgium	2,116	D	D	15	9	D	D	D	*	321
Czech Republic	68	D	9	6	D	0	9	D	0	2
Denmark	196	D	D	8	63	*	0	D	3	2
Finland	221	D	12	D	D	4	2	2	0	D
France	1,984	1,783	410	96	575	D	347	83	41	73
Germany	6,713	5,505	341	275	1,017	190	3,162	568	48	552
Greece	27	26	22	0	*	0	0	1	0	*
Hungary	65	30	5	2	*	2	D	3	0	31
Ireland	1,431	1,045	585	*	283	0	2	3	297	D
Italy	589	401	187	76	29	4	52	8	2	176
Luxembourg	D	D	D	0	0	0	0	1	*	D
Netherlands	1,290	1,074	701	28	41	D	D	10	52	151
Norway	137	D	3	D	38	0	0	*	D	2
Poland	136	62	7	1	1	*	45	1	2	71
Portugal	56	D	29	1	1	1	D	1	D	*
Russia	65	D	5	0	1	0	2	6	*	D
Spain	607	545	146	3	D	10	92	D	0	D
Sweden	520	334	52	49	D	4	D	4	D	D
Switzerland	1,558	935	460	56	185	17	D	259	D	D
Turkey	53	50	31	*	0	0	14	1	1	1
United Kingdom	5,905	3,736	1,695	191	323	28	984	D	183	1,778
Other	D	D	D	2	1	1	14	2	0	28
Latin America and OWH	1,949	1,725	356	D	96	D	1,030	D	D	142
Argentina	115	73	47	D	D	0	9	1	0	D
Brazil	1,372	1,281	215	51	77	1	D	22	D	33
Mexico	338	305	D	4	D	D	D	2	*	31
Africa	88	D	23	1	*	0	9	4	0	D
South Africa	74	D	23	*	0	0	6	3	0	D
Middle East	1,965	D	50	D	640	0	0	D	D	D
Israel	1,948	D	47	D	640	0	0	D	D	950
Asia and Pacific	8,313	5,290	1,319	275	2,011	275	962	289	765	1,955
Australia	767	560	162	12	D	D	D	28	4	170
China	1,452	D	101	41	348	109	55	9	D	443
Hong Kong	153	104	12	0	86	5	0	6	6	37
India	1,644	446	83	D	231	6	73	D	D	778
Indonesia	28	D	2	0	0	0	*	*	0	D
Japan	1,885	1,576	808	152	300	D	74	57	D	D
Malaysia	376	337	2	*	320	*	0	2	0	37
New Zealand	21	18	2	1	*	5	0	1	0	2
Philippines	55	D	4	0	18	*	1	*	0	D
Singapore	753	514	67	D	424	8	12	12	18	206
South Korea	835	780	49	19	166	0	D	D	D	27
Taiwan	235	127	21	D	82	D	D	14	D	D
Thailand	106	D	6	4	D	0	8	3	0	D
Other	2	2	*	0	2	0	0	0	0	0

* = ≤ $500,000; D = suppressed to avoid disclosure of confidential information.

OWH = other Western Hemisphere.

NOTES: Preliminary 2010 estimates are for majority-owned (> 50%) affiliates of U.S. parent companies by host country and industry of affiliate. Includes R&D conducted by foreign affiliates, whether for themselves or others under contract; excludes R&D conducted by others for affiliates.

SOURCE: Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad (annual series), http://www.bea.gov/international, accessed January 2013.

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Table 4-11
R&D performed abroad, shares, and R&D intensity of majority-owned foreign affiliates of U.S. parent companies, by selected host country: 2007 and 2010

	R&D performed (US$millions)		R&D performed shares (%)		R&D/value added ratio (%)	
Country	2007	2010	2007	2010	2007	2010
Total	34,446	39,470	100.0	100.0	3.1	3.2
Germany	6,403	6,713	18.6	17.0	7.2	8.0
United Kingdom	6,000	5,905	17.4	15.0	3.6	3.9
Canada	2,712	2,749	7.9	7.0	2.3	2.1
Belgium	1,191	2,116	3.5	5.4	5.1	8.6
France	1,557	1,984	4.5	5.0	2.8	4.0
Israel	1,025	1,948	3.0	4.9	22.9	28.0
Japan	1,919	1,885	5.6	4.8	4.8	3.9
India	382	1,644	1.1	4.2	5.2	9.9
Switzerland	1,162	1,558	3.4	3.9	4.4	4.7
China	1,173	1,452	3.4	3.7	5.5	3.9
Ireland	1,510	1,431	4.4	3.6	2.7	2.3
Brazil	607	1,372	1.8	3.5	1.9	3.0
Netherlands	752	1,290	2.2	3.3	2.7	5.4

NOTES: Sorted by 2010 R&D performed. Data are for majority-owned (> 50%) foreign affiliates of U.S. parent companies. Data include R&D expenditures performed by affiliates, whether for themselves or for others under contract. Data exclude R&D expenditures by others for affiliates under contract.

SOURCE: Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad (annual series), http://www.bea.gov/international/index.htm#omc, accessed 14 January 2013.

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This is consistent with increases in total R&D performed in China in recent years and its emergence as the second-largest R&D-performing country (see section, "International Comparisons of R&D Performance"). Single-digit declines in 2009 and 2010 put R&D performed by U.S. MOFAs in China at $1.5 billion in 2010 (appendix table 4-26).

Reported R&D activity by U.S. MOFAs tripled in India and more than doubled in Brazil from 2007 to 2010 in current dollars, growing much faster than U.S. MOFA production activity in those countries measured as value added (thus increasing their R&D intensity measured as the ratio to value added). U.S. MOFA R&D expenditures in Brazil and India are now on par with affiliates in China. Among countries with at least $1 billion in R&D performed by U.S. MOFAs in 2010, U.S. MOFAs located in Israel have the largest R&D intensity (table 4-11).

Three manufacturing industries, chemicals (which includes pharmaceuticals), transportation equipment, and computer and electronic products accounted for 56% of U.S. MOFA R&D in 2010. Overall, affiliates classified in manufacturing accounted for 70%. The largest R&D-performing nonmanufacturing industries were information services and PST services (table 4-10; appendix table 4-28).

In spite of the relative decline in the share of traditional locations such as Europe as a whole and Japan, they remain the top R&D hosts for U.S. MNCs in major industries, reflecting both strengths of host countries in certain technologies and the large R&D stocks by U.S. MNCs in these locations.

Germany is by far the largest location of U.S. MOFA R&D in transportation equipment ($3.2 billion of $7.6 billion in this industry by U.S. MOFAs globally) and in computers and electronic products manufacturing ($1.0 billion out of $6.0 billion by U.S. MOFAs globally). The United Kingdom is the top location in chemicals manufacturing R&D and in PST services R&D by U.S. MOFAs. Japan is the second-largest host for R&D performed by U.S. MOFAs classified in chemicals manufacturing.

On the other hand, among MOFAs classified in PST services, India has emerged as the second-largest host country for U.S.-owned R&D performance after the United Kingdom ($0.8 billion compared with the United Kingdom's $1.8 billion), based on available preliminary 2010 country-industry details from BEA (table 4-10).

Cross-National Comparisons of Business R&D

This section compares business R&D across OECD countries across two dimensions: the distribution of business R&D across industries and the role of affiliates of foreign MNCs.

Companies classified in manufacturing perform most business R&D in the top seven R&D-performing countries, with shares ranging from 89% in Germany to 69% in the United States, based on OECD's Analytical Business Enterprise R&D (ANBERD) database (see table 4-12).[18] These countries, however, differ in terms of the focus of their business R&D.

Pharmaceuticals manufacturing is the largest business R&D sector in the United Kingdom (28% of United Kingdom business enterprise R&D) and in the United States (16% of U.S. business enterprise R&D). Motor vehicles R&D has the largest share in Germany (33%). R&D in radio, television, and communication equipment manufacturing,

Table 4-12
Share of manufacturing and nonmanufacturing in business R&D, by selected country: 2010 or most recent year
(Percent)

Country	Manufacturing	Nonmanufacturing
Germany (2008)	89.0	11.0
South Korea (2010)	87.7	12.3
Japan (2010)	87.1	12.9
China (2009)	84.0	16.0
France (2007)	83.6	16.4
United Kingdom (2009)	73.9	26.1
United States (2009)	69.3	30.7

NOTES: Industry classifications for France and South Korea are based on product field. For all other countries, data are based on main activity.

SOURCE: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D (ANBERD) Statistical Analysis Database (STAN), R&D Expenditures in Industry, http://stats.oecd.org/Index.aspx?DataSetCode=ANBERD2011_REV3, accessed 7 February 2013.

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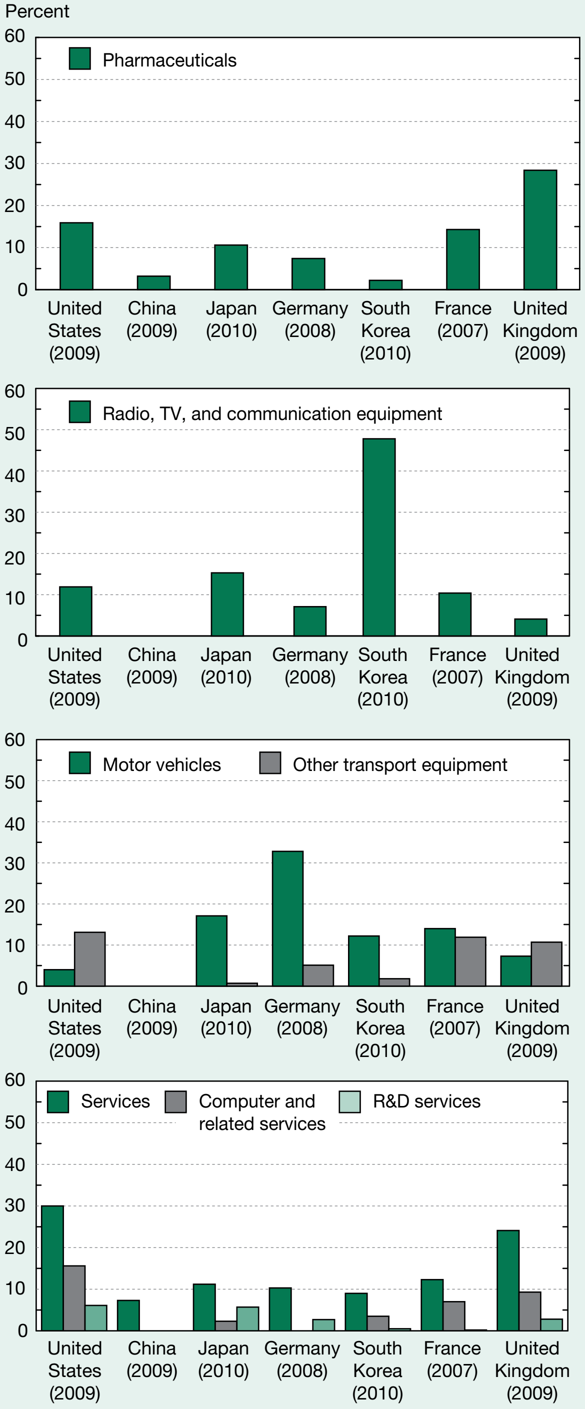
which includes semiconductor devices, accounts for close to half (48%) of South Korea's business enterprise R&D (figure 4-15).

Business R&D in other transportation equipment (appendix table 4-31), which includes commercial and defense-related aerospace and spacecraft, has the highest shares in the United States (13%), France (12%), and the United Kingdom (11%).[19] These three countries also report the largest proportion of defense R&D within government budget appropriations or outlays for R&D (GBAORD) (table 4-15) discussed elsewhere in this chapter. In addition, France and the United Kingdom host 17 of the top 25 EU R&D-performing companies classified in the related category of aerospace and defense, according to the 2012 EU Scoreboard (EC 2012).

R&D in services industries (the main R&D performing component in nonmanufacturing) had the largest share in the United States (30%) and the lowest share in China (7%), based on the most recent comparable industry-level ANBERD data. Within services, computer and related services accounted for the largest share in the United States and the United Kingdom (figure 4-15; appendix table 4-31).

R&D performed within a country by affiliates of foreign MNCs represented more than half of business enterprise R&D in smaller OECD countries such as Belgium, Ireland, Israel, and several Eastern and Central European countries in 2009 (figure 4-16). Japan, the second-largest business R&D performer among countries reporting foreign-affiliate R&D, had the lowest share (6%), compared with about 14% for the United States.

Figure 4-15
Industry share of business R&D in selected countries: 2010 or most recent year



NOTES: Data for China are not available for all industries. Data are classified according to International Standard Industrial Classification, Revision 3.1, by Organisation for Economic Co-operation and Development source. Data for France and South Korea are based on product field. For all other countries, data are based on main activity.

SOURCE: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D (ANBERD) Statistical Analysis Database (STAN), R&D Expenditures in Industry, http://stats.oecd.org/Index.aspx?DataSetCode=ANBERD2011_REV3, accessed 7 February 2013.

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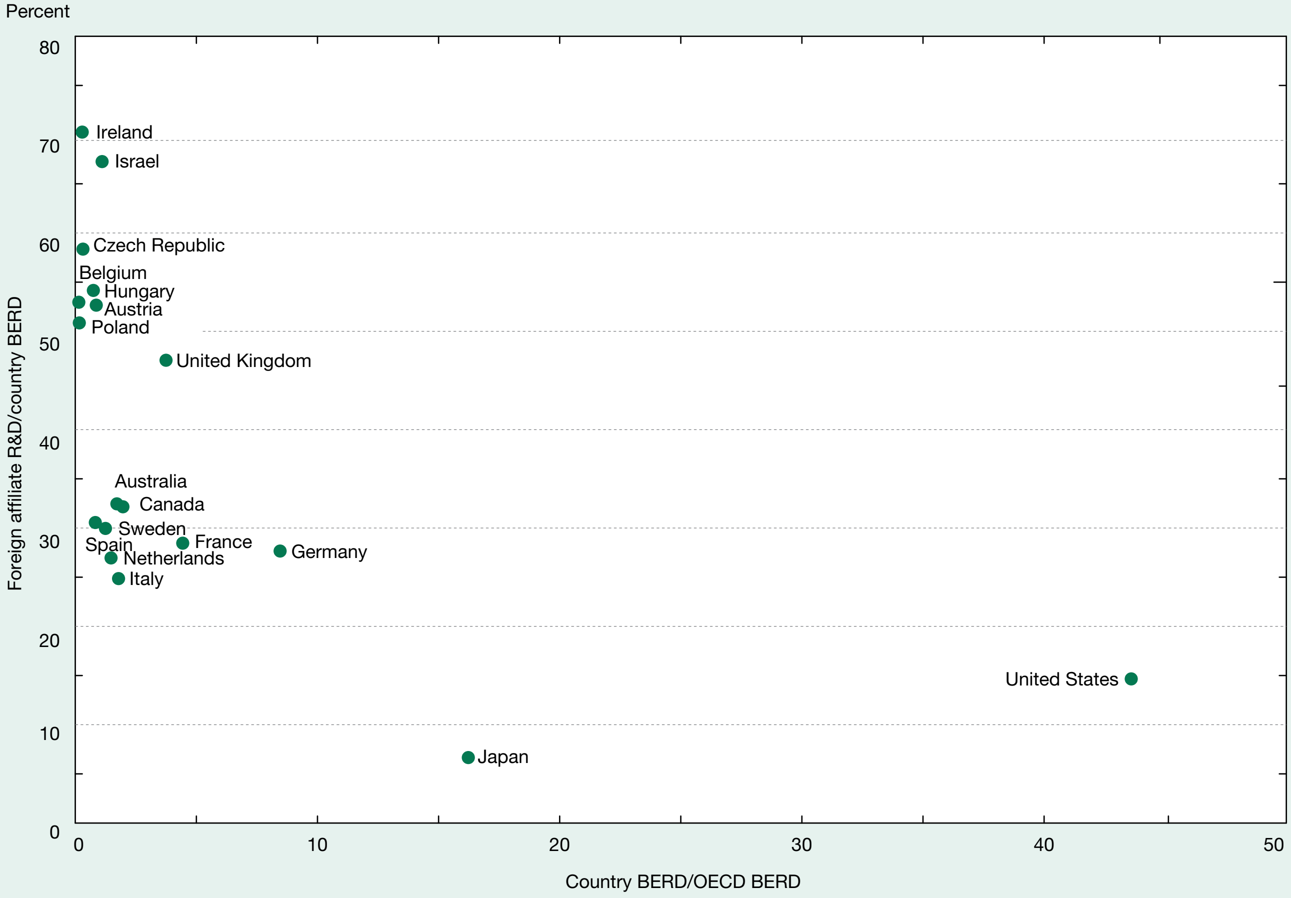
Figure 4-16
Business enterprise R&D and R&D by foreign affiliates, by selected shares: 2009



BERD = Business Enterprise R&D; OECD = Organisation for Economic Co-operation and Development.

SOURCE: OECD, *Main Science and Technology Indicators* (2012/2).

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Federal R&D Performance and Funding

The U.S. government supports and facilitates the nation's R&D system through various policy avenues. The most direct of these are the R&D activities conducted by federal organizations (whether agency intramural laboratories and facilities or FFRDCs) and the funding for R&D provided to other performers (such as businesses and academic institutions).[20] This section provides statistical detail on these federally performed and funded R&D activities—in particular, how the funding has been allocated among differing national objectives, how current federal spending on R&D differs across the agencies, and how the current spending is allocated among differing research fields. The next section compares federal R&D spending priorities with those of national governments in the other major R&D-performing countries. (For definitions of key federal budget terms used in this section, see the sidebar, "Federal Budgetary Concepts and Related Terms.")

Federal R&D Budget, by National Objectives

Federal support for the nation's R&D spans a range of objectives: national defense, health, space, energy, natural resources and environment, general science, and various other categories. The Office of Management and Budget (OMB) classifies agency funding requests into 20 broad categories termed *budget functions* (OMB 2012a). Federal agency R&D activities appear in 15 of these 20 functional categories.[21] While the authority for spending granted to the agencies (termed *budget authority* or *appropriations*) through the federal budget legislation enacted annually by the Congress is not yet actual spending, a look at how this budget authority divides among the various functional categories provides a useful picture of the present priorities and trends in federal support for U.S. R&D.

Budget authority for all spending on R&D by the federal agencies totaled $144.4 billion (current dollars) in FY 2011 (figure 4-17; appendix tables 4-32 and 4-33). In FY 2010, the total was $149.0 billion. It was $164.3 billion in FY 2009—noticeably higher because of the one-time $18.7

billion increase from ARRA.[22] The totals in FYs 2006 and 2001 were $136.0 billion and $91.5 billion, respectively.

Defense-Related R&D

R&D directed at national defense objectives is supported primarily by the Department of Defense (DOD) but also includes some R&D by the Department of Energy (DOE) and the Department of Justice (where some R&D by the Federal Bureau of Investigation comes under a defense category). National defense represented about 58% ($83.2 billion) of the total budget authority for R&D in FY 2011 (appendix table 4-32). It also accounted for 58% in FY 2006 and 51% in FY 2001.

This predominance of national defense R&D goes back many years. In FY 1980, there was rough equivalence between national defense and nondefense R&D. By FY 1985, national defense had become more than twice as large as nondefense, but from 1986 to 2001, nondefense R&D surged, with the national defense share shrinking back to just over half. Following September 11, 2001, however, national defense R&D again increased as a share, accounting for 59% of federal R&D budget authority in FY 2008. The drop to 52% in FY 2009 reflects chiefly an effect of the one-time increase in R&D budget authority from ARRA, primarily targeted at health, energy, and general science research.

Federal Budgetary Concepts and Related Terms

Budget authority. This refers to the funding authority conferred by federal law to incur financial obligations that will result in outlays. The basic forms of budget authority are appropriations, contract authority, and borrowing authority.

Obligations. Federal obligations represent the dollar amounts for orders placed, contracts and grants awarded, services received, and similar transactions during a given period, regardless of when funds were appropriated or payment was required.

Outlays. Federal outlays represent the dollar amounts for checks issued and cash payments made during a given period, regardless of when funds were appropriated or obligated.

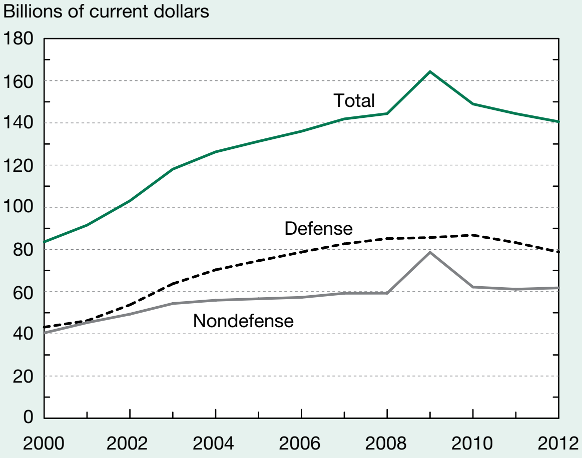
R&D plant. In general, R&D plant refers to the acquisition of, construction of, major repairs to, or alterations in structures, works, equipment, facilities, or land for use in R&D activities. Data included in this section refer to obligated federal dollars for R&D plant.

Nondefense R&D

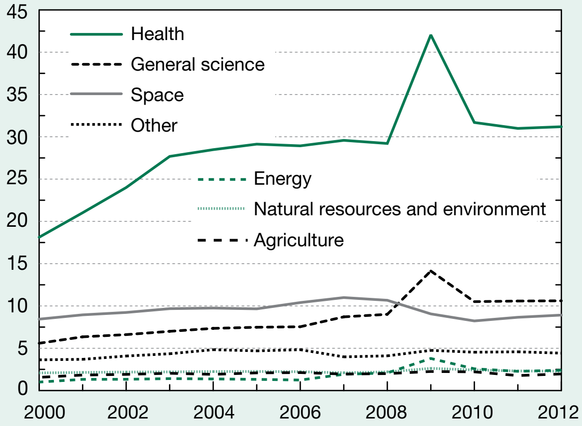
Nondefense R&D spans the other 14 budget function categories, which include activities in the areas of health, space research and technology, energy, general science, natural resources and environment, transportation, agriculture, education, international affairs, veterans benefits, and a number of other small categories related to economic and governance matters. Budget authority for nondefense R&D accounted for 42% ($61.2 billion) in FY 2011 (appendix table 4-32). It was also 42% in FY 2006, but it was just under 50% in FY 2001.

Figure 4-17
Federal budget authority for R&D and R&D plant, by budget function: FYs 2000–12

Budget function



Nondefense budget function



NOTES: Data for FY 2012 are preliminary. Data for FY 2009 include the additional federal funding for R&D appropriated by the American Recovery and Reinvestment Act of 2009. Other includes all nondefense functions not separately graphed: international affairs, commerce and housing credit, transportation, community and regional development, education and training, Medicare, income security, veterans benefits, and administration of justice.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal R&D Funding by Budget Function (FYs 2010–12). See appendix table 4-32.

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The most striking change in federal R&D priorities over the past two decades has been the considerable increase in health-related R&D, which now accounts for just over half of all nondefense R&D (figure 4-17). Health R&D was 12% of total federal R&D budget authority in FY 1980 but rose to 22% in FY 2011. This rise in share jumped after FY 1998, when national policymakers set the National Institutes of Health (NIH) budget on course to double by FY 2003. Health research was also particularly favored by the ARRA increment, rising to 26% of the total R&D budget authority in FY 2009 (appendix table 4-32).

The budget allocation for space-related R&D peaked in the 1960s during the height of the nation's efforts to surpass the Soviet Union in space exploration. It stood at 10%–11% of total R&D budget authority throughout the 1990s. The loss of the Space Shuttle *Columbia* and its crew in February 2003 prompted curtailment of manned space missions. In FY 2006, the space R&D share was down to about 8%; it was 6% in FY 2011.

Nondefense federal R&D classified as general science had about a 4% share of total federal R&D in the mid-1990s, growing to 7% in FY 2011. However, much of this change reflected an important reclassification: starting in FY 1998, several DOE programs were shifted from the energy category to general science.

Federal Spending on R&D, by Agency

Fifteen federal departments and a dozen other agencies engage in and/or fund R&D in the United States. Nine of these departments/agencies reported R&D spending in excess of $1 billion annually in FY 2011, and these nine accounted for 97% of the total (table 4-13; appendix table 4-35). Another six of the departments/agencies reported spending above $100 million annually.

(The budget figures reported in this section are in *obligations*. For the distribution of federal R&D across the agencies, data on spending in *obligations* terms provide the most comprehensive and consistent account. *Budget authority*, as discussed earlier, lays out the themes of the broad federal spending plan. Spending *obligations* reflect federal dollars as they are spent, that is, the implementation of the plan by federal agencies. Because planning and actual spending are different steps, the reported statistics on R&D in obligations

Table 4-13
Federal obligations for R&D and R&D plant, by agency and performer: FY 2011
(Millions of dollars)

				Total by performers			
Agency	Total	R&D	R&D plant	Intramural and FFRDCs	Percent of total	Extramural performers	Percent of total
All agencies	136,418.1	132,140.6	4,277.4	44,196.3	32.4	92,221.7	67.6
Department of Defense	71,842.3	71,684.2	158.1	22,268.8	31.0	49,573.5	69.0
Department of Health and Human Services	31,766.3	31,573.7	192.6	6,200.1	19.5	25,566.2	80.5
Department of Energy	9,923.2	9,136.2	786.9	7,516.7	75.7	2,406.5	24.3
National Aeronautics and Space Administration	8,429.0	6,570.5	1,858.5	2,070.2	24.6	6,358.7	75.4
National Science Foundation	5,373.3	4,924.4	448.9	350.6	6.5	5,022.6	93.5
Department of Agriculture	2,634.6	2,591.3	43.3	1,657.2	62.9	977.4	37.1
Department of Commerce	1,419.7	1,135.5	284.2	1,011.3	71.2	408.3	28.8
Department of Homeland Security	1,051.1	634.7	416.4	667.5	63.5	383.6	36.5
Department of Transportation	1,021.2	997.0	24.2	349.2	34.2	671.9	65.8
Department of the Interior	694.8	688.6	6.3	571.5	82.2	123.4	17.8
Department of Veterans Affairs	579.0	579.0	0.0	579.0	100.0	0.0	0.0
Environmental Protection Agency	577.0	577.0	0.0	464.9	80.6	112.1	19.4
Department of Education	346.3	346.3	0.0	19.1	5.5	327.3	94.5
Smithsonian Institution	227.0	169.0	58.0	227.0	100.0	0.0	0.0
Department of Justice	101.0	101.0	0.0	27.9	27.6	73.1	72.4
All other agencies	432.3	432.3	0.0	215.3	49.8	217.0	50.2

FFRDC = federally funded R&D center.

NOTES: The table lists all agencies with R&D obligations greater than $100 million in FY 2011. R&D is basic research, applied research, and development and does not include R&D plant. Intramural activities include actual intramural R&D performance and costs associated with planning and administration of both intramural and extramural programs by federal personnel. Extramural performers includes federally funded R&D performed in the United States and U.S. territories by businesses, universities and colleges, other nonprofit institutions, state and local governments, and foreign organizations. All other agencies includes Department of Housing and Urban Development, Department of Labor, Department of State, Department of Treasury, Agency for International Development, Appalachian Regional Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Administration, Nuclear Regulatory Commission, and Social Security Administration.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, *Federal Funds for Research and Development* (FYs 2010–12). See appendix table 4-35.

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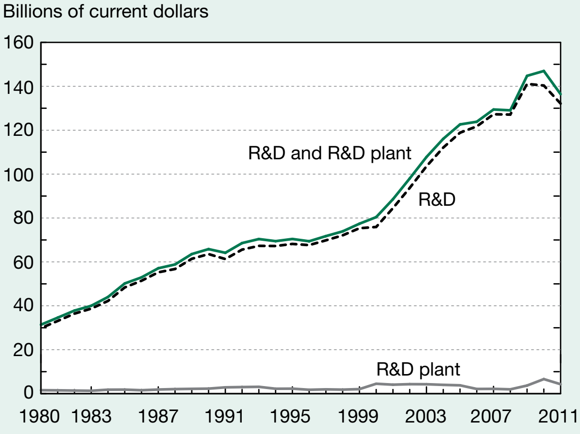
typically differ from the corresponding items in budget authority terms.)

In FY 2011, federal obligations for R&D and R&D plant together totaled $136.4 billion: $132.1 billion for R&D and an additional $4.3 billion for R&D plant (table 4-13). The corresponding figures for FY 2010 were $147.0 billion in total, $140.4 billion for R&D, and $6.6 billion for R&D plant; for FY 2009, they were $144.8 billion in total, $141.1 billion for R&D, and $3.7 billion for R&D plant (appendix table 4-34). Federal obligations for R&D increased annually on both a current and constant dollar basis from the late 1990s through FY 2010 (figure 4-18; appendix table 4-34). The FY 2011 drop in funding was a noticeable departure from this trend.

(The corresponding figures for federal funding of U.S. R&D cited in table 4-1 earlier in this chapter are lower. The table 4-1 figures are based on performers' reports of their R&D expenditures from federal funds. This difference between performer and source of funding reports of the level of R&D expenditures has been present in the U.S. data for more than 15 years and reflects various technical issues. For a discussion, see the sidebar, "Tracking R&D: The Gap between Performer- and Source-Reported Expenditures.")

The nine departments/agencies that account presently for almost all federal R&D differ widely in the balance of R&D performed and/or funded among intramural laboratories, FFRDCs, and various extramural performers (including private businesses, universities and colleges, other nonprofit organizations, state and local governments, and foreign organizations). There are also significant differences in the character-of-work profiles, that is, the balances among the basic research, applied research, and development conducted.

Figure 4-18
Federal obligations for R&D and R&D plant: FYs 1980–2011



NOTE: Data for FYs 2009 and 2010 include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (annual series). See appendix table 4-34.

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Department of Defense

In FY 2010, DOD obligated a total of $71.8 billion for R&D and R&D plant (table 4-13), which represented a little over half (53%) of all federal spending on R&D and R&D plant that year. Nearly the entire DOD total was R&D spending ($71.7 billion), with the remainder spent on R&D plant.

Thirty-one percent ($22.3 billion) of the total was spending by the department's intramural labs, related agency R&D program activities, and FFRDCs (table 4-13). Extramural performers accounted for 69% ($49.6 billion) of the obligations, with the bulk going to business firms ($46.6 billion; appendix table 4-35).

Considering just the R&D component, relatively small amounts were spent on basic research ($1.9 billion, 3%) and applied research ($4.7 billion, 7%) in FY 2011 (table 4-14). The vast majority of obligations, $65.1 billion (91%), went to development. Furthermore, the bulk of this DOD development ($59.0 billion) was allocated for major systems development, which includes the main activities in developing, testing, and evaluating combat systems (figure 4-19). The remaining DOD development ($6.1 billion) was allocated for advanced technology development, which is more similar to other agencies' development obligations.

Department of Health and Human Services

The Department of Health and Human Services (HHS) is the main federal source of spending for health-related R&D. In FY 2011, the department obligated $31.8 billion for R&D and R&D plant, or 23% of the total of federal obligations that year (appendix table 4-35). Nearly all of this was for R&D ($31.6 billion). Furthermore, much of the total, $29.9 billion, represented the R&D activities of NIH.

For the department as a whole, R&D and R&D plant obligations for agency intramural activities and FFRDCs accounted for 20% ($6.2 billion) of the total. Extramural performers accounted for 81% ($25.6 billion). Universities and colleges ($18.3 billion) and other nonprofit organizations ($4.9 billion) conducted the most sizable of these extramural activities (appendix table 4-35).

Nearly all of HHS R&D funding is allocated to research: 51% for basic research and 49% for applied research (table 4-14).

Department of Energy

DOE obligated $9.9 billion for R&D and R&D plant in FY 2011, about 8% of the total of federal obligations that year. Of this amount, $9.1 billion was for R&D and $0.8 billion was for R&D plant.

The department's intramural laboratories and FFRDCs accounted for 76% of the total obligations. Many of DOE's

Tracking R&D: The Gap between Performer- and Source-Reported Expenditures

In the United States—and in some other Organisation for Economic Co-operation and Development (OECD) countries—the figures for total government support of R&D reported by government agencies differ from those reported by the performers of R&D. In keeping with international guidance and standards, most countries provide totals and time series of national R&D expenditures based primarily on data reported by R&D performers (OECD 2002). Differences between the data provided by funders and that provided by performers can arise for numerous reasons, such as the different calendars for reporting government obligations (fiscal years) and performance expenditures (calendar years). In the United States, there has been a sizable gap between performer and funder data for federal R&D over the past two decades.

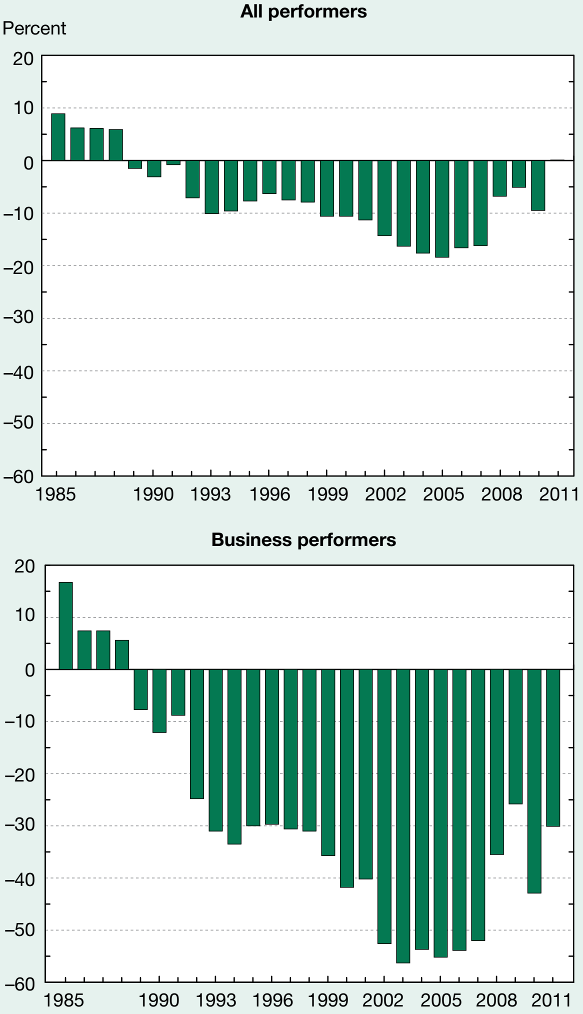
In the mid-1980s, performer-reported federal R&D in the United States exceeded federal reports of funding by $3 billion to $4 billion annually (5%–10% of the government total). This pattern reversed itself, however, at the end of the decade: in 1989, the government-reported R&D total exceeded performer reports by almost $1 billion. The government-reported excess increased noticeably from then to 2007, when federal agencies reported obligating $127 billion in total R&D to all R&D performers ($55 billion to the business sector), compared with $107 billion in federal funding reported by the performers of R&D ($27 billion by businesses). In other words, the business-reported total was some 50% less than the federally reported R&D support to industry in FY 2007 (figure 4-A; appendix table 4-36). These differences in federal R&D totals were seen primarily in DOD funding of development activities by industry. The figures for 2008–11 suggest a narrowing of the federal agency reporting excess, but they are primarily the result of a manual imputation procedure for business R&D performers in these years.

Several investigations into the possible causes for the data gap have produced insights but no conclusive explanation. A General Accounting Office investigation made the following assessment:

> Because the gap is the result of comparing two dissimilar types of financial data [federal obligations and performer expenditures], it does not necessarily reflect poor quality data, nor does it reflect whether performers are receiving or spending all the federal R&D funds obligated to them. Thus, even if the data collection and reporting issues were addressed, a gap would still exist. (GAO 2001:2)

Echoing this assessment, the National Research Council (NRC 2005) noted that comparing federal outlays for R&D (as opposed to obligations) with performer expenditures results in a smaller discrepancy. (In FY 2007, federal agencies reported total R&D outlays of $109 billion, compared with the performer-related total of $107 billion. In FY 2011, federal agencies reported R&D outlays of $131 billion, compared with the performer-reported total of $134 billion.)

Figure 4-A
Differences in federal R&D support, as reported by performers and federal agencies: 1985–2011



NOTE: Difference is defined as the percentage of federally reported R&D, with a positive difference indicating that performer-reported R&D exceeds agency-reported R&D.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES), National Patterns of R&D Resources (annual series); and NSF/NCSES, Federal Funds for Research and Development (FYs 2010–12). See appendix table 4-36.

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Table 4-14

Federal obligations for R&D, by agency and character of work: FY 2011

(Millions of current dollars)

Agency	Total R&D	Basic research	Applied research	Development	Percent of total R&D: Basic research	Percent of total R&D: Applied research	Percent of total R&D: Development
All agencies	132,140.6	29,060.8	29,105.9	73,973.9	22.0	22.0	56.0
Department of Defense	71,684.2	1,903.9	4,674.3	65,106.1	2.7	6.5	90.8
Department of Health and Human Services	31,573.7	16,123.7	15,316.7	133.3	51.1	48.5	0.4
Department of Energy	9,136.2	3,717.2	3,054.2	2,364.8	40.7	33.4	25.9
National Aeronautics and Space Administration	6,570.5	856.8	717.8	4,995.8	13.0	10.9	76.0
National Science Foundation	4,924.4	4,581.2	343.2	0.0	93.0	7.0	0.0
Department of Agriculture	2,591.3	1,078.8	1,293.4	219.1	41.6	49.9	8.5
Department of Commerce	1,135.5	149.8	839.3	146.4	13.2	73.9	12.9
Department of Transportation	997.0	8.1	704.6	284.2	0.8	70.7	28.5
Department of the Interior	688.6	48.9	564.6	75.1	7.1	82.0	10.9
Department of Homeland Security	634.7	91.2	208.2	335.2	14.4	32.8	52.8
Department of Veterans Affairs	579.0	218.0	314.0	47.0	37.7	54.2	8.1
Environmental Protection Agency	577.0	88.0	403.4	85.6	15.3	69.9	14.8
Department of Education	346.3	7.5	205.6	133.2	2.2	59.4	38.5
Smithsonian Institution	169.0	169.0	0.0	0.0	100.0	0.0	0.0
Department of Justice	101.0	17.5	65.8	17.7	17.3	65.1	17.5
All other agencies	432.2	1.2	400.8	30.4	0.3	92.7	7.0

NOTES: The table lists all agencies with R&D obligations greater than $100 million in FY 2011. Detail may not add to total due to rounding. All other agencies includes Department of Housing and Urban Development, Department of Labor, Department of State, Department of the Treasury, Agency for International Development, Appalachian Regional Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Administration, Nuclear Regulatory Commission, and Social Security Administration.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FYs 2010–12). See appendix table 4-35.

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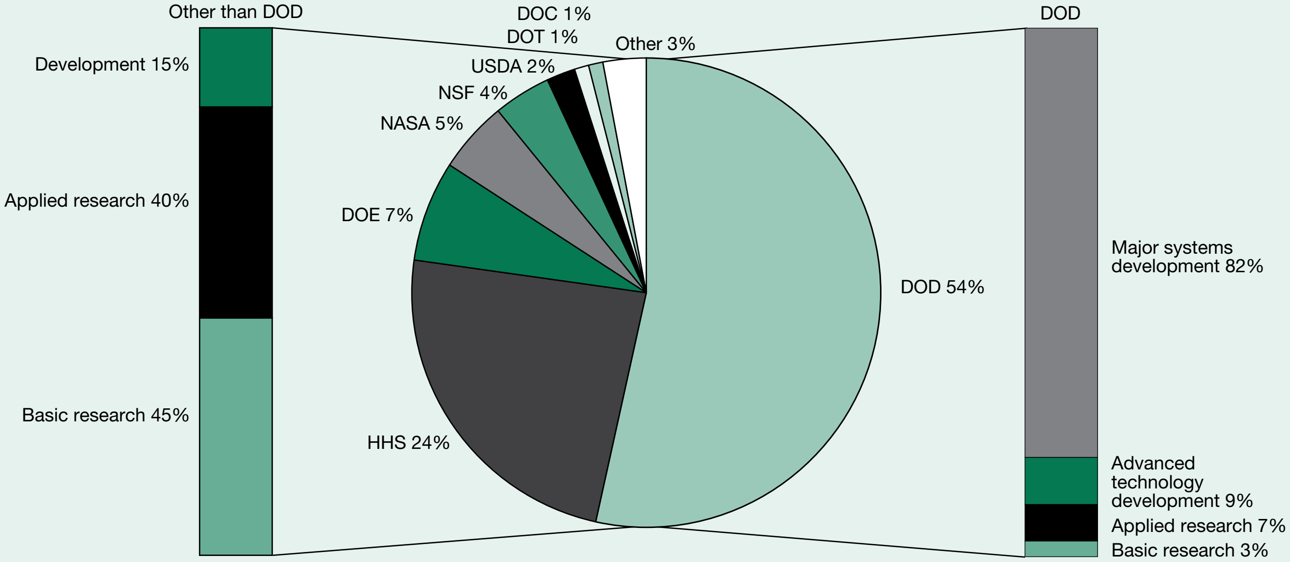
Figure 4-19

Federal obligations for R&D, by agency and character of work: FY 2011



DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; DOT= Department of Transportation; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = U.S. Department of Agriculture.

NOTE: Detail may not add to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FYs 2010–12). See appendix table 4-35.

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research activities require specialized equipment and facilities available only at its intramural laboratories and FFRDCs, which are used by scientists and engineers from other agencies and sectors as well as by DOE researchers. Accordingly, DOE invests more resources in its intramural laboratories and FFRDCs than other federal agencies. The 24% of obligations to extramural performers went chiefly to businesses and universities and colleges.

For the $9.1 billion obligated to R&D, basic research accounted for 41%, applied research accounted for 33%, and development accounted for 26%. DOE R&D activities are distributed among domestic energy systems, defense (much of it funded by the department's National Nuclear Security Administration), and general science (much of which is funded by the department's Office of Science).

National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) obligated $8.4 billion to R&D in FY 2011, 6% of the federal total. Seventy-five percent of these obligations were for extramural R&D, given chiefly to business sector performers. Agency intramural R&D and that by FFRDCs represented 25% of the NASA obligations total. By character of work, 76% of the NASA R&D obligations funded development activities, 13% funded basic research, and 11% funded applied research.

National Science Foundation

NSF obligated $5.4 billion for R&D and R&D plant in FY 2011, or 4% of the federal total. Extramural performers, chiefly universities and colleges ($5.0 billion), represented 94% of this total. Basic research accounted for about 93% of the R&D component. NSF is the federal government's primary source of funding for academic basic science and engineering research and the second-largest federal source (after HHS) of R&D funds for universities and colleges.

Department of Agriculture

The Department of Agriculture (USDA) obligated $2.6 billion for R&D in FY 2011, with the main focus on life sciences. The agency is also one of the largest research funders in the social sciences, particularly agricultural economics. Of USDA's total obligations for FY 2011, about 63% ($1.7 billion) funded R&D by agency intramural performers, chiefly the Agricultural Research Service. Basic research accounts for about 42%, applied research accounts for 50%, and development accounts for 9%.

Department of Commerce

The Department of Commerce (DOC) obligated $1.4 billion for R&D in FY 2011, most of which represented the R&D and R&D plant spending of the National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology. Seventy-one percent of this total was for agency intramural R&D; 29% went to extramural performers, primarily businesses and universities and colleges. For the R&D component, 13% was basic research, 74% was applied research, and 13% was development.

Department of Homeland Security

The Department of Homeland Security (DHS) obligated $1.1 billion for R&D and R&D plant in FY 2011, nearly all of which was for activities by the department's Science and Technology Directorate. Sixty-four percent of this total was for agency intramural and FFRDC activities. Just under 37% was conducted by extramural performers—mainly businesses—but also universities and colleges and other nonprofit organizations. Of the obligations for R&D, 14% was basic research, 33% was applied research, and 53% was development.

Department of Transportation

The Department of Transportation (DOT) obligated $1.0 billion for R&D and R&D plant in FY 2011, most of which was for activities by the department's Federal Aviation Administration and Federal Highway Administration. Thirty-four percent of this obligations total was for agency intramural and FFRDC activities. Sixty-six percent was conducted by extramural performers—mainly businesses—but also state and local governments, universities and colleges, and other nonprofit organizations. Of the obligations for R&D, barely 1% was basic research, 71% was applied research, and 29% was development.

Other Agencies

The six other departments/agencies obligating more than $100 million annually for R&D in FY 2011 were the Departments of Education (ED), the Interior (DOI), Justice, and Veterans Affairs; the Environmental Protection Agency (EPA); and the Smithsonian Institution (tables 4-13 and 4-14). These agencies varied with respect to the character of research and the roles of intramural, FFRDC, and extramural performers.

Federal Spending on Research, by Field

The research conducted and/or funded by the federal government spans the full range of S&E fields. These fields vary widely with respect to their current funding levels and the history of support (appendix tables 4-37 and 4-38).

Funding for basic and applied research combined accounted for $58.2 billion (about 44%) of the $132.1 billion total of federal obligations for R&D in FY 2011 (table 4-14). Of this amount, $30.2 billion (52% of $58.2 billion) supported research in the life sciences (figure 4-20; appendix table 4-37). The fields with the next-largest amounts were engineering ($10.1 billion, 17%) and the physical sciences ($5.5 billion, 10%), followed by mathematics and computer sciences ($3.3 billion, 6%) and environmental sciences ($3.1 billion, 5%). The balance of federal obligations for research in FY 2011 supported psychology, the social sciences, and all other sciences ($5.9 billion overall, or 10% of the total for research).

With differing missions, the federal agencies vary significantly in the types of S&E fields emphasized. HHS accounted for the largest share (54%) of federal obligations for research in FY 2011 (appendix table 4-37). Most of this amount funded research in medical and related life sciences, primarily through NIH. The five next-largest federal agencies for research funding that year were DOE (12%), DOD (11%), NSF (8%), USDA (4%), and NASA (3%).

DOE's $6.8 billion in research obligations provided funding for research in the physical sciences ($2.6 billion) and engineering ($2.3 billion), along with mathematics and computer sciences ($1.0 billion). DOD's $6.6 billion of research funding emphasized engineering ($3.6 billion) but also included mathematics and computer sciences ($1.0 billion), physical sciences ($0.8 billion), and life sciences ($0.6 billion). NSF—not a mission agency in the traditional sense—is charged with "promoting the health of science." Consequently, it had a comparatively diverse $4.9 billion research portfolio that allocated about $0.7 billion to $0.9 billion in each of the following fields: environmental, life, mathematics and computer, and physical sciences and engineering. Lesser amounts were allocated to psychology and the social and other sciences. USDA's $2.4 billion was directed primarily at the life (agricultural) sciences ($1.9 billion). NASA's $1.6 billion for research emphasized engineering ($0.6 billion), followed by the physical sciences ($0.4 billion) and environmental sciences ($0.4 billion).

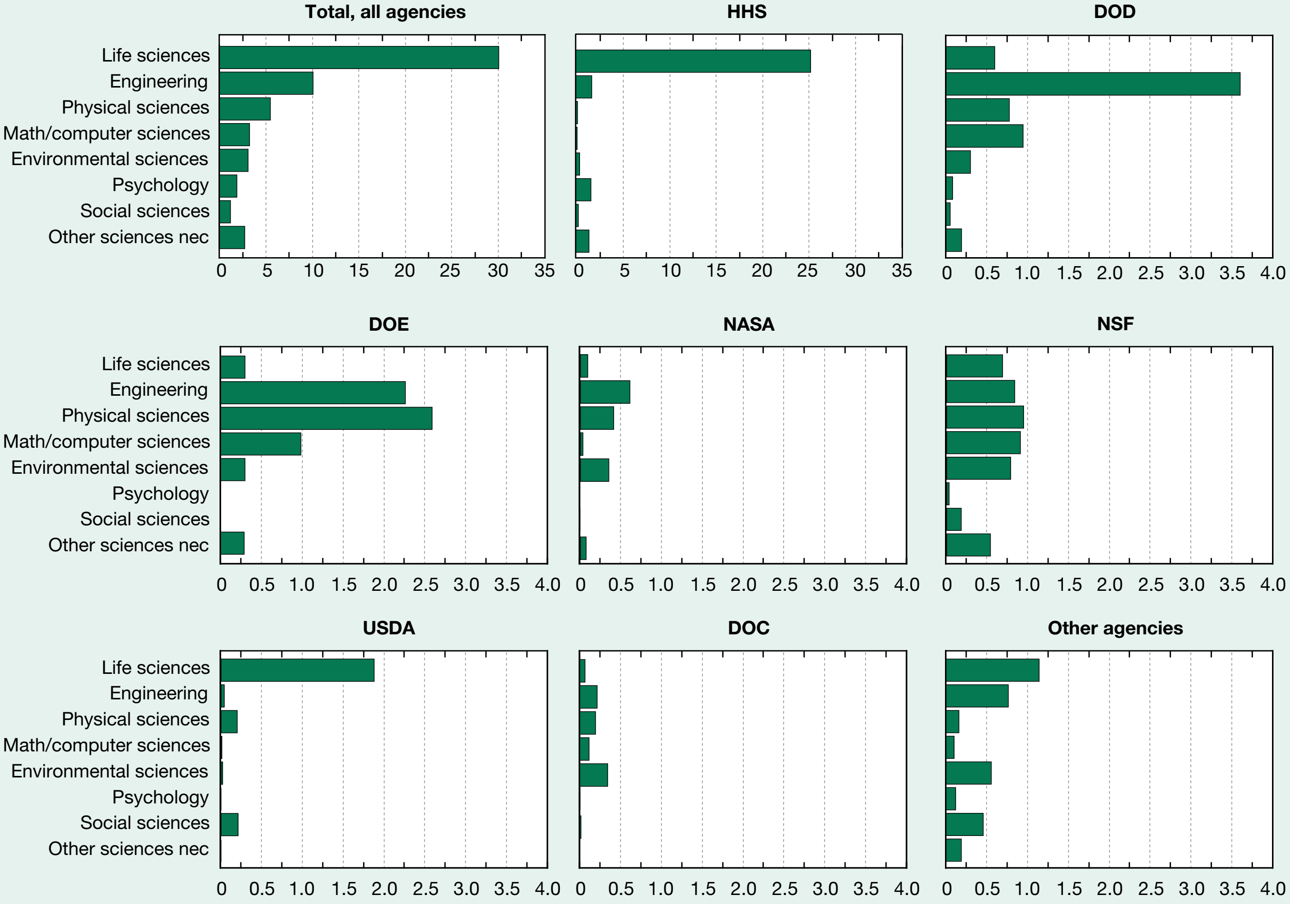
Growth in federal research obligations has slowed in recent years. Federal obligations for research in all S&E fields expanded on average at 1.7% annually (in current dollars) over the 2006–11 period but at a much higher 2.7% over the 2001–11 period (appendix table 4-38).

Looking just at the recent period of FY 2006–11, the level of federal research obligations in the life sciences, psychology, and the social sciences experienced average annual growth at or just below the pace of expansion for all S&E (1.7%), meaning these fields essentially maintained their

Figure 4-20

Federal obligations for research, by agency and major S&E field: FY 2011

Billions of current dollars



DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; nec = not elsewhere classified; NSF = National Science Foundation; USDA = U.S. Department of Agriculture.

NOTES: The scales for Total, all agencies, and HHS differ from those of other agencies listed. Research includes basic and applied research.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FYs 2010–12). See appendix table 4-37.

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shares of the total (appendix table 4-38). Obligations for the fields of mathematics/computer sciences and engineering, however, expanded at average paces well above that for all S&E, meaning these fields' shares of the total were increasing. Obligations for the physical sciences grew at less than half the rate of all S&E, a greater level of obligations in FY 2011 than in FY 2006, but a declining share of the whole. The field of environmental sciences experienced both a declining share and a lower absolute level in FY 2011 compared with that in FY 2006.

Cross-National Comparisons of Government R&D Priorities

Government R&D funding statistics compiled annually by the OECD provide insights into how national government priorities for R&D differ across countries. Known technically as government budget appropriations or outlays for R&D (GBAORD), this indicator provides data on how a country's overall government funding for R&D splits among a set of socioeconomic categories (e.g., defense, health, space, general research).[23] These GBAORD statistics for the United States and other top R&D-performing countries appear in table 4-15 (with added detail in appendix table 4-39).[24]

Defense is an objective for government funding of R&D for the top seven R&D-performing countries, but the share varies widely (table 4-15). Defense accounted for 57% of U.S. federal R&D support in 2011, but it was markedly lower elsewhere: a smaller but still sizable 16% in South Korea and 15% in the United Kingdom, and below 7% in France, Germany, and Japan. (GBAORD statistics have not yet been available for China.)

Defense has received more than 50% of the federal R&D budget in the United States for much of the past 20 years. It was 63% in 1990 as the long Cold War period drew to a close, but it dropped in subsequent years. The defense share of government R&D funding for the other countries over the past 20 years has generally declined or remained at a stable, low level.

The health and environment objective accounted for some 57% of nondefense federal R&D budget support in the United States in FY 2011 and 33% in the United Kingdom. For both countries, the share has expanded markedly over the share prevailing several decades ago. The health and environment share is currently 14% in South Korea and 10% or less in France, Germany, and Japan. The funding under this objective is predominantly health (in contrast to the environment) in the United States and mainly health in the United Kingdom (appendix table 4-39). However, in the other countries, it is more balanced between health and the environment.

The economic development objective encompasses agriculture, fisheries and forestry, industry, infrastructure, and energy. In the United States, government R&D funding in this category was 20% of all nondefense federal support for R&D in 1990, dropping to 11% in 2011 (table 4-15).[25] In the United Kingdom, it was 32% in 1990 but declined to 8% in 2011. France was 33% in 1990 but dropped to 17% in 2011. Japan was 34% in 1990 but dropped to only 27% in 2011 (with particular emphasis on energy and industrial production and technology). Germany was 26% in 1990 and 24% in 2011 (with an industrial production and technology emphasis). South Korea (50%) exhibits the largest share by far in this category in 2011 (with a strong emphasis on industrial production and technology).

The civil space objective now accounts for 14% of nondefense federal R&D funding in the United States (table 4-15). The share has generally been declining over the last 20 years: 21% in 2000 and 24% in 1990. The share in France is currently about 14% and has been around that level for almost 20 years. The share has been well below 10% for the rest of the top R&D countries.

Both the nonoriented research fund and general university fund (GUF) objectives reflect government funding for R&D by academic, government, and other performers that is directed chiefly at the general advancement of knowledge in the natural sciences, engineering, social sciences, humanities, and related fields. For some of the countries, the sum of these two objectives currently represents by far the largest part of nondefense GBAORD: Japan (59%), Germany (58%), and the United Kingdom (52%). France (42%) and South Korea (31%) were below half but still sizable. The corresponding 2011 share for the United States (16%) was substantially smaller. Nevertheless, cross-national comparisons of these particular indicators can be difficult because some countries (notably the United States) do not use the GUF mechanism to fund R&D for general advancement of knowledge, do not separately account for GUF funding (e.g., South Korea), and/or more typically direct R&D funding to project-specific grants or contracts, which are then assigned to the more specific socioeconomic objectives (see the sidebar, "Government Funding Mechanisms for Academic Research").

Finally, the education and society objective represents a comparatively small component of nondefense government R&D funding for all seven of the countries. However, it is notably higher in Germany (4%), France (5%), and the United Kingdom (4%) than in Japan (1%). The United States (3%) and South Korea (3%) are in between.

Federal Programs to Promote Technology Transfer and the Commercialization of Federal R&D

Starting in the late 1970s, concerns by domestic policymakers about the strength of U.S. industries and their ability to succeed in the increasingly competitive global economy took on greater intensity. The issues raised included whether the new knowledge and technologies arising from federally funded R&D were being fully and effectively exploited for the benefit of the national economy, whether there were undue barriers in the private marketplace that worked to slow

Table 4-15

Government R&D support by major socioeconomic objectives, for selected countries and years: 1990–2011

Region/country and year	GBAORD (current US$ millions, PPP)	Percent of GBAORD		Percent of nondefense					
		Defense	Nondefense	Economic development programs	Health and environment	Education and society	Civil space	Non-oriented research	General university funds
United States									
1990	63,781.0	62.6	37.4	20.1	40.2	3.4	24.2	10.1	na
2000	83,612.5	51.6	48.4	13.4	49.9	1.8	20.9	13.8	na
2005	131,259.0	56.9	43.1	11.2	55.8	2.8	17.1	13.2	na
2011	144,379.0	56.8	43.2	10.5	56.8	2.9	13.9	16.0	na
EU									
1990	na	na	na	na	na	na	na	na	na
2000	76,388.3	12.9	87.1	22.4	11.5	3.4	6.0	15.4	34.7
2005	90,797.3	10.4	89.6	19.8	13.3	4.1	5.4	20.0	36.4
2011	111,574.9	4.6	95.4	21.0	13.7	4.7	5.9	17.6	34.1
France									
1990	13,650.6	40.0	60.0	32.8	9.3	0.8	13.0	24.6	18.9
2000	14,740.2	21.4	78.6	17.7	9.7	1.1	13.2	27.4	28.5
2005	18,084.5	20.8	79.2	16.4	11.8	0.4	10.9	28.3	29.4
2011	19,422.2	6.8	93.2	17.3	9.8	5.4	13.9	17.9	24.4
Germany									
1990	13,328.4	13.5	86.5	25.9	10.8	2.9	6.8	15.2	37.6
2000	16,808.7	7.8	92.2	21.6	9.4	3.9	5.1	17.5	42.4
2005	19,865.0	5.8	94.2	20.3	10.1	4.1	5.2	18.0	43.1
2011	29,234.2	4.0	96.0	24.4	9.5	3.9	4.9	17.0	41.0
United Kingdom									
1990	8,102.3	43.5	56.5	31.9	18.1	4.0	5.5	10.3	29.8
2000	10,359.1	36.2	63.8	12.1	28.3	6.4	3.5	18.8	30.4
2005	13,228.0	23.9	76.1	7.1	25.8	7.4	3.0	25.9	30.2
2011	13,280.0	14.6	85.4	7.9	32.5	4.4	3.4	22.5	29.3
China									
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA	NA	NA	NA	NA
2005	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA
Japan									
1990	10,133.6	5.4	94.6	34.1	4.5	1.1	6.9	8.4	45.1
2000	21,173.8	4.1	95.9	33.4	6.6	1.0	5.8	14.6	37.0
2005	27,617.8	4.0	96.0	33.2	6.8	0.8	7.0	16.9	35.3
2011	34,172.2	2.7	97.3	26.6	7.0	0.7	6.7	21.5	37.9
South Korea									
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	5,024.7	20.5	79.5	53.4	14.8	3.8	3.1	24.9	**
2005	8,539.3	14.6	85.4	51.9	18.8	5.1	4.2	20.1	**
2011	15,897.8	16.3	83.7	49.9	14.1	2.7	2.4	30.9	**

** = included in other categories; na = not applicable; NA = not available.

EU = European Union; GBAORD = government budget appropriations or outlays for R&D; PPP = purchasing power parity.

NOTES: Foreign currencies are converted to dollars through PPPs. GBAORD data are not yet available for China. The socioeconomic objective categories are aggregates of the 14 categories identified by Eurostat's 2007 Nomenclature for the Analysis and Comparison of Scientific Programs and Budgets. The figures are as reported by the Organisation for Economic Co-operation and Development.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2012/2). See appendix table 4-39.

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businesses in the creation and commercialization of innovations and new technologies, and whether better public-private partnerships for R&D and business innovation had the potential to significantly aid the nation's economy in responding to these emerging challenges (Tassey 2007). As the reality of the global economic changes deepened throughout the 1980s and 1990s (and into the present), it became apparent that the United States' global science and technology leadership needed to have a match in a dynamic economic system able to quickly absorb and capitalize on R&D advances in ways beneficial to the economic fortunes of U.S. consumers and businesses.

Government Funding Mechanisms for Academic Research

U.S. universities generally do not maintain data on departmental research (i.e., research that is not separately budgeted and accounted for). As such, U.S. R&D totals are understated relative to the R&D effort reported for other countries. The national totals for Europe, Canada, and Japan include the research component of general university fund (GUF) block grants provided by all levels of government to the academic sector. These funds can support departmental R&D programs that are not separately budgeted. GUF is not equivalent to basic research. The U.S. federal government does not provide research support through a GUF equivalent, preferring instead to support specific, separately budgeted R&D projects. However, some state government funding probably does support departmental research, not separately accounted for, at U.S. public universities.

The treatment of GUF is one of the major areas of difficulty in making international R&D comparisons. In many countries, governments support academic research primarily through large block grants that are used at the discretion of each higher education institution to cover administrative, teaching, and research costs. Only the R&D component of GUF is included in national R&D statistics, but problems arise in identifying the amount of the R&D component and the objective of the research. Moreover, government GUF support is in addition to support provided in the form of earmarked, directed, or project-specific grants and contracts (funds that can be assigned to specific socioeconomic categories).

In several large European countries (France, Germany, Italy, and the United Kingdom), GUF accounts for 50% or more of total government R&D funding to universities. In Canada, GUF accounts for about 38% of government academic R&D support. Thus, international data on academic R&D reflect not only the relative international funding priorities but also the funding mechanisms and philosophies regarded as the best methods for financing academic research.

Numerous national policies and related initiatives have been directed at these challenges over the last 30 years, including how to better transfer and economically exploit the results of federally funded R&D. One major national policy thrust has been to enhance formal mechanisms for transferring knowledge arising from federally funded and performed R&D (Crow and Bozeman 1998; NRC 2003). Other policies have taken on strengthening the prospects for the development and flow of early-stage technologies into the commercial marketplace, accelerating the commercial exploitation of academic R&D, and facilitating the conduct of R&D on ideas and technologies with commercial potential by entrepreneurial small and/or minority-owned businesses. (For an overview of major federal policy initiatives in this realm since the early 1980s, see the sidebar, "Major Federal Policies Promoting Technology Transfer and Commercialization of R&D.")

The sections immediately below focus on this theme of the transfer and commercial exploitation of federally funded R&D and review the status indicators for several major federal policies and programs directed at these objectives. (Chapter 5 contains related information about the knowledge diffusion and patents arising from academic research.)

Federal Technology Transfer

Technology transfer is "the process by which technology or knowledge developed in one place or for one purpose is applied and used in another place for the same or different purpose" (FLC 2011:3). As applied in the federal setting, technology transfer refers to the various processes through which inventions and other intellectual assets arising from federal laboratory R&D are conveyed to outside parties for further development and commercial applications. It can also involve linking R&D capabilities and the resources of federal laboratories with outside public or private organizations for mutual benefit, including flowing know-how and technologies developed on the outside into federal research facilities to better meet mission objectives and enhance internal capabilities.

The Stevenson-Wydler Act of 1980 (P.L. 96-480) directed federal agencies with laboratory operations to become active in the technology transfer process. It also required these agencies to establish technology transfer offices (termed an Office of Research and Technology Applications [ORTA]) to assist in identifying transfer opportunities and establishing appropriate arrangements for transfer relationships with nonfederal parties. Follow-on legislation in the 1980s through 2000 amending Stevenson-Wydler have worked to extend and refine the authorities available to the agencies and their federal labs to identify and manage intellectual assets created by their R&D and to participate in collaborative R&D relationships with nonfederal parties, including private businesses, universities, and nonprofit organizations (FLC 2011).

Major Federal Policies Promoting Technology Transfer and Commercialization of R&D

Technology Innovation Act of 1980 (Stevenson-Wydler Act) (P.L. 96-480)—Established technology transfer as a federal government mission by directing federal labs to facilitate the transfer of federally owned and originated technology to nonfederal parties.

University and Small Business Patent Procedures Act of 1980 (Bayh-Dole Act) (P.L. 96-517)—Permitted small businesses, universities, and nonprofits to obtain titles to inventions developed with federal funds. Also allowed government-owned and government-operated laboratories to grant exclusive patent rights to commercial organizations.

Small Business Innovation Development Act of 1982 (P.L. 97-219)—Established the Small Business Innovation Research (SBIR) program, which required federal agencies to set aside funds for small businesses to engage in R&D connected to agency missions.

National Cooperative Research Act of 1984 (P.L. 98-462)—Encouraged U.S. firms to collaborate in generic precompetitive research by establishing a rule of reason for evaluating the antitrust implications of research joint ventures.

Patent and Trademark Clarification Act of 1984 (P.L. 98-620)—Provided further amendments to the Stevenson-Wydler Act and the Bayh-Dole Act regarding the use of patents and licenses to implement technology transfer.

Federal Technology Transfer Act of 1986 (P.L. 99-502)—Enabled federal laboratories to enter cooperative research and development agreements (CRADAs) with outside parties and to negotiate licenses for patented inventions made at the laboratory.

Executive Order 12591, Facilitating Access to Science and Technology (April 1987)—Issued by President Reagan, this executive order sought to ensure that the federal laboratories implemented technology transfer.

Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418)—Directed attention to public-private cooperation on R&D, technology transfer, and commercialization (in addition to measures on trade and intellectual property protection). Also established the Manufacturing Extension Partnership (MEP) program at the National Institute of Standards and Technology.

National Competitiveness Technology Transfer Act of 1989 (P.L. 101-189)—Amended the Federal Technology Transfer Act to expand the use of CRADAs to include government-owned, contractor-operated federal laboratories and to increase nondisclosure provisions.

Small Business Innovation Development Act of 1992 (P.L. 102-564)—Reauthorized the existing SBIR program, increasing both the percentage of an agency's budget to be devoted to SBIR and the maximum level of awards. Also established the Small Business Technology Transfer (STTR) program to enhance opportunities for collaborative R&D efforts between government-owned, contractor-operated federal laboratories and small businesses, universities, and nonprofit partners.

National Cooperative Research and Production Act of 1993 (P.L. 103-42)—Relaxed restrictions on cooperative production activities, enabling research joint venture participants to work together on jointly acquired technologies.

National Technology Transfer and Advancement Act of 1995 (P.L. 104-113)—Amended the Stevenson-Wydler Act to make CRADAs more attractive to federal laboratories, scientists, and private industry.

Technology Transfer Commercialization Act of 2000 (P.L. 106-404)—Broadened CRADA licensing authority to make such agreements more attractive to private industry and increase the transfer of federal technology. Established technology transfer performance reporting requirements for agencies with federal laboratories.

America COMPETES Act of 2007 (America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Sciences [COMPETES] Act) (P.L. 110-69)—Authorized increased investment in R&D; strengthened educational opportunities in science, technology, engineering, and mathematics from elementary through graduate school; and further promoted the nation's innovation infrastructure. Among various provisions, the act created the Advanced Research Project Agency–Energy (ARPA-E) to promote and fund R&D on advanced energy technologies; it also called for a President's Council on Innovation and Competitiveness.

America COMPETES Reauthorization Act of 2010 (P.L. 111–358)—Updated the America COMPETES Act of 2007 and authorized additional funding to science, technology, and education programs over the succeeding 3 years. Numerous provisions were intended to broadly strengthen the foundation of the U.S. economy, create new jobs, and increase U.S. competitiveness abroad.

Presidential Memorandum, Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses (October 2011)—Issued by President Obama, this memorandum directed a variety of actions by federal departments and agencies to establish goals and measure performance, streamline administrative processes, and facilitate local and regional partnerships to accelerate technology transfer and support private sector commercialization.

The metrics on federal technology transfer continue to primarily track the number of activities, that is, invention disclosures, patent applications and awards, licenses to outside parties of patents and other intellectual property, and agreements to conduct collaborative research with outside parties (IDA STPI 2011). Systematic documentation of the downstream outcomes and impacts of transfer remains a challenge. Also notably missing for most agencies and their labs is an accounting of the technical articles published in professional journals, conference papers, and other kinds of scientific communications. Most federal laboratory scientists, engineers, and managers continue to view these traditional forms of new knowledge dissemination as an essential technology transfer mechanism. (For further discussion of the current mechanisms and main metrics for federal technology transfer, see the sidebar “Federal Technology Transfer: Activities and Metrics.”)

Six agencies continue to account for most of the annual total of federal technology transfer activities: DOD, HHS, DOE, NASA, USDA, and DOC. Statistics for these six agencies in FYs 2006 and 2010, spanning the activity areas of invention disclosures and patenting, intellectual property licensing, and collaborative relationships for R&D, appear in table 4-16. (Similar statistics for a larger set of agencies, going back to FY 2001, appear in appendix table 4-40.)

As is apparent in the distribution of the statistics across the activity types in table 4-16, most agencies engage in all of the transfer activity types to some degree, but there are differences in the emphases. Some agencies are more intensive in patenting and licensing activities (such as HHS, DOE, and NASA); some place greater emphasis on transfer through collaborative R&D relationships (such as DOD, USDA, and DOC). Some agencies have unique transfer authorities that can confer practical advantages. NASA, for example, can establish collaborative R&D relationships through special authorities it has under the NASA Space Act of 1958; USDA has a number of special authorities for establishing R&D collaborations other than through Cooperative Research and Development Agreements (CRADAs); DOE has contractor-operated national labs, with nonfederal staff, that are not constrained by the normal federal limitation on copyright by federal employees and can use copyright to protect and transfer computer software. In general, the mix of technology transfer activities pursued by each agency reflects a broad range of considerations such as agency mission priorities, the technologies principally targeted for development, the intellectual property protection tools and policies available, and the types of external parties through which transfer and collaboration are chiefly pursued.

Small Business Innovation-Related Programs

The Small Business Innovation Research (SBIR) program and Small Business Technology Transfer (STTR) program are longstanding federal programs that provide competitively awarded funding to small businesses for various purposes. These include stimulating technological innovation,

Federal Technology Transfer: Activities and Metrics

Federal technology transfer can take a variety of forms (FLC 2011), including the following:

Commercial transfer. Movement of knowledge or technology developed by a federal laboratory to private organizations into the commercial marketplace.

Scientific dissemination. Publications, conference papers, and working papers, distributed through scientific/technical channels; other forms of data dissemination.

Export of resources. Federal laboratory personnel made available to outside organizations with R&D needs through collaborative agreements or other service mechanisms.

Import of resources. Outside technology or expertise brought in by a federal laboratory to enhance the existing internal capabilities.

Dual use. Development of technologies, products, or families of products with both commercial and federal applications.

Federal technology transfer metrics to date have typically covered activities in three main classes of intellectual asset management and transfer:

Invention disclosure and patenting. Counts of invention disclosures filed (typically, an inventing scientist or engineer filing a written notice of the invention with the laboratory’s technology transfer office), patent applications filed with the U.S. Patent and Trademark Office (or abroad), and patents granted.

Licensing. Licensing of intellectual property, such as patents or copyrights, to outside parties.

Collaborative relationships for R&D. Including, but not limited to, Cooperative Research and Development Agreements (CRADAs).

Data on technology transfer metrics such as these are now increasingly available. Nonetheless, it has been long and well recognized by the federal technology transfer community that counts of patent applications and awards, intellectual property licenses, CRADAs, and the like cannot, normally, by themselves provide a reasonable gauge of the downstream outcomes and impacts that result from the transfers—many of which involve considerable time and numerous subsequent developments to reach full fruition. There is a growing literature on federal technology transfer success stories, facilitated in part by the annual agency technology transfer performance reporting mandated by the Technology Transfer Commercialization Act of 2000 and through regularly updated reports by technology transfer professional organizations such as the Federal Laboratory Consortium. Even so, the documentation of these downstream outcomes and impacts is well short of complete.

addressing federal R&D needs, increasing private sector commercialization of innovations flowing from federal R&D, and fostering technology transfer through cooperative R&D between small businesses and research institutions. The U.S. Small Business Administration provides overall coordination for both programs, with implementation by the federal agencies that participate (SBA 2013). The attention devoted to smaller and/or startup R&D-based companies by these programs exemplifies the promotion of innovation-based entrepreneurship via public-private partnerships that enable not only financing but also R&D collaboration and commercialization opportunities (Gilbert, Audretsch, and McDougall 2004; Link and Scott 2010).

The SBIR program was established by the Small Business Innovation Development Act of 1982 (P.L. 97-219) for the purpose of stimulating technological innovation by increasing the participation of small companies in federal R&D projects, increasing private sector commercialization of innovation derived from federal R&D, and fostering participation by minority and disadvantaged persons in technological innovation. The program was reauthorized by the Small Business Reauthorization Act of 2000 (P.L. 106-544), extending the program through the end of September 2008. Subsequently, the program has received several extensions from the Congress, which now carries the program through 2017. Eleven federal agencies currently participate in the SBIR program: USDA, DOC, DOD, ED, DOE, HHS, DHS, DOT, EPA, NASA, and NSF.

The STTR program was established by the Small Business Technology Transfer Act of 1992 (P.L. 102-564, Title II) for the purpose of facilitating cooperative R&D by small businesses, universities, and nonprofit research organizations and encouraging the transfer of technology developed through such research by entrepreneurial small businesses.

Table 4-16
Federal laboratory technology transfer activity indicators, total and selected U.S. agencies: FYs 2006 and 2010
(Number)

Technology transfer activity	All federal laboratories	DOD	HHS	DOE	NASA	USDA	DOC
	FY 2006						
Invention disclosures and patenting							
Inventions disclosed	5,193	1,056	442	1,694	1,749	105	14
Patent applications	1,912	691	166	726	142	83	5
Patents issued	1,284	472	164	438	85	39	7
Licensing							
All licenses, total active in the FY	10,186	444	1,535	5,916	2,856	332	111
Invention licenses	4,163	438	1,213	1,420	308	332	111
Other intellectual property licenses	6,023	6	322	4,496	2,548	0	0
Collaborative relationships for R&D							
CRADAs, total active in the FY	7,268	2,999	164	631	1	195	3,008
Traditional CRADAs	3,666	2,424	92	631	1	163	149
Other collaborative R&D relationships	9,738	0	0	0	4,275	3,477	2,114
	FY 2010						
Invention disclosures and patenting							
Inventions disclosed	4,783	698	363	1,616	1,722	164	34
Patent applications	1,830	436	113	965	144	112	19
Patents issued	1,143	304	153	480	129	44	11
Licensing							
All licenses, total active in the FY	13,542	397	1,941	6,224	3,901	343	41
Invention licenses	4,004	341	1,240	1,453	354	343	41
Other intellectual property licenses	9,121	56	683	4,771	3,547	0	0
Collaborative relationships for R&D							
CRADAs, total active in the FY	8,525	3,248	447	697	1	287	2,399
Traditional CRADAs	4,768	2,516	300	697	1	233	101
Other collaborative R&D relationships	18,667	287	0	0	4,246	11,214	2,897

CRADA = Cooperative Research and Development Agreement; DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; NASA = National Aeronautics and Space Administration; HHS = Department of Health and Human Services; USDA = U.S. Department of Agriculture.

NOTES: Other federal agencies not listed but included in the All federal laboratories totals are the Department of Homeland Security, Department of the Interior, Department of Transportation, Department of Veterans Affairs, and Environmental Protection Agency. Invention licenses refers to inventions that are patented or could be patented. Other intellectual property licenses refers to intellectual property protected through mechanisms other than a patent (e.g., copyright). Total CRADAs refers to all agreements executed under CRADA authority (15 USC 3710a). Traditional CRADAs are collaborative R&D partnerships between a federal laboratory and one or more nonfederal organizations. Federal agencies have varying authorities for other kinds of collaborative R&D relationships. Detail may not add to total due to categories in the source data that are not displayed or other distinctions in the source data.

SOURCE: National Institute of Standards and Technology, *Federal Laboratory Technology Transfer, Fiscal Year 2010 Summary Report to the President and the Congress*, August 2012, http://www.nist.gov/tpo/publications/index.cfm. See appendix table 4-40.

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The program was reauthorized through the end of September 2009 by the Small Business Technology Transfer Program Reauthorization Act of 2001 (P.L. 107-50). Congress has likewise provided a number of extensions since then, with the program now continuing through 2017. Five federal agencies currently participate in the STTR program: DOD, DOE, HHS, NASA, and NSF.

For SBIR, federal agencies with extramural R&D budgets exceeding $100 million annually must set aside 2.5% (since FY 1997) for SBIR awards to U.S.-located small businesses (defined as those with fewer than 500 employees, including any affiliates). Three phases of activities are recognized. Phase I: A small company can apply for a Phase I funding award (normally not exceeding $150,000) for up to 6 months to assess the scientific and technical feasibility of an idea with commercial potential. Phase II: Based on the scientific/technical achievements in Phase I and continued expectation of commercial potential, the company can apply for Phase II funding (normally, not exceeding $1,000,000) for 2 years of further development. Phase III: Where the Phase I and II results warrant, the company pursues a course toward commercialization. The SBIR program itself does not provide funding for Phase III, but depending on the agency Phase III may involve non-SBIR-funded R&D or production contracts for products, processes, or services intended for use by the federal government. Several agencies offer bridge funding to Phase III and other commercialization support for startups (NRC 2008:208–16).

The initial round of SBIR awards was for FY 1983. This amounted to 789 Phase I awards, across all the participating agencies, for a total of $38.1 million of funding (table 4-17; appendix table 4-41). By FY 2011, the program had expanded considerably: 5,396 awards (3,626 Phase I; 1,770 Phase II), with total funding of $1.946 billion ($502 million Phase I; $1.444 billion Phase II). In FY 2011, the majority of the funding reflected awards by DOD (43%) and HHS (32%) (appendix table 4-42). NASA (9%), DOE (7%), and NSF (5%) accounted for smaller shares. The other six participating agencies were 1% or less of the total.

For the STTR program, federal agencies with extramural R&D budgets that exceed $1 billion annually must reserve 0.3% for STTR awards to small businesses. STTR operates within the same three-phase framework as SBIR. Phase I provides awards for company efforts to establish the technical merit, feasibility, and commercial potential of proposed projects; the funding in this phase normally does not exceed $100,000 over 1 year. Phase II is for continued R&D efforts, but award is conditional on success in Phase I and continued expectation of commercial potential. Phase II funding normally does not exceed $750,000 over 2 years. Phase III is for the small business to pursue commercialization objectives, based on the Phase I and II results. The STTR program does

Table 4-17
SBIR and STTR awards, number and funding, by type of award: Selected years, FYs 1983–2011

	Number of awards			Funding ($millions)		
Fiscal year	Total	Phase I	Phase II	Total	Phase I	Phase II
SBIR						
1983	789	789	0	38.1	38.1	0.0
1985	1,839	1,483	356	195.5	74.5	121.0
1990	3,225	2,379	846	453.7	121.2	332.4
1995	4,366	3,092	1,274	960.8	236.5	724.3
2000	5,307	3,959	1,348	1,062.2	295.0	767.2
2005	6,083	4,216	1,867	1,857.6	452.5	1,405.1
2009	5,796	4,016	1,780	1,926.2	503.4	1,422.8
2010	6,184	4,271	1,913	2,115.2	548.0	1,567.3
2011	5,396	3,626	1,770	1,946.0	502.1	1,443.9
STTR						
1983	na	na	na	na	na	na
1985	na	na	na	na	na	na
1990	na	na	na	na	na	na
1995	1	1	0	0.1	0.1	0.0
2000	410	315	95	64.0	23.7	40.3
2005	802	579	223	227.7	66.1	161.6
2009	831	593	238	236.8	72.2	164.6
2010	905	625	280	289.2	77.5	211.6
2011	708	468	240	234.6	64.2	170.4

na = not applicable.

SBIR = Small Business Innovation Research program; STTR = Small Business Technology Transfer program.

NOTES: The first SBIR program awards were made in FY 1983. The first STTR program award was made in FY 1995.

SOURCE: Small Business Administration, SBIR/STTR official website, http://www.sbir.gov/past-awards, accessed 25 February 2013. See appendix tables 4-41–4-43.

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not provide funding for Phase III activities. Furthermore, to pursue Phase III, companies must secure non-STTR R&D funding and/or production contracts for products, processes, or services for use by the federal government.

The STTR program started with a single Phase I award for $100,000 in FY 1995 (table 4-17). In FY 2011, there were 708 awards (468 Phase I; 240 Phase II), with funding totaling $235 million ($64 million Phase I; $170 million Phase II). Fewer federal agencies participate in STTR, but those dominant in SBIR are also dominant in STTR. STTR awards from DOD accounted for 44% of the $235 million award total in FY 2011 (appendix table 4-43). HHS accounted for 36% of the STTR awards, and the remainder was from NASA (9%), DOE (8%), and NSF (4%).

Other Programs

The federal policies, authorities, and incentives established by the Stevenson-Wydler Act (and the subsequent amending legislation) and the SBIR and STTR programs are far from the whole of federal efforts to promote the transfer and commercialization of federal R&D. Numerous programs for these purposes exist in the federal agencies. Given the specifics of agency missions, they have a narrower scope and smaller pools of resources. Several examples are described below.

The Hollings Manufacturing Extension Partnership (MEP) is a nationwide network of manufacturing extension centers located in all 50 U.S. states and Puerto Rico. MEP was created by the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418) and is headed by the Department of Commerce's National Institute of Standards and Technology (NIST 2013a). The MEP centers (nonprofit) exist as a partnership among the federal government, state and local governments, and the private sector. MEP provides technical expertise and other services to small and medium-sized U.S. manufacturers to improve their ability to develop new customers, expand into new markets, and create new products. The centers work directly with manufacturers to engage specific issues, including technology acceleration, process improvements, innovation strategies, workforce training, supply-chain development, and exporting. They also serve to connect manufacturers with universities and research laboratories, trade associations, and other relevant public and private resources. A recent MEP annual report (FY 2012) describes the program as operating with $300 million of annual resources: $100 million from the federal government, and $200 million from state and local governments and the private sector (NIST 2013b). The MEP report indicates that technical expertise and other services were provided during FY 2012 to 31,373 U.S. manufacturing companies and attributes impacts of $6.6 billion in increased or retained sales, 61,139 increased or retained jobs, and $900 million in cost savings for these businesses.

The Department of Energy's Advanced Research Projects Agency—Energy (ARPA-E) provides funding, technical assistance, and market development to advance high-potential, high-impact energy technologies that are too early stage for private sector investment (DOE 2013). The main interest is energy technology projects with the potential to radically improve U.S. economic security, national security, and environmental quality—in particular, short-term research that can have transformational impacts, not basic or incremental research. ARPA-E was authorized by the America COMPETES Act of 2007 (P.L. 110-69), and it received $400 million of initial funding through the American Recovery and Investment Act of 2009 (P.L. 111-5). Federal funding (appropriations) for ARPA-E was $180 million in FY 2011 and $275 million in FY 2012. The program is currently authorized through FY 2013, although the FY 2013 funding level remains unresolved at this time (DOE 2013). ARPA-E reports 190 funded projects active as of November 2012, with a total of 275 projects funded since 2009. The program currently identifies 14 project areas, with topics including advanced batteries, energy storage technologies, improved building energy efficiencies, biofuels, and solar energy.

The National Science Foundation's Industry/University Cooperative Research Centers (I/UCRC) Program supports university/industry partnerships for the conduct of industrially relevant fundamental research, collaborative education, and the transfer of university-developed ideas, research results, and technology to industry (NSF 2013). NSF provides support to I/UCRC through partnership mechanisms where, according to NSF, funding is typically leveraged from 10 to 15 times by business and other nonfederal funding. The I/UCRC Program reports there are currently 60 such centers across the United States, with over 1,000 nonacademic members: 85% are industrial firms, with the remainder comprised of state governments, national laboratories, and other federal agencies. NSF funding to I/UCRC was about $15 million in FY 2011. Research is prioritized and executed in cooperation with each center's membership organizations.

Conclusion

Worldwide R&D performance (measured as expenditures) totaled an estimated $1,435 billion (current PPP dollars) in 2011 (latest global total available). The comparable figure for 2001 was $753 billion, which reflected a brisk, 6.7% average annual growth over this 10-year period.

U.S. R&D increased to $407 billion in 2010 and to $424 billion in 2011 (table 4-1). At just under 30% of the global total in 2011, the United States remains, by far, the world's largest R&D performer. Nonetheless, with other countries also expanding their investments in R&D, the U.S. share has declined since 2001, when it was 37%. From 2001 to 2011, the share of total global R&D accounted for by East/Southeast Asia and South Asia—including China, India, Japan, Singapore, South Korea, and Taiwan—increased from 25% to 34% in 2011. By contrast, the EU countries accounted for 22% of total global R&D in 2011, down from 26% in 2001.

China continues to exhibit the most dramatic R&D growth pattern. At $208 billion of R&D expenditures in 2011, China is the world's second-largest R&D performer. While this is less than half the U.S. level, the growth in China's R&D spending has averaged an exceptionally high 20.7% annually in 2001–11 (18.1% adjusted for inflation). By comparison, the annual growth rate for U.S. R&D averaged 4.3% over this same period. Corresponding average annual growth rates for the largest R&D countries of the EU (Germany, France, United Kingdom) are in the 3%–6% range.

The growth in total of U.S. R&D expenditures in 2010 and 2011 followed a shallow decline in 2009 ($1.9 billion or 0.5%), mainly the result of a drop in business R&D in the face of the national and international financial crisis and economic downturn that started in late 2008. But while small, this was only the second such (current dollar) decline in U.S. R&D since the early 1950s. R&D's year-over-year expansion from 2009 to 2010 was 0.5%; for 2010 to 2011, it was 4.4%. R&D growth in 2010 was well behind that of GDP (4.2%) that year, but in 2011 R&D returned to the more normal circumstance of outpacing that year's GDP growth (3.9%). The ratio of R&D to GDP dropped from 2.90% in 2009 to 2.81% in 2010 and rose slightly to 2.81% in 2011. The statistics for 2012 and beyond, when they are available, will be important in determining if the historic pattern whereby R&D growth matches or exceeds GDP growth has resumed.

Notes

1. In this chapter constant or inflation-adjusted dollars are based on the GDP implicit price deflator (in 2005 dollars) as published by BEA (NIPA Table 1.1.9. Implicit Price Deflators for Gross Domestic Product) as of May 2012. See appendix table 4-1. GDP deflators are calculated on an economy-wide rather than an R&D-specific basis.

2. In this chapter, GDP data are from BEA, Survey of Current Business, 31 May 2012.

3. The data for academic R&D described in this chapter adjust the academic fiscal year basis of the survey data to calendar year and net out double-counting from pass-throughs of research funds from one academic institution to another. Accordingly, the data may differ from what is cited in chapter 5.

4. Furthermore, this figure does not include federal government investments in R&D infrastructure and equipment, which support the maintenance and operation of unique research facilities and the conduct of research activities that would be too costly or risky for a single company or academic institution to undertake.

5. R&D funding by business in this section refers to nonfederal funding for domestic business R&D plus business funding for U.S. academic R&D and nonprofit R&D performers.

6. It is straightforward arithmetic, based on the data in appendix tables 4-2–4-5, to calculate similar character-of-work shares for years earlier than 2011. Nonetheless, care must be applied in describing character-of-work shares over time. The survey methods for collecting data on character-of-work shares have on occasion been revised, most notably for the academic, business, and FFRDC R&D expenditure surveys. Some differences observed in the shares directly calculated from the appendix table time series data more nearly reflect the result of these improvements in the character-of-work questions.

7. The OECD notes that in measuring R&D, the greatest source of error is typically the difficulty of locating the dividing line between experimental development and related activities needed to realize an innovation (OECD 2002, paragraph 111). Most definitions of R&D set the cutoff at the point when a particular product or process reaches "market readiness." At this point, the defining characteristics of the product or process are substantially set (at least for manufactured goods, if not also for services), and further work is primarily aimed at developing markets, engaging in preproduction planning, and streamlining the production or control system.

8. The figures cited here for total global R&D in 2001, 2006, and 2011 are NSF estimates. R&D expenditures for all countries are denominated in U.S. dollars, based on purchasing power parities. These estimates are based on data from the OECD, *Main Science and Technology Indicators* (Volume 2013/1) and from R&D statistics for additional countries assembled by UNESCO, Institute for Statistics (as of early August 2013). At present, there is no database on R&D spending that is comprehensive and consistent for all nations performing R&D. The OECD and UNESCO databases together provide R&D performance statistics for 214 countries, although the data are not current or complete for all. NSF's estimate of total global R&D reflects 91 countries, with reported annual R&D expenditures of $50 million or more, which accounts for most all of current global R&D.

9. The figures cited for the EU in 2001 are adjusted to include all of the current 28 member countries.

10. The last recession was officially dated December 2007 to June 2009. For details, see http://www.nber.org/cycles.html.

11. See Archibugi, Filippetti, and Frenz (2013) and references therein for studies on the relationship of R&D, innovation, and business cycles.

12. BRDIS does not collect data for companies with fewer than five employees. See sidebar, "Measured and Unmeasured R&D," for more details including a new survey under development to cover these companies.

13. For forthcoming releases from a project linking and comparing BEA's MNC and BRDIS foreign statistics, see http://www.nsf.gov/statistics/rdlink/.

14. BEA releases MNC statistics in current dollars. Figures in the text were deflated by the authors using the GDP implicit price deflator (2005 = 1.00000) published separately by BEA (see endnote 1; appendix table 4-1).

15. Some companies are both parents of U.S. MNCs and subsidiaries of foreign MNCs, so the latter shares overlap.

16. For value-added and other MNCs operations data, see http://www.bea.gov/iTable/index_MNC.cfm.

17. See additional MNC R&D parent data by industry in appendix table 4-29.

18. U.S. business R&D data in ANBERD are for 2009. U.S. (BRDIS) 2010 statistics were used elsewhere in this chapter. ANBERD industry-level data presented here are based on International Standard Industrial Classification (ISIC) Revision 3.1. For ANBERD methodology, see OECD (2012). For additional cross-country indicators such as value added and trade in high-technology industries, see chapter 6.

19. Note that 2007 data for France in this section are arguably less comparable than more recent data from the other countries given the economic and financial crisis that started in 2008.

20. The analysis in this section focuses primarily on developments in federal R&D priorities and funding support over the course of the last decade. But there is a particularly interesting story to tell in how the comparatively minor federal role in the nation's science and research system up until World War II was reconsidered, redirected, and greatly enlarged, starting shortly after the end of the war and up through the subsequent decades to the present. For a review of the essential elements of this evolving postwar federal role, see Jankowski (2013).

21. The 15 budget function categories in which federally performed and/or funded R&D activities typically appear are national defense (050); international affairs (150); general science, space, and technology (250); energy (270); natural resources and environment (300); agriculture (350); commerce and housing credit (370); transportation (400); community and regional development (450); education, training, and social services (500); health (550); Medicare (570); income security (600); veterans benefits and services (700); and administration of justice (750). The other five categories in which R&D typically does not occur are social security (650), general government (800), net interest (900), allowances (920), and undistributed offsetting receipts (950). Furthermore, to clarify analysis, NCSES statistics on federal R&D funding by budget function normally separate the (250) function into subfunctions: general science and basic research (251) and space flight, research, and supporting activities (252).

22. For more on the effect of ARRA in R&D performance, see chapter 5.

23. GBAORD parses total government funding on R&D into the 14 socioeconomic categories specified by the EU's 2007 edition of the Nomenclature for the Analysis and Comparison of Scientific Programs and Budgets (NABS). These categories are exploration and exploitation of the earth; environment; exploration and exploitation of space; transport, telecommunications, and other infrastructures; energy; industrial production and technology; health; agriculture; education; culture, recreation, religion, and mass media; political and social systems, structures, and processes; general advancement of knowledge: R&D financed from general university funds; general advancement of knowledge: R&D financed from sources other than general university funds; and defense. GBAORD statistics published by the OECD in the *Main Science and Technology Indicators* series report on clusters of these 14 NABS categories.

24. GBAORD statistics reported for the United States are budget authority figures.

25. Some analysts argue that the low nondefense GBAORD share for economic development in the United States reflects the expectation that businesses will finance industrial R&D activities with their own funds. Moreover, government R&D that may be useful to industry is often funded with other purposes in mind, such as defense and space, and is, therefore, classified under other socioeconomic objectives.

Glossary

Affiliate: A company or business enterprise located in one country but owned or controlled (in terms of 10% or more of voting securities or equivalent) by a parent company in another country; may be either incorporated or unincorporated.

Applied research: The objective of applied research is to gain knowledge or understanding to meet a specific, recognized need. In industry, applied research includes investigations to discover new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

Basic research: The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study without specific applications in mind. Although basic research may not have specific applications as its goal, it can be directed in fields of present or potential interest. This is often the case with basic research performed by industry or mission-driven federal agencies.

Development: Development is the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

European Union (EU): As of June 2013, the EU comprised 27 member nations: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Croatia joined the EU in July 2013. Unless otherwise noted, Organisation for Economic Co-operation and Development data on the EU include all 28 members; data on the EU from other sources are limited to the 27 nations that were members as of June 2013.

Federally funded research and development center (FFRDC): R&D-performing organizations that are exclusively or substantially financed by the federal government either to meet a particular R&D objective or, in some instances, to provide major facilities at universities for research and associated training purposes. Each FFRDC is administered by an industrial firm, a university, or a nonprofit institution.

Foreign affiliate: Company located outside the United States but owned by a U.S. parent company.

Foreign direct investment (FDI): Ownership or control of 10% or more of the voting securities (or equivalent) of a business located outside the home country.

Gross domestic product (GDP): The market value of goods and services produced within a country. It is one of the main measures in the national income and product accounts.

G20: Group of Twenty brings together finance ministers and central bank governors from Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, the Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, and the EU.

Innovation: The introduction of new or significantly improved products (goods or services), processes, organizational methods, and marketing methods in internal business practices or in the open marketplace (OECD/Eurostat 2005).

Majority-owned affiliate: Company owned or controlled, by more than 50% of the voting securities (or equivalent), by its parent company.

Multinational company (MNC): A parent company and its foreign affiliates.

National income and product accounts (NIPA): The economic accounts of a country that display the value and composition of national output and the distribution of incomes generated in this production.

Organisation for Economic Co-operation and Development (OECD): An international organization of 34 countries, headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected nonmember countries.

R&D: Research and development, also called research and experimental development; comprises creative work undertaken on a systematic basis to increase the stock of knowledge—including knowledge of man, culture, and society—and its use to devise new applications (OECD 2002).

R&D intensity: A measure of R&D expenditures relative to size, production, financial, or other characteristic for a given R&D-performing unit (e.g., country, sector, company). Examples include R&D-to-GDP ratio and R&D value-added ratio.

Technology transfer: The process by which technology or knowledge developed in one place or for one purpose is applied and exploited in another place for some other purpose. In the federal setting, technology transfer is the process by which existing knowledge, facilities, or capabilities developed under federal research and development funding are utilized to fulfill public and private needs.

U.S. affiliate: Company located in the United States but owned by a foreign parent.

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Chapter 5

Academic Research and Development

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Highlights

Spending for Academic R&D

In 2012, U.S. academic institutions spent $65.8 billion on research and development in all fields, including $62.3 billion on S&E R&D and an additional $3.5 billion in non-S&E fields.

- Academic R&D expenditures rose by almost 14% from 2009–11, with the American Recovery and Reinvestment Act of 2009 (ARRA) providing almost $7 billion during these years.
- In 2012, ARRA expenditures dropped to $2.5 billion. Total academic R&D expenditures increased by less than 1% from the 2011 level (and decreased by 1% after adjusting for inflation).
- In 2012 and throughout the past four decades, expenditures were concentrated in a relatively small number of public and private research-intensive universities.
- The federal government provided about 60% of total academic R&D in FY 2012 (over $40 billion), a share that has remained relatively constant since the late 1980s. Six agencies provide over 90% of federal support for academic R&D in S&E—the Department of Health and Human Services (mainly through the National Institutes of Health), the National Science Foundation (NSF), the Department of Defense, the National Aeronautics and Space Administration, the Department of Energy, and the Department of Agriculture.

Institutions' own funds provided nearly 20% of S&E R&D in FY 2012 ($12.1 billion), while state and local governments, nonprofit organizations, and businesses funded smaller shares.

- State and local governments funded $3.4 billion of S&E R&D in FY 2012 (5.5%).
- Nonprofit organizations funded $3.7 billion of S&E academic R&D in FY 2012 (just under 6%).
- Businesses funded $3.2 billion of S&E academic R&D in FY 2012 (just over 5%).

Over the last 20 years, the distribution of academic R&D expenditures across the broad S&E fields shifted in favor of life sciences and away from physical sciences.

- In 2012, life sciences continued to receive the largest share (60%) of funding in academic S&E R&D.
- Over the last 20 years, life sciences was the only broad S&E field to experience a sizable increase in share—6 percentage points—of total academic S&E R&D.

Infrastructure for Academic R&D

Research space at academic institutions has continued to grow annually over the last two decades, although the pace of growth has slowed in the last few years.

- Total research space at research-performing universities and colleges was 3.5% greater at the end of FY 2011 than it was in FY 2009.
- Research space for the biological and biomedical sciences accounted for 26.8% of all S&E research space in FY 2011, making it the largest of all the major fields.

In FY 2012, about $2.0 billion was spent for academic research equipment (i.e., movable items such as computers or microscopes), an 11.6% decrease from FY 2011 after adjusting for inflation.

- Equipment spending as a share of total R&D expenditures fell from 4.6% in FY 2001 to a three-decade low of 3.2% in FY 2012.
- Three S&E fields accounted for 86% of equipment expenditures in FY 2012: life sciences (41%), engineering (28%), and physical sciences (17%).
- In FY 2012, the federal share of support for all academic research equipment funding was 57%, which was below the average (58.7%) for the FY 2000–09 decade preceding the full impact of ARRA.

Cyberinfrastructure

Academic networking infrastructure is rapidly expanding in capability and coverage.

- Research-performing institutions have gained greater access to high-performance networks since FY 2005, when NSF began collecting these data.
- Due to their research demands, doctorate-granting institutions have significantly higher bandwidth access and high-performance computing resources than non-doctorate-granting institutions.

Doctoral Scientists and Engineers in Academia

The doctoral academic S&E workforce numbered about 360,000 in 2010.

- The U.S.-trained portion of the workforce numbered about 295,000, while the foreign-trained portion numbered about 64,000.
- The growth from 2008–10 in the doctoral academic S&E workforce reflects an increase in the overall population of doctoral scientists and engineers across the various sectors of the economy.

- The share of all U.S.-trained S&E doctorate holders employed in academia dropped from 55% in 1973 to 44% in 2010.

Among U.S.-trained S&E doctorate holders employed full-time in academia, faculty positions remained the predominant type of employment in 2010. However, the number of nonfaculty positions, including postdoctorates (postdocs), grew more rapidly than the number of faculty, particularly in recent years.

- The percentage of S&E doctorate holders employed in academia who held full-time faculty positions declined from about 90% in the early 1970s to less than 75% in 2010.
- Compared to 1997, a smaller share of the doctoral academic S&E workforce had achieved tenure in 2010. In 1997, tenured positions accounted for an estimated 53% of doctoral academic employment; this decreased to 48% in 2010.

The demographic profile of the U.S.-trained academic doctoral workforce has shifted substantially over time.

- The number of women in academia grew substantially between 1997 and 2010, from about 60,000 to 105,000. Women as a share of full-time senior doctoral S&E faculty also increased.
- In 2010, underrepresented minorities (blacks, Hispanics, and American Indians or Alaska Natives) constituted 8.3% of total U.S.-trained academic S&E doctoral employment and of full-time faculty positions, up from about 2% in 1973 and 7%–8% of these positions in 2003.
- The foreign-born share of U.S.-trained S&E doctorate holders in academia increased from about 12% in 1973 to 26% in 2010.
- In 2010, about one-half of all U.S.-trained postdocs and almost three-fourths of total academically employed postdocs were born outside of the United States.
- The U.S.-trained doctoral academic S&E workforce has aged substantially since 1995. In 2010, 20% of this workforce was between 60 and 75 years of age.

Since 1997, there have been modest increases in the share of full-time faculty who identify research as their primary work activity.

- The share of full-time faculty with S&E degrees who identified research as their primary work activity rose from 33% in 1997 to 36% in 2010, while the share identifying teaching as their primary activity fell from 54% to 47%.
- In 2010, 37% of recently degreed S&E doctoral faculty identified research as their primary work activity.

A substantial pool of academic researchers exists outside the ranks of tenure-track faculty.

- Approximately 40,000 S&E doctorate holders were employed in academic postdoc positions in 2011. Of these, about 23,000 were trained in the United States.
- In 2010, 41% of recently degreed U.S.-trained S&E doctorate holders in academia (less than 4 years beyond the doctorate) held postdoc positions, exceeding the share (35%) employed in full-time faculty positions. Among U.S.-trained S&E doctorate holders 4–7 years beyond their doctorate degrees, 13% held postdoc positions.
- Almost 500,000 graduate research assistants worked in academia in 2011.

For S&E as a whole and for many fields, the share of U.S.-trained academic S&E doctorate holders receiving federal support declined since the early 1990s.

- In 2010, about the same percentage of S&E doctorate holders received federal support as had received support in the early 1970s (about 45%).
- During the late 1980s and very early 1990s, a somewhat higher share of S&E doctorate holders received federal support (49%).
- Among full-time faculty, recent doctorate recipients were less likely to receive federal support than their more established colleagues.

Outputs of Academic S&E Research: Articles and Patents

Global shares of S&E article output of the United States, the European Union (EU), and Japan have declined. China's global share has risen sharply.

- The United States, the world's second-largest producer, accounted for 26% of the world's total S&E articles in 2011, down from 30% in 2001. The share for the EU, the world's largest producer, also declined, from 35% in 2001 to 31% in 2011. Japan's share fell from 9% to 6%.
- China grew the fastest among larger developing economies, with its share rising from 3% to 11%. China has become the world's third-largest producer of scientific articles, after the EU and the United States.
- Brazil and India also grew rapidly, with their global shares reaching 2% and 3%, respectively. Iran, a developing nation with a much smaller publication base in 2001, grew to a 1% global share by 2011.

More than two-thirds of global S&E articles had authors from different institutions or different countries in 2012, compared with just over half of such articles 15 years earlier.

- Coauthored articles with only domestic institutional authors increased from 36% of all articles in 1997 to 44% in 2012. Internationally coauthored articles grew from 16% to 25% over the same period.
- In the United States, 35% of its articles were coauthored with institutions in other countries in 2012, compared with 16% in 1997. The center of U.S. collaboration is the U.S. academic sector, which coauthored 53% of its articles with other U.S. sectors or foreign institutions in 2012.

Citation data suggest that the influence of U.S.-authored articles remains quite high but has dropped some over the past 10 years.

- In 2012, articles with U.S. authors were among the top 1% most-cited articles about 74% more often than expected, based on the U.S. share of all articles, compared with 85% in 2002.
- Between 2002 and 2012, EU-authored articles, on average, became more influential. In 2002, they were cited 21% less often than expected among the top 1% most-cited articles; in 2012, the EU improved to 6% less often. In 2012, China's share of highly cited articles was 37% less than expected.

U.S. academic patents rose sharply from 3,300 in 2009 to 5,100 in 2012.

- Patents granted by the U.S. Patent and Trademark Office (USPTO) to U.S. academic institutions increased by more than 50% from 2009 to 2012, mirroring strong growth of all USTPO patents.
- Biotechnology patents made up 1% of all USPTO patents but 25% of U.S. university patents in 2012.

Introduction

Chapter Overview

U.S. academic institutions prepare the next generation of science, engineering, and mathematics professionals and conduct about half of the nation's basic research, giving them a central position in the nation's research and development system.

This chapter reports trends in academic R&D inputs—funding, infrastructure, and personnel—and academic R&D outputs—journal articles, citations to these articles, and various patent-based measures. (An additional major output of academic R&D, educated and trained personnel, is discussed in chapter 2.) Throughout the chapter, two key trends are explored: a generally stable distribution of academic R&D resources across different types of institutions, and a continuous increase in collaboration in research and research outputs. The consistent distribution of academic resources is evident in the relatively stable pattern of R&D expenditures over time among the major categories of colleges and universities as well as the primacy of certain fields and agencies in the funding for research and research infrastructure. Growing research collaboration is seen in increases in the amount of funds that universities pass through to others and in articles that are authored by more than one department, institution, sector, or country.

Chapter Organization

The first section of this chapter examines trends in spending and funding for academic R&D, identifies key funders of academic R&D, and describes the allocation of funds across academic institutions and S&E fields. Because the federal government has been the primary source of funding for academic R&D for more than half a century, the section highlights the importance of federal-agency support both historically and more recently, as universities have spent American Recovery and Reinvestment Act of 2009 (ARRA) funds. This section highlights new data from the Higher Education Research and Development Survey (HERD) covering 2010–12, including improved information on the distribution of academic R&D among basic research, applied research, and development. This section also includes new data on R&D collaboration, as evidenced by the growth of pass-through funding arrangements.

The chapter's second section summarizes data on infrastructure for academic R&D. The section reports on current trends in academic research facilities, research equipment, and cyberinfrastructure. These trends include changes, by field, in research space and equipment as well as data on universities' access to high-performance computing (HPC) and networking resources.

The third section discusses trends in the employment of doctoral scientists and engineers working in academia. Major trends examined include the numbers of doctoral scientists and engineers who are academically employed, their changing demographic composition, and the types of positions they hold. The section further examines employment patterns in the different segments of the academic workforce that are engaged in research, especially full-time faculty, postdoctorates (postdocs), and graduate research assistants. In addition, the section reports data on academic scientists and engineers receiving research support from the federal government. A central theme in this section is that whether looking across 15–20 years or across four decades, the academically employed S&E workforce, like the S&E workforce throughout the economy, has changed substantially.

The fourth and final section of this chapter analyzes trends in two types of research outputs: S&E articles, which are largely (but not exclusively) produced by the academic sector, and patents issued to U.S. universities. This section first compares the volume of S&E articles for selected regions, countries, and economies, focusing (when appropriate) on patterns and trends in articles by U.S. academic researchers. Trends in coauthored articles, both across U.S. sectors and internationally, are indicators of increasing collaboration in S&E research. Trends in production of influential articles, as measured by the frequency with which articles are cited, are examined, with emphasis on international comparisons. The analysis of academic patenting activities examines patents, licenses, and income from these as forms of academic R&D output. Patent citations to the S&E literature are also examined, with emphasis on citations in awarded patents for clean energy and related technologies.

Expenditures and Funding for Academic R&D

Academic R&D is a key component of the overall U.S. R&D enterprise.[1] Academic scientists and engineers conduct the bulk of the nation's basic research and are especially important as a source of the new knowledge that basic research produces. Indicators tracking the status of the financial resources, research facilities, and instrumentation that are used in this work are discussed in this and the next section of the chapter (for an overview of the sources of data used, see sidebar, "Data on the Financial and Infrastructure Resources for Academic R&D").

National Academic R&D Expenditures

Expenditures by U.S. colleges and universities on R&D in all fields totaled $65.8 billion in 2012 (appendix table 5-1).[2] When adjusted for inflation, academic R&D fell by 1% from 2011 to 2012.[3] Expenditures in life sciences, physical sciences, and social sciences dropped by between 2% and 3% after adjusting for inflation. Expenditures in computer sciences and mathematical sciences increased by around 3% after adjusting for inflation; in other broad fields of science, expenditures remained relatively constant. Engineering expenditures increased by just below 1% after adjusting for inflation.

Data on the Financial and Infrastructure Resources for Academic R&D

Recent data on the financial and infrastructure resources supporting U.S. academic R&D are drawn from two ongoing National Science Foundation (NSF) surveys, the annual Higher Education Research and Development Survey (HERD) and the Survey of Science and Engineering Research Facilities.

Data on current operating expenditures for academic R&D are derived from HERD and its predecessor, NSF's Survey of Research and Development Expenditures at Universities and Colleges, which covered the period from 1972 to 2009. The survey population for the predecessor survey comprised academic institutions that granted a bachelor's degree or a higher degree in S&E fields and spent at least $150,000 annually on separately budgeted S&E R&D.

HERD updated data collection to reflect current accounting principles that provide more valid and reliable measurements of the amount of U.S. academic R&D expenditures. Data from the revised and expanded survey cover expenditures starting with academic FY 2010. The survey population is made up of academic institutions that grant a bachelor's degree or a higher degree in any field and spend at least $150,000 annually on all separately budgeted R&D.

Like its predecessor, HERD captures comparable information on R&D expenditures by sources of funding and field, which allows for continued trend analysis. It also includes a more comprehensive treatment of S&E and non-S&E fields, an expanded population of surveyed institutions, and greater detail about the sources of funding for R&D expenditures by field. Improvements in the redesigned survey are more fully described in Britt (2010).

As did its predecessor, HERD captures data on moveable research equipment purchased from current operating funds. Fixed equipment and capital construction projects are not included in the R&D expenditure totals.

HERD data are in current-year dollars and reported on an academic-year basis (e.g., FY 2012 covers July 2011–June 2012 for most institutions).

Data on federal obligations for academic R&D are reported in chapter 4; that chapter also provides data on the academic sector's share of the nation's overall R&D.

The data on research facilities and cyberinfrastructure come from the Survey of Science and Engineering Research Facilities. The facilities survey includes all universities and colleges in HERD with $1 million or more in R&D expenditures. Starting in 2003, the facilities survey included data on computing and networking capacities.

One-time ARRA funding was responsible for a sizable amount of academic R&D expenditures from 2010 to 2012 (over $9.3 billion). ARRA expenditures peaked in 2011 at $4.2 billion. In 2010 and 2012, they were similar—around $2.5 billion in each of these years (table 5-1). Looking across the period from 2009 to 2012, academic R&D expenditures would have increased by an average annual rate of 1.8% after adjusting for inflation if ARRA had not been enacted; with ARRA funds, these expenditures increased by an average annual rate of 3.1% after adjusting for inflation.[4] ARRA expenditures are expected to appear in the academic R&D total through 2014, in diminishing amounts.

A methodological change also contributed to the growth in reported academic R&D expenditures in recent years. As a result of a more extensive screening effort during the first year of the redesigned HERD survey to include institutions with substantial non-S&E R&D, 170 institutions were added to the survey population. The additional universities accounted for $533 million in total R&D expenditures in FY 2011.

Academic R&D spending is primarily for basic research—in 2012, 64% was spent on basic research, 27% was spent on applied research, and 9% was spent on development (table 5-2).[5] The estimated percentage of spending on basic research is somewhat less than institutions had reported throughout the late 1990s and the 2000–09 decade (appendix table 5-2). Improvements to the survey question in 2010 likely affected how universities reported these shares.[6]

Academic institutions spent a total of $3.5 billion on R&D in non-S&E fields in FY 2012, an increase of 7% (before adjusting for inflation) over the $3.3 billion spent in 2011 (table 5-3).[7] The federal government funds a much smaller proportion of R&D in non-S&E than in S&E fields: 34% of the $3.5 billion spent on non-S&E R&D in FY 2012, compared to 63% of the $62.3 billion spent that year on S&E R&D. The largest amounts reported for R&D in non-S&E fields were for education ($1.2 billion), business and management ($440 million), and humanities ($340 million).

Sources of Support for Academic S&E R&D

Academic R&D relies on funding support from a variety of sources, including the federal government, universities' and colleges' own institutional funds, state and local government, business, and other organizations (appendix table 5-3). The federal government has consistently provided the majority of funding for academic R&D in S&E. In 2012, the National Research Council reviewed the state of U.S. research universities and issued a report exploring ways to strengthen the partnership between government, universities, and industry in support of national goals (see the sidebar "National Research Council: Recommendations to Strengthen America's Research Universities").

Federal Expenditures

The federal government provided $38.9 billion (63%) of the $62.3 billion of academic spending on S&E R&D in FY 2012 (figure 5-1).[8] The federal share was somewhat higher in the 1970s, although the federal government has long contributed the majority of funds for S&E academic R&D (figure 5-2). For the most part, federal R&D funding to the academic sector is allocated through competitive peer review.

Federal expenditures for S&E academic R&D increased more from 2009 to 2012 (4.5% inflation-adjusted annual growth rate) than they did from 2005 to 2008 (–0.6% inflation-adjusted annual growth rate). The higher growth rates in later years largely reflect ARRA expenditures. Universities

Table 5-1

Federally financed higher education R&D expenditures funded by the American Recovery and Reinvestment Act of 2009, by institution type and control: FYs 2010–12

(Thousands of dollars)

Type of institution	2010			2011			2012		
	All federal R&D expenditures	ARRA	Non-ARRA	All federal R&D expenditures	ARRA	Non-ARRA	All federal R&D expenditures	ARRA	Non-ARRA
All institutions	37,477,100	2,684,122	34,792,978	40,771,096	4,173,353	36,597,743	40,130,460	2,446,913	37,683,547
Very high research	27,641,468	1,980,718	25,660,750	30,047,688	3,113,463	26,934,225	29,845,004	1,814,405	28,030,599
High research and doctoral research	4,166,736	235,252	3,931,484	4,539,039	398,103	4,140,936	4,488,204	286,804	4,201,400
Special focus	3,728,104	317,508	3,410,596	3,989,628	484,395	3,505,233	3,682,928	234,013	3,448,915
Other	1,940,792	150,644	1,790,148	2,194,741	177,392	2,017,349	2,114,324	111,691	2,002,633
Public	23,351,313	1,609,243	21,742,070	25,388,804	2,547,655	22,841,149	25,112,353	1,612,725	23,499,628
Private	14,125,787	1,074,879	13,050,908	15,382,292	1,625,698	13,756,594	15,018,107	834,188	14,183,919

ARRA = American Recovery and Reinvestment Act of 2009.

NOTES: Data include S&E and non-S&E federal expenditures. Data for FY 2012 include only those institutions with $1 million or more in total R&D expenditures. Institutions reporting less than $1 million in total R&D expenditures completed a shorter version of the FY 2012 survey form and that form did not request information on ARRA-funded expenditures.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Higher Education Research and Development Survey.

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Table 5-2

Higher education R&D expenditures, by source, character of work, and institutional control: FYs 2010–12

(Thousands of dollars)

Fiscal year and institution type	All sources				Federal sources			
	Total	Basic research	Applied research	Development	Total	Basic research	Applied research	Development
2010								
All institutions	61,257,398	40,447,510	15,509,065	5,300,823	37,477,100	25,385,643	9,417,733	2,673,724
Public	41,233,759	27,269,400	10,397,033	3,567,326	23,351,313	15,806,171	5,733,271	1,811,871
Private	20,023,639	13,178,110	5,112,032	1,733,497	14,125,787	9,579,472	3,684,462	861,853
2011								
All institutions	65,274,235	42,524,917	17,015,016	5,734,302	40,771,096	27,096,972	10,713,838	2,960,286
Public	43,913,855	28,865,817	11,350,366	3,697,672	25,388,804	16,970,999	6,599,322	1,818,483
Private	21,360,380	13,659,100	5,664,650	2,036,630	15,382,292	10,125,973	4,114,516	1,141,803
2012								
All institutions	65,774,524	41,992,517	17,718,281	6,063,726	40,130,460	26,072,764	10,890,277	3,167,419
Public	44,180,528	28,635,051	11,785,332	3,760,145	25,112,353	16,524,660	6,715,555	1,872,138
Private	21,593,996	13,357,466	5,932,949	2,303,581	15,018,107	9,548,104	4,174,722	1,295,281

NOTE: Data include S&E and non-S&E R&D expenditures.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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Table 5-3
R&D expenditures in non-S&E fields at universities and colleges: FYs 2010–12
(Millions of current dollars)

Field	2010 Total expenditures	2010 Federal expenditures	2011 Total expenditures	2011 Federal expenditures	2012 Total expenditures	2012 Federal expenditures
All non-S&E fields	2,897	967	3,278	1,118	3,508	1,195
Business and management	368	86	400	100	442	96
Communication, journalism, and library science	130	41	153	53	159	53
Education	995	536	1,115	630	1,229	686
Humanities	263	58	313	61	341	68
Law	98	19	125	27	132	25
Social work	177	94	194	105	199	109
Visual and performing arts	66	5	77	7	85	10
Other non-S&E fields	800	127	901	134	922	148

NOTE: Detail may not add to total because some respondents reporting non-S&E R&D expenditures did not break out total and federal funds by non-S&E fields.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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reported $4.2 billion in expenditures funded by ARRA in FY 2011 and an additional $2.4 billion in ARRA expenditures in FY 2012 (table 5-1). The distribution of ARRA funds across institutions—with just under three-quarters of these funds spent at the nation's most research-intensive schools—generally mirrored the overall federal distribution of funds for academic R&D discussed below.

Basic research activities represented 65% of federal expenditures for academic R&D in FY 2012 (table 5-2).[9] Applied research represented 27%, and development activities accounted for the remaining 8%. The distribution in FY 2011 was very similar. Chapter 4 provides further detail on federal obligations for academic R&D, by character of work.

Top Federal Agency Supporters

Six agencies are responsible for the vast majority of annual federal expenditures for academic R&D: the Department of Health and Human Services (HHS), in particular, the National Institutes of Health (NIH); the National Science Foundation (NSF); the Department of Defense (DOD); the Department of Energy (DOE); the National Aeronautics and Space Administration (NASA); and the Department of Agriculture (USDA). In federal FY 2012, these six agencies represented over 92% of the estimated $38.9 billion federal expenditures for academic S&E R&D (appendix table 5-4; chapter 4 provides data on these agencies' obligations for academic R&D).[10]

Among these six agencies, HHS is by far the largest funder, providing about 56% of total federal academic S&E R&D expenditures in FY 2012. NSF and DOD follow HHS, each providing between 12% and 13%; DOE, NASA, and USDA provided smaller shares of between 3% and 5% of total federal academic S&E R&D expenditures in FY 2012. From 2003 to 2012, the relative ranking of the top six funding agencies in terms of academic S&E R&D expenditures has remained relatively stable (table 5-4).

The federal government's overall support for academic R&D is the combined result of numerous discrete funding decisions made by the R&D-supporting federal agencies, with input from the White House and Congress. Varying missions, priorities, and objectives affect the level of funds that universities and colleges receive as well as how they are spent. Broad geographic distribution of academic research capability and federal funding of academic R&D is one such objective. The Experimental Program to Stimulate Competitive Research (EPSCoR) is a long-standing, multiagency federal program that seeks to increase the geographical dispersion of federal support for academic R&D. An overview of the program and recent statistics on its activities are presented in the sidebar "Experimental Program to Stimulate Competitive Research."

Other Sources of Funding

Notwithstanding the continuing dominant federal role in academic S&E R&D funding, nonfederal funding sources have also grown steadily over the past 15 years (figure 5-1). Adjusted for inflation, annual growth in nonfederal funding for academic R&D averaged almost 4% from 1996 to 2012.

- **University and college institutional funds.** In FY 2012, institutional funds from universities and colleges comprised the second-largest source of funding for academic S&E R&D, accounting for over 19% ($12.1 billion) of the total (appendix table 5-5). The share of support represented by institutional funds has remained near 20% since 1990 (appendix table 5-3). In addition to internal funding from general revenues, institutionally financed R&D includes unrecovered indirect costs and committed cost sharing.[11]

- **State and local government funds.** State and local governments provided 5.5% ($3.4 billion) of academic S&E R&D funding in FY 2012. The state and local government funding share has declined from a peak of 10% in the early 1970s to below 6% in recent years. However, these figures are likely to understate the actual contribution of state and local governments to academic R&D, particularly for public institutions, because they reflect only funds that these governments directly target to academic R&D activities.[12] They exclude any general-purpose, state government, or local government appropriations that academic institutions designate and use to fund separately budgeted research or to pay for unrecovered indirect costs; such funds are categorized as institutional funds. (See chapter 8, "State Indicators," for some indicators of academic R&D by state.)
- **Nonprofit funds.** Nonprofit organizations provided 5.9% ($3.7 billion) of academic S&E R&D funding in FY 2012, a slightly higher share than that provided by state and local governments. A relatively large share of S&E nonprofit

National Research Council: Recommendations to Strengthen America's Research Universities

In 2010, the Committee on Research Universities of the National Academies' National Research Council (NRC) undertook a 2-year effort to examine the health and competitiveness of the nation's research universities and assess their capacity to compete globally. Prompted by a request from a bipartisan group of senators and congressmen, the NRC study Research Universities and the Future of America: Ten Breakthrough Actions Vital to Our Nation's Prosperity and Security (NRC 2012) emphasized the importance of partnerships among institutions involved in research, efficiency and productivity in research operations, and efforts to cultivate research talent.

The NRC report gave the following recommendations:

- The federal government should adopt stable, efficient, and effective policies and funding for university R&D and for graduate education.
- States should provide public research universities with greater autonomy to compete strategically. States also should strive to restore per-student funding to the mean inflation-adjusted level for the 15-year period covering 1987–2002. The federal government should provide incentives to strengthen state support for public research universities.
- The partnership between businesses and other research-performing institutions should be strengthened so that new knowledge, ideas, and technology are transferred more rapidly into the economy.
- Universities, university associations, and key stakeholders should work together to increase university efficiency and provide a greater return on investment for research sponsors while also educating key audiences about the value of U.S. research universities.
- The federal government should create a Strategic Investment Program to fund education and research initiatives that advance key national priorities. This effort should include a program of endowed faculty chairs to facilitate the careers of young investigators and a program to strengthen universities' research infrastructures, with an initial focus on cyberinfrastructure.
- The federal government and other research sponsors should strive to fund the full costs of research projects that they sponsor at research universities.
- Federal and state governments should eliminate regulations that increase administrative costs and impede research productivity without improving the research environment. Specifically, state and federal policymakers should review the costs and benefits of regulations and eliminate those regulations whose costs outweigh their benefits. Furthermore, the federal government should make regulations and reporting requirements more consistent across agencies.
- Research universities, federal agencies, and employers across all sectors should improve the capacity of graduate programs to attract talented students by addressing attrition rates, length of time to degree, funding, and alignment with both student career opportunities and national interests. To do so, the federal government should increase its support for graduate education, and employers should engage more deeply with research university programs, for example, by providing internships and advising on curriculum design.
- Research universities, government at all levels, and other stakeholders should strive to ensure that all Americans, including women and underrepresented minorities, have the opportunity to study and eventually pursue careers in science, technology, engineering, and mathematics (STEM). To do so, research universities should participate in efforts to improve STEM education at the primary- and secondary-school levels.
- The federal government should ensure that the United States continues to benefit strongly from the participation of international students and scholars in research. Specifically, federal agencies should recruit international scholars; make it easier for researchers to obtain permanent residency or U.S. citizenship; and, consistent with homeland security considerations, improve the efficiency of visa processing.

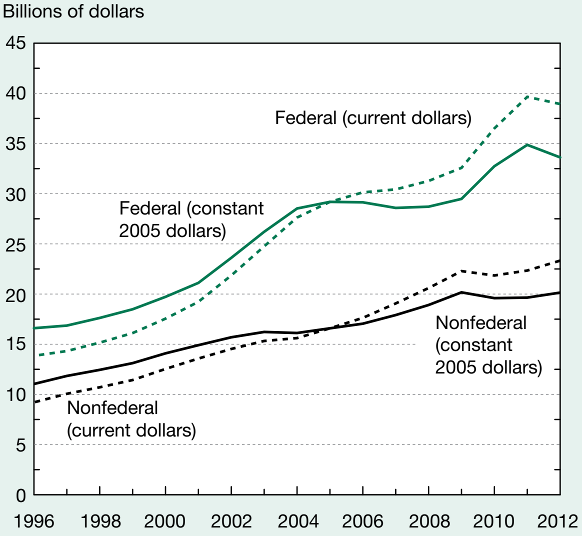
funding (73%) is directed toward R&D in life sciences. Life sciences comprise somewhat less (60%) of total federal funding for S&E academic R&D (appendix table 5-5).

- **Business funds.** At $3.2 billion in FY 2012, support from the business sector accounts for the smallest share of academic S&E R&D funding (5.1%). Support for academia has never been a major component of business-funded R&D in the United States, although it is in some other countries (figure 5-3).
- **Other sources of funds.** In FY 2012, all other sources of support, such as foreign-government funding or gifts designated for research, accounted for less than 2% (just under $1 billion) of academic S&E R&D funding.

Academic R&D Expenditures, by Field

Investment in academic S&E R&D is distributed across eight broad fields, including life sciences, engineering, physical sciences, environmental sciences, social sciences, computer sciences, psychology, and mathematical sciences (appendix table 5-5). Expenditures have long been concentrated in life sciences, which have received more than half of

Figure 5-1
Federal and nonfederal academic S&E R&D expenditures: FYs 1996–2012



NOTES: Data include expenditures for S&E R&D. Gross domestic product implicit price deflators were used to convert current dollars to constant 2005 dollars.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey. See appendix table 5-2.

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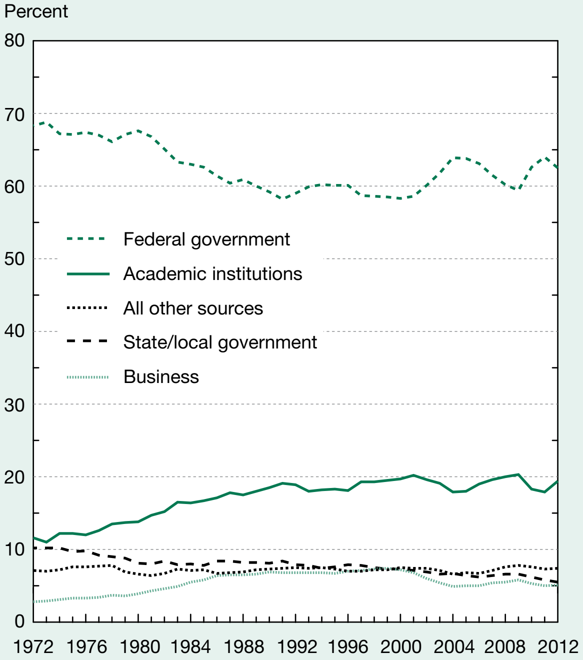
Figure 5-2
Academic S&E R&D expenditures, by source of funding: FYs 1972–2012



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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Table 5-4
Top six federal agencies' shares of federally funded academic R&D expenditures: FYs 2003–12
(Percent)

Agency	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Health and Human Services............	44.3	51.8	55.8	56.7	56.1	56.0	55.4	57.3	57.4	55.6
National Science Foundation	9.9	11.7	12.1	11.9	11.7	12.1	12.1	12.5	12.5	13.0
Department of Defense	8.2	9.0	8.9	9.2	9.1	9.8	10.4	12.1	12.0	12.4
Department of Energy	3.3	3.4	3.6	3.7	3.7	3.6	3.8	4.2	4.7	5.0
National Aeronautics and Space Administration..................	3.8	4.0	3.9	3.5	3.5	3.4	3.4	4.0	3.6	3.4
Department of Agriculture	2.6	2.8	2.8	2.9	3.0	2.9	2.8	2.6	2.5	2.8

NOTE: Health and Human Services includes primarily the National Institutes of Health.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Higher Education Research and Development Survey.

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all academic R&D expenditures for more than three decades. Life sciences consist primarily of medical sciences, biological sciences, and agricultural sciences. In FY 2012, academic R&D in life sciences accounted for $37.2 billion (60%) of the $62.3 billion academic S&E R&D total. R&D projects in life sciences constituted a slightly smaller share—58%—of federally supported academic S&E R&D that year.

Within life sciences, medical sciences accounted for 55% of the total academic R&D; biological sciences accounted for another 31%. Adjusted for inflation, academic R&D expenditures in medical sciences almost doubled from FY 1999 to FY 2011 (figure 5-4) and then dropped slightly in FY 2012. The sizeable increase from FY 1999 to FY 2011 resulted, in part, from a near-doubling of NIH's budget from 1998 to 2003. Academic R&D expenditures in biological sciences (and in life sciences as a whole) increased by about 80% from FY 1999 to FY 2011 after adjusting for inflation. As with medical sciences, academic R&D expenditures in biological sciences dipped slightly in FY 2012. Meanwhile, expenditures in agricultural sciences rose slightly from FY 2011 to FY 2012.

Experimental Program to Stimulate Competitive Research

The Experimental Program to Stimulate Competitive Research (EPSCoR) is based on the premise that universities and their S&E faculty and students are valuable resources that potentially can influence a state's development in the 21st century in much the same way that agricultural, industrial, and natural resources did in the 20th century.

EPSCoR's purposes and early history are rooted in the early history of the National Science Foundation (NSF) and federal support of R&D. In 1978, Congress authorized NSF to initiate EPSCoR in response to broad public concerns about the extent of geographical concentration of federal funding for R&D. Eligibility for EPSCoR participation was limited to those jurisdictions that historically have received lesser amounts of federal R&D funding and have demonstrated a commitment to develop their research bases and improve the quality of S&E research conducted at their universities and colleges. EPSCoR sought to increase the R&D competitiveness of eligible states through the development and utilization of the science and technology (S&T) resources residing in their most research-oriented universities. The program sought to achieve this objective by (1) stimulating sustainable S&T infrastructure improvements at the state and institutional levels that would significantly increase the ability of EPSCoR researchers to compete for federal and private sector R&D funding, and (2) accelerating the movement of EPSCoR researchers and institutions into the mainstream of federal and private-sector R&D support.

The experience of the NSF EPSCoR program during the 1980s prompted Congress to authorize the creation of EPSCoR and EPSCoR-like programs in six other federal agencies: the Departments of Energy, Defense (DOD), and Agriculture; the National Aeronautics and Space Administration; the National Institutes of Health; and the Environmental Protection Agency (EPA). Two of these, EPA and DOD, discontinued issuing separate EPSCoR program solicitations in FY 2006 and FY 2010, respectively.

In FY 2012, the five remaining agencies spent a total of $483.8 million on EPSCoR and EPSCoR-like programs, up from $225.3 million in 2001 (table 5-A).

Table 5-A

EPSCoR and EPSCoR-like program budgets, by agency: FYs 2001–12

(Millions of dollars)

Agency	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
All agencies	225.3	288.9	358.0	353.3	367.4	367.1	363.1	418.9	437.2	460.1	436.0	483.8
DOD	18.7	15.7	15.7	8.4	11.4	11.5	9.5	17.0	14.1	0.0	0.0	0.0
DOE	7.7	7.7	11.7	7.7	7.6	7.3	7.3	14.7	16.8	21.6	8.5	8.5
EPA	2.5	2.5	2.5	2.5	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NASA	10.0	10.0	10.0	10.0	12.0	12.5	12.8	15.5	20.0	25.0	25.0	18.4
NIH	100.0	160.0	210.0	214.0	222.0	220.0	218.0	223.6	224.3	228.8	226.5	276.5
NSF	74.8	79.3	88.8	93.7	93.4	97.8	101.5	120.0	133.0	147.1	146.8	150.9
USDA	11.6	13.7	19.3	17.0	18.6	18.0	14.0	28.1	29.0	37.6	29.2	29.5

DOD = Department of Defense; DOE = Department of Energy; EPA = Environmental Protection Agency; EPSCoR = Experimental Program to Stimulate Competitive Research; NASA = National Aeronautics and Space Administration; NIH = National Institutes of Health; NSF = National Science Foundation; USDA = U.S. Department of Agriculture.

NOTES: EPA and DOD discontinued issuing separate EPSCoR program solicitations in FY 2006 and FY 2010, respectively. USDA reported budget in FY 2012 includes $6.8 million in unobligated funds.

SOURCE: Data are provided by agency EPSCoR representatives and are collected by the NSF Office of Integrative Activities, Office of EPSCoR, January 2013.

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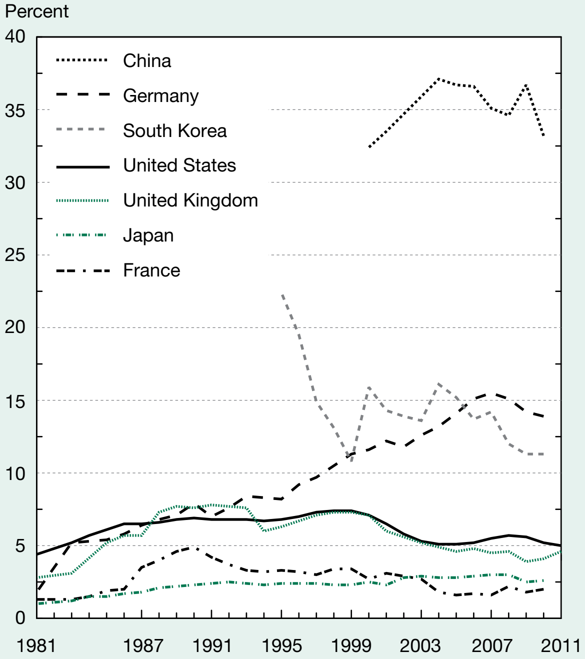
The other broad fields of S&E experienced different rates of growth in recent years. Growth in inflation-adjusted academic R&D expenditures from FY 1999 to FY 2012 was greater in engineering (82%) than in environmental sciences (35%), physical sciences (37%), or social sciences (29%). Inflation-adjusted expenditures for computer sciences and mathematical sciences increased by from 50% to 60% from FY 1999 to FY 2012, and expenditures for psychology doubled, although the growth in these fields started at lower bases than the other broad fields of S&E (figure 5-4). Certain smaller fields within the broad fields have experienced steady growth in recent years. For example, academic R&D expenditures for astronomy, a field within physical sciences, although small relative to other fields, have increased steadily in recent years (appendix table 5-1). Even after adjusting for inflation, academic expenditures for astronomy grew by 34% from 2005 to 2012. Similarly, within the social sciences, sociology has also seen steady growth in recent years; from 2005 to 2012, expenditures increased by 24% after adjusting for inflation.

Figure 5-3

Academic R&D financed by business for selected countries: 1981–2011



NOTES: Data are from the top seven R&D performing countries. Data are not available for all countries for all years. Data for Japan for 1996 onward may not be consistent with earlier data due to changes in methodology. Data for China for 2001 and 2002 are estimated by the National Science Foundation. Data for the United States are collected as part of *National Patterns of R&D Resources* and differ from Higher Education Research and Development expenditures data; pass-through funds are removed.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2012/2).

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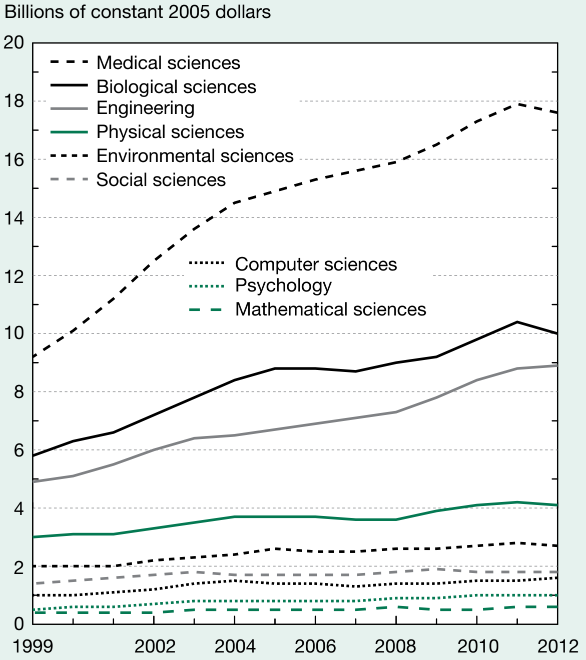
Agencies differ in the extent to which they focus funds on various fields of S&E (figure 5-5). HHS—primarily NIH—supports the vast majority of federal funding in life sciences (84%) and is also the lead funding agency in psychology and the social sciences. By contrast, and while their shares of total academic R&D funding are much smaller, DOD, DOE, NASA, and NSF have more diversified funding patterns. In FY 2012, NSF was the lead federal funding agency for academic research in physical sciences, mathematics, computer sciences, and environmental sciences. DOD was the lead funding agency in engineering.

Federal funding has played a larger role in overall support for some fields than others (appendix table 5-5). The federal government is the dominant funder in S&E fields such as atmospheric sciences (82% in FY 2012), physics (77%), and aeronautical and astronautical engineering (76%). It plays a smaller role in other S&E fields, such as agricultural sciences (34%).

The federally financed proportion of R&D spending in *all* of the broad S&E fields has generally been stable or has increased since 1990.[13] This reverses the trend between 1975 and 1990, when the federal share had declined in all the broad fields.

Figure 5-4

Academic R&D expenditures, by selected S&E field: FYs 1999–2012



NOTE: See appendix table 4-1 for the gross domestic product implicit price deflators used to convert current dollars to constant 2005 dollars.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey. See appendix table 5-1.

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Academic R&D, by Institution Type

The prior discussion examined R&D for the academic sector as a whole. This section discusses some of the differences in S&E R&D conducted by public and private universities and colleges. Although public and private universities rely on the same major sources of S&E R&D funding, the importance of the different sources varies substantially (figure 5-6). For example, endowments generally provide a larger share of total revenue at private universities than at public universities, while state appropriations provide a larger share of total revenue at public universities. (See the section "Trends in Higher Education Expenditures and Revenues" in chapter 2 for a discussion of average university revenue and expenditures per student at different types of institutions.)

R&D Expenditures at Public and Private Universities and Colleges

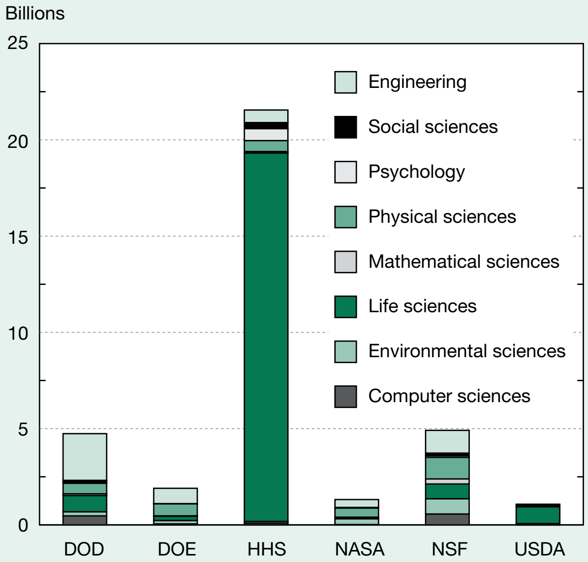
In FY 2012, public institutions spent $41.6 billion in academic S&E R&D, and private institutions spent $20.6 billion, about one-half as much (appendix table 5-3). Similarly, of the top 100 academic institutions in academic R&D expenditures in 2012, two-thirds were public universities and colleges, and one-third were private schools (appendix table 5-6).

The federal government provided the majority of the S&E R&D funds that public and private institutions spent on R&D in FY 2012 (just under 60% and just over 70%, respectively). Public institutions received around 7% of their S&E R&D funds from state and local governments, while private institutions received a little less than 2%.

At both public and private academic universities, institutions' own funds were a significant source of support for S&E R&D expenditures. Public academic institutions supported a larger portion of their S&E R&D from their own sources—22%, compared to 13% at private institutions. This larger proportion of institutional R&D funds in public institutions may reflect the general-purpose state and local government funds that public institutions directed toward R&D. Private institutions, in contrast, reported a larger proportion of unrecovered indirect costs (43% of their institutional total in FY 2012 versus 31% for public institutions).[14] Private institutions also reported a larger proportion of cost sharing (14% of their institutional total in FY 2012 versus 8% for public institutions).

Public and private institutions both received 5%–6% of their R&D support from business in FY 2012. Nonprofit organizations funded 5.5% of total R&D expenditures in public institutions and 7.4% in private institutions. Funding from all other sources was less than 2% in both public and private institutions.

Figure 5-5
Federally financed academic R&D expenditures, by agency and S&E field: FY 2012



DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = U.S. Department of Agriculture.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey, FY 2012. See appendix table 5-4.

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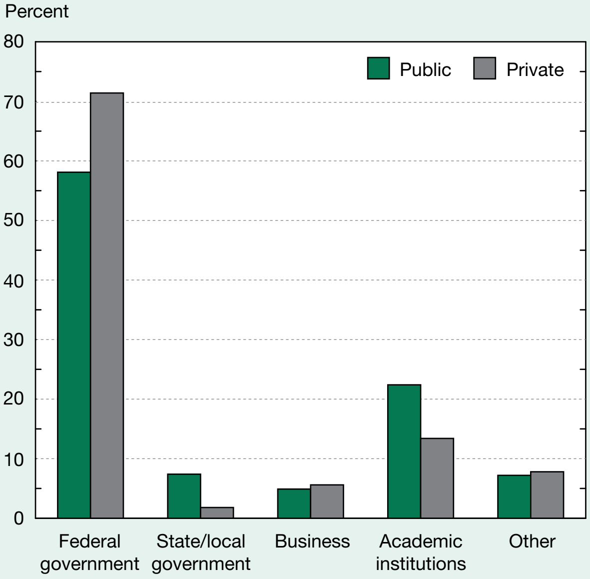
Figure 5-6
Sources of S&E R&D funding for public and private academic institutions: FY 2012



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey, FY 2012. See appendix table 5-3.

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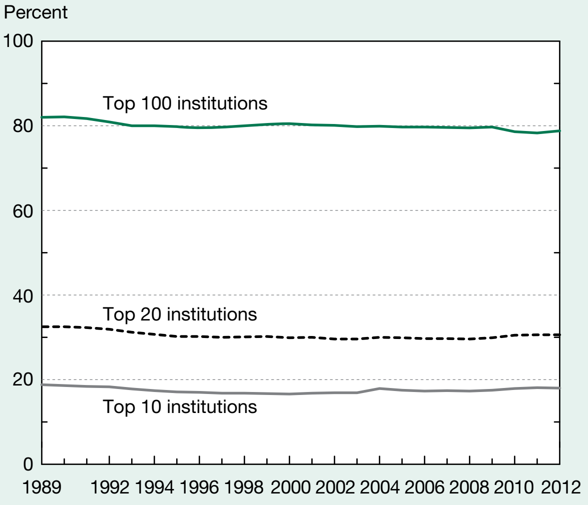
Distribution of R&D Funds across Academic Institutions

Academic R&D expenditures are concentrated in a relatively small number of institutions. In FY 2012, 907 out of a total of approximately 2,250 baccalaureate-, master's-, and doctorate-granting institutions reported spending at least $150,000 on R&D. Of these, the top-spending 20 institutions accounted for 31% of total academic S&E R&D spending, and the top-spending 100 institutions accounted for 79% of this spending. Although there were slight shifts in the share of academic S&E R&D expenditures accounted for by the top 20 and top 100 institutions in recent years, the relative shares have been remarkably stable over the past two decades (figure 5-7). Even so, the identities of the universities in each of these groups have varied over time. The top 100 institutions in S&E R&D are listed in appendix table 5-6.

R&D Collaboration between Academic Institutions

Research collaboration involving multiple institutions is a growing trend. Contributing to this growth are federal initiatives to encourage collaborative research and also technological advances that facilitate communication and provide opportunities to mobilize specialized skills beyond the capacity of an individual institution. Opportunities to share risk and increase research credibility have also contributed to the growth of collaborative R&D (Cummings and Kiesler 2007). Academic R&D collaboration is notably evident in the growth of jointly authored research articles (for details, see the section "Outputs of Academic S&E Research: Articles and Patents" in this chapter).

Figure 5-7
Share of academic S&E R&D, by institution rank in R&D expenditures: FYs 1989–2012



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Higher Education Research and Development Survey. See appendix table 5-6.

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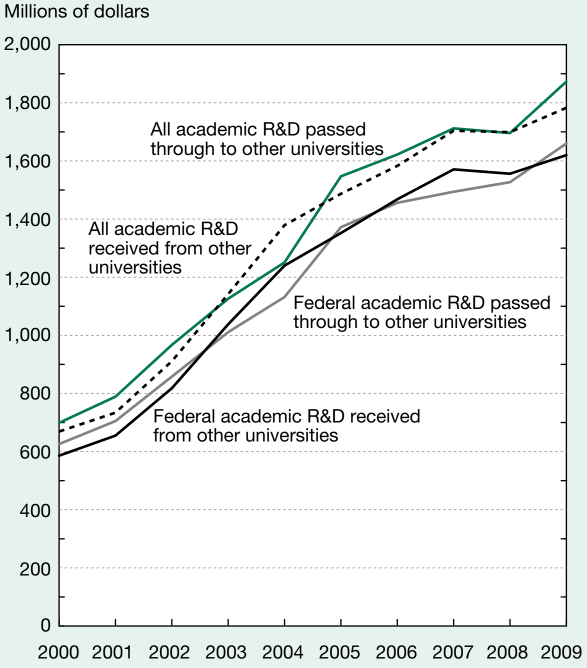
This trend is also evident in flows of funds among institutions to support collaborative research activities. One measure of this research collaboration is the amount of total expenditures for R&D that universities pass through to others, including academic institutions and other entities. Available data on pass-through funding encompass S&E R&D from 2000 to 2009 and total R&D (including non-S&E as well as S&E funds) from 2010 to 2012. As with overall academic R&D funding, pass-through funding arrangements are heavily concentrated in the most research-intensive institutions.

Between FY 2000 and FY 2009, pass-through funding for collaborative projects among universities and colleges grew more rapidly (although from a much lower base) than the decade's growth in overall academic R&D expenditures (appendix table 5-7; see also Hale [2012]). In FY 2000, total academic S&E R&D expenditures stood at $30.1 billion; this grew to $54.9 billion in FY 2009, an increase of 47% after adjusting for inflation. In contrast, the pass-through funds that universities provided to other universities from FY 2000 to FY 2009 more than doubled over this period of time, rising from $700 million in FY 2000 to $1.9 billion in FY 2009.[15]

The federal government contributed extensively to the growth in pass-through funding from FY 2000 to FY 2009. Almost 90% of all pass-through funds that universities provided to other universities came from federal funds during this decade (figure 5-8), a larger share than the federal government's share of total academic R&D expenditures.

Figure 5-8
Total and federally funded academic S&E R&D pass-throughs: FYs 2000–09



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges.

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From 2010 to 2012, pass-through funding continued to increase. The federal government continues to be the major provider of pass-through funds; in FY 2012, it was the source for over 85% of all pass-through funds provided or received (tables 5-5 and 5-6).

The growth in pass-through funding has been accompanied by changing research practices, seen particularly in the growth of larger research teams, including many that span multiple disciplines, and in increasing numbers of coauthored articles (discussed later in this chapter in the section “Outputs of Academic S&E Research: Articles and Patents”). Although interdisciplinary research is widely viewed as a growing trend in academic S&E R&D, developing a generally agreed-on concept of interdisciplinary research and measuring how it has grown have proven to be challenging. (See the sidebar “Can Bibliometric Data Provide Accurate Indicators of Interdisciplinary Research?” in *Science and Engineering Indicators 2010* [NSB 2010:5–35].) Efforts have been undertaken to measure the extent to which interdisciplinary research involves closely related versus dissimilar fields. For example, Porter and Rafols (2009) suggest that article citations are mainly distributed among closely related disciplinary areas, reflecting relatively modest increases in interdisciplinarity over the past 30–40 years.

Infrastructure for Academic R&D

Physical infrastructure is an essential resource for the conduct of R&D. Not long ago, the capital infrastructure for R&D consisted primarily of research space (e.g., laboratories and computer rooms) and instrumentation. Accordingly, the square footage of a designated research space and counts of instruments have been the principal indicators of the status of research infrastructure.

Advances in information technology have brought significant changes to both the methods of scientific research and the infrastructure necessary to conduct R&D. The technologies, human interfaces, and associated processing

Table 5-5

Total and federally financed higher education R&D expenditures passed through to subrecipients, by institutional control: FY 2012

(Thousands of dollars)

		R&D expenditures passed through to subrecipients				
R&D expenditures and type of institution	All R&D expenditures	Total	Higher education subrecipients	Businesses	Nonprofit organizations	Other subrecipients
Total R&D, all institutions	65,774,524	5,538,500	3,069,428	1,059,136	831,731	578,205
Public	44,180,528	3,508,057	1,947,649	730,506	475,926	353,976
Private	21,593,996	2,030,443	1,121,779	328,630	355,805	224,229
Federally financed R&D, all institutions	40,130,460	4,825,558	2,747,592	875,356	719,952	482,658
Public	25,112,353	3,073,569	1,724,890	641,078	413,454	294,147
Private	15,018,107	1,751,989	1,022,702	234,278	306,498	188,511

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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Table 5-6

Total and federally financed higher education R&D expenditures received as a subrecipient, by institutional control: FY 2012

(Thousands of dollars)

		R&D expenditures received as a subrecipient				
R&D expenditures and type of institution	All R&D expenditures	Total	Higher education passthrough entities	Businesses	Nonprofit organizations	Other passthrough entities
Total R&D, all institutions	65,774,524	6,412,757	2,922,945	1,127,495	1,176,053	1,186,264
Public	44,180,528	4,421,429	1,873,170	802,323	727,619	1,018,317
Private	21,593,996	1,991,328	1,049,775	325,172	448,434	167,947
Federally financed R&D, all institutions	40,130,460	5,650,745	2,687,335	938,593	1,004,832	1,019,985
Public	25,112,353	3,860,761	1,712,539	651,948	621,515	874,759
Private	15,018,107	1,789,984	974,796	286,645	383,317	145,226

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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capabilities resulting from these innovations are often called *cyberinfrastructure.*

Cyberinfrastructure has become an essential resource for science. It helps researchers process, transfer, manage, and store large quantities of data. Cyberinfrastructure includes resources such as high-capacity networks, which are used to transfer information, and data storage systems, which are used for short-term access or long-term curation. It may also involve HPC systems used to analyze data, create visualization environments, or facilitate remote use of scientific instrumentation (NSF 2012). Indicators for research facilities, research equipment, and cyberinfrastructure are highlighted below.

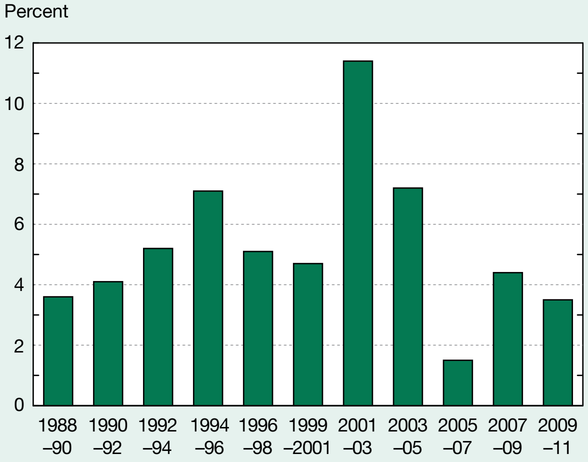
Research Facilities

Research Space

The nation's research-performing colleges and universities had 202.9 million net assignable square feet (NASF) of research space available at the end of FY 2011 (appendix table 5-8).[16] This was 3.5% above the net assignable square footage at the end of FY 2009 and continued more than two decades of expansion. However, this increase was less than the median growth (4.7%) for all biennial periods measured from FY 1988 to FY 2011 (figure 5-9).

Biological and biomedical sciences continued to account for the bulk of growth, increasing by 8.0% during the FY 2009–11 period (appendix table 5-8). This field accounted for the largest portion of research space (26.8%), which totaled 54.3 million NASF.[17] From FY 2001 to FY 2011, research space in biological and biomedical sciences grew 64.5% (figure 5-10). The related field of health and clinical sciences was the second largest in FY 2011, accounting for 36.7 million NASF and 18.1% of the total. Still sizable are engineering (31.7 million NASF, 15.6%); physical sciences (29.6 million NASF, 14.6%); and agricultural and natural resources (27.6 million NASF, 13.6%). Excluding biological and biomedical sciences, total S&E research space has grown only 1.4% since FY 2005. The growth rates have varied across the S&E fields (appendix table 5-8). The computer and information sciences, engineering, and psychology have all increased research space by at least 10%, while

Figure 5-9
Change in S&E research space in academic institutions, by 2-year period: FYs 1988–2011



NOTES: Space is measured in net assignable square feet. The biennial survey cycle ran on even years from FYs 1988–98 and, subsequently, on odd years from FYs 1999–2011.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities.

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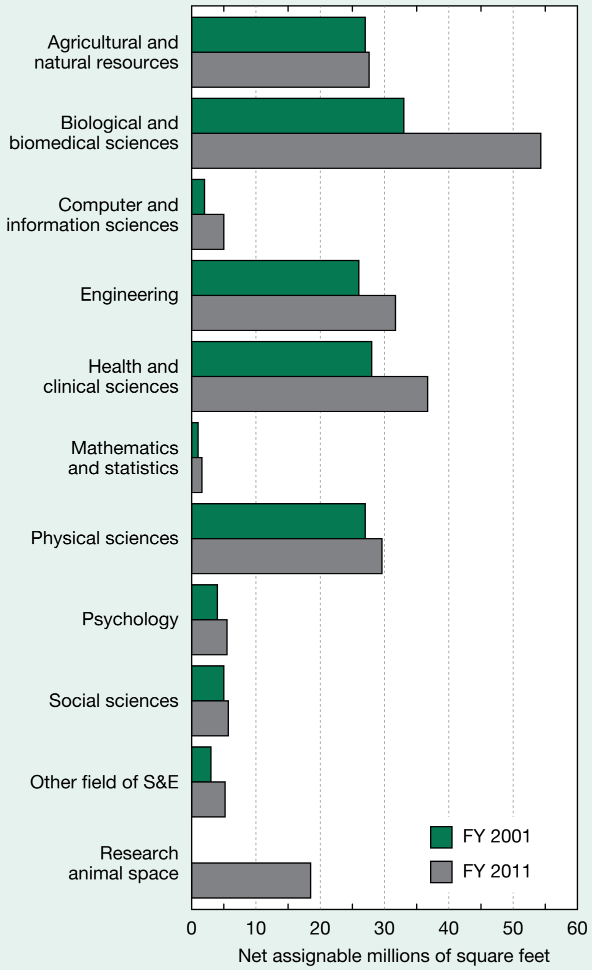
Figure 5-10
S&E research space at academic institutions, by field: FYs 2001 and 2011



NOTES: Research animal space was not collected in FY 2001. S&E fields are those used in the National Center for Education Statistics (NCES) Classification of Instructional Programs (CIP). NCES updates the CIP every 10 years. S&E fields here reflect the NCES 2010 CIP update.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities. See appendix table 5-8.

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space devoted to the other broad science fields has declined or remained the same.[18]

New Construction

New research space is added each year through new construction projects and the repurposing of existing space. Along similar lines, some space is withdrawn from use. The net result has been an increase in research space for more than two decades. As part of this process, academic institutions broke ground on 8.1 million NASF of new S&E research space construction projects in FYs 2010–11. This total is 50% lower than NASF constructed in FYs 2002–03 (table 5-7). Although the growth rate of new construction projects has declined over the past decade, institutions initiated new

Table 5-7
New construction of S&E research space in academic institutions, by field and time of construction: FYs 2002–11

Field	Started in FY 2002 or FY 2003	Started in FY 2004 or FY 2005	Started in FY 2006 or FY 2007	Started in FY 2008 or FY 2009	Started in FY 2010 or FY 2011
	Net assignable square feet (millions)				
All fields	16.2	10.1	8.8	9.9	8.1
Agricultural and natural resources	0.8	0.4	0.5	0.4	0.4
Biological and biomedical sciences	4.0	3.2	2.9	3.5	2.0
Computer and information sciences	1.0	0.3	0.6	0.3	0.1
Engineering	2.2	1.5	1.3	2.1	1.3
Health and clinical sciences	5.0	3.3	1.7	1.9	2.8
Mathematics and statistics	*	*	*	*	*
Physical sciences	2.1	0.8	1.0	1.0	0.9
Earth, atmospheric, and ocean sciences	0.6	0.3	0.3	0.1	0.3
Astronomy, chemistry, and physics	1.5	0.5	0.7	0.9	0.6
Psychology	0.2	0.2	0.1	0.3	0.1
Social sciences	0.2	0.1	0.1	0.2	0.1
Other sciences	0.7	0.3	0.7	0.3	0.3
Research animal space[a]	1.4	1.2	1.0	0.8	0.6
	Share of total new construction square feet (%)				
All fields	100.0	100.0	100.0	100.0	100.0
Agricultural and natural resources	4.9	3.9	5.7	4.0	4.9
Biological and biomedical sciences	24.7	31.4	33.0	35.4	24.7
Computer and information sciences	6.2	2.9	6.8	3.0	1.2
Engineering	13.6	14.7	14.8	21.2	16.0
Health and clinical sciences	30.9	32.4	19.3	19.2	34.6
Mathematics and statistics	*	*	*	*	*
Physical sciences	13.0	7.8	11.4	10.1	11.1
Earth, atmospheric, and ocean sciences	3.7	2.9	3.4	1.0	3.7
Astronomy, chemistry, and physics	9.3	4.9	8.0	9.1	7.4
Psychology	1.2	2.0	1.1	3.0	1.2
Social sciences	1.2	1.0	1.1	2.0	1.2
Other sciences	4.3	2.9	8.0	3.0	3.7
Research animal space[a]	8.6	11.8	11.4	8.1	7.4

* = > 0 but < 50,000 net assignable square feet.

[a] Figures for research animal space are listed separately and are also included in individual field totals.

NOTES: Detail may not add to total because of rounding. S&E fields are those used in the National Center for Education Statistics (NCES) Classification of Instructional Programs (CIP). NCES updates the CIP every 10 years; S&E fields here reflect the NCES 2010 CIP update. For comparison of subfields in the FY 2005 and FY 2007 surveys, see S&E Research Facilities: FY 2007, detailed statistical tables.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities.

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construction in all fields in this latest period. The health and clinical sciences and the biological and biomedical sciences fields both saw 2.0 million NASF or more of new construction initiated. Engineering research space construction accounted for 1.3 million NASF. No other fields added more than 0.9 million NASF through new construction during this time.

Academic institutions draw on various sources to fund their capital projects, including the institutions' own funds, state or local governments, and the federal government (appendix table 5-9). Institutions provide the majority of funds for construction of new research space, typically accounting for over 60.0% of the cost. For the construction of new research space initiated in FYs 2010–11, 61.9% of the funding came from institutions' internal sources, 30.5% from state and local governments, and the remaining 7.6% from the federal government. The percentage of this funding from institutional sources has remained the same since FYs 2006–07.[19] The federal portion of funding has been under 10.0% in recent years but declined to 3.2% in FYs 2008–09 before this recent bounce.

Repair and Renovation

Academic institutions expended $3.5 billion on major repairs and renovations of S&E research space in FYs 2010–11 (appendix table 5-10).[20] They anticipated $3.1 billion in costs for planned repair and renovation of research space with start dates in FYs 2012–13. Nearly $1.0 billion was planned to improve space in biological and biomedical sciences as well as close to $1.0 billion for improvements to health and clinical sciences space. In addition to these slated improvements, academic institutions reported $4.8 billion in repair and renovation projects from their institutional plans that were not yet funded or scheduled to start in FYs 2012–13. An additional $2.6 billion in needed improvements were identified that lay beyond institutional plans. The total backlog of deferred improvements was greater than all projects started or planned for the FY 2010–13 period. The costs for deferred repairs and renovations have consistently been greater than those started or planned for similar cycles in the past.

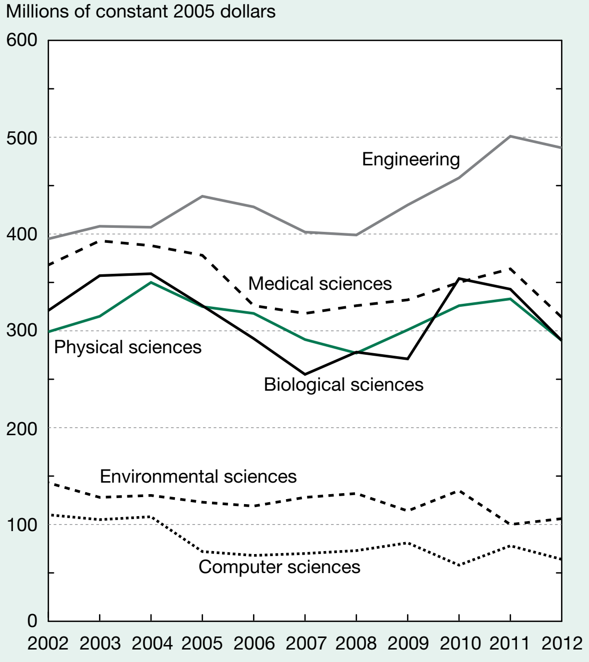
Research Equipment

In FY 2012, about $2.0 billion in current funds were spent for movable S&E academic research equipment necessary for the conduct of organized research projects (appendix table 5-11).[21] This spending accounted for 3.2% of the $62.3 billion of total academic S&E R&D expenditures. Spending decreased 11.6% from FY 2011 to FY 2012 when adjusted for inflation. Expenditures for academic research equipment reached the highest mark in several decades in FY 2004. Due in part to ARRA funding, research equipment expenditures approached this level again in FYs 2010–11. After this temporary increase, the FY 2012 expenditures fell to the lowest level measured in constant dollars since FY 2001.

Research equipment expenditures continue to be concentrated in just a few S&E fields. In FY 2012, three fields accounted for 85.8% of the annual total: life sciences (41.0%), engineering (28.1%), and physical sciences (16.7%). The shares for these three fields have remained similarly predominant for many years (appendix table 5-11). Even so, when adjusted for inflation, the annual level of equipment spending in engineering, physical sciences, and the largest life sciences subfields of biological sciences and medical sciences declined from FY 2011 to FY 2012 to pre–FY 2010 levels (figure 5-11).

Some academic research equipment funding comes from the federal government. These federal funds are generally received as part of research grants or as separate equipment grants. In FY 2012, the federal government supported 57.0% of total academic S&E research equipment funding, which marked a 6 percentage point decline from the 25-year high reached in FY 2011 (appendix table 5-12). The federal share of funding varies significantly by S&E field, ranging from 34% to 84% in FY 2012. Atmospheric sciences had the largest proportion of federally funded R&D equipment (83.6%), with astronomy (83.4%) and physics (80.8%) ranking just behind. Agricultural sciences (34.1%) received the smallest

Figure 5-11
Current fund expenditures for S&E research equipment at academic institutions, by field: FYs 2002–12



NOTE: See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 2005 dollars.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges, and Higher Education Research and Development Survey. See appendix table 5-11.

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share of federal research equipment funding, followed by civil engineering (37.2%).

Cyberinfrastructure

Academic institutions continue to enhance their cyberinfrastructure, which is an essential component to both research and instruction. The cyberinfrastructure indicators noted here include access to high-speed/high-capacity bandwidth, dark fiber, HPC, and the ability to store large amounts of data for immediate access or long-term curation.

Networking

Networking is an essential component of cyberinfrastructure. It facilitates research-related activities such as communication, data transfer, HPC, and remote use of instrumentation.[22] Universities may have networks that are available to the entire campus community for both research and nonresearch activities. The traffic on these campus networks cannot be differentiated between administrative, instructional, research, and general student purposes. Thus, total bandwidth capacity cannot be treated as an indicator solely of research capacity, and changes in research uses cannot be inferred from changes in bandwidth capacity.

Some cyberinfrastructure is dedicated primarily to research activities. For example, research-performing universities may have access to high-performance networks such as Internet2, an organization established in 1997 that is composed of research, academic, industry and government partners, and National LambdaRail, a university-owned organization established in 2003 that manages a 12,000-mile high-speed network.[23] The Energy Sciences Network, a DOE-funded network supporting 30 major DOE sites as well as researchers at universities and other research institutions, serves a similar purpose. Regional networks or *gigapops* (gigabit points of presence) facilitate access by providing networking resources and supplemental bandwidth to the national networks, which are often referred to as the *network backbone*. These resources are provided to universities as well as government agencies, federally funded research and development centers (FFRDCs), and other entities. The regional networks not only serve as network access points, they also provide advanced network services to ensure reliable and efficient data transfer.

By FY 2012, access to high-performance networks had become widespread at research universities, which is evidenced by the 63% of institutions reporting bandwidth of at least 1 gigabit per second (Gbps) (table 5-8). Thirty percent of academic institutions anticipated network connections of 10 Gbps or greater in FY 2012, compared with 15% of institutions with such access in 2009.

Doctorate-granting institutions have significantly higher bandwidth capacity than non-doctorate-granting institutions due to their research demands. In FY 2011, the percentage of doctorate-granting institutions with bandwidth of at least 2.5 Gbps (43%) was more than 10 times greater than that of non-doctorate-granting institutions (4%). Furthermore, in FY 2012, 53% of doctorate-granting institutions estimated that they would have bandwidth of 2.5 Gbps or greater, compared to 5% of non-doctorate-granting institutions.

Dark fiber is fiber-optic cable that has already been laid but is not yet being used. The amount of dark fiber controlled by institutions indicates the ability to expand existing

Table 5-8
Bandwidth at academic institutions: FYs 2005–12
(Percent distribution)

Bandwidth	FY 2005	FY 2007	FY 2009	FY 2011	FY 2012[a]
All bandwidth	100	100	100	100	100
No bandwidth	0	0	0	0	0
10 Mbps or less	6	3	1	1	*
11 Mbps–100 Mbps	42	33	19	9	8
101 Mbps–999 Mbps	30	31	35	31	27
1 Gbps–2.4 Gbps	15	23	25	28	26
2.5 Gbps–9 Gbps	4	4	5	6	7
10 Gbps	*	2	4	7	10
More than 10 Gbps	2	4	11	18	20
More than 20 Gbps[b]	na	na	na	6	8
Number of institutions	449	448	495	539	538

* = > 0 but < 0.5%. na = not applicable; category was added to FY 2011 survey.

Gbps = gigabits/second; Mbps = megabits/second.

[a] Figures for 2012 are estimated.
[b] More than 20 Gbps is a subset of more than 10 Gbps.

NOTES: Detail may not add to total because of rounding. FYs 2009, 2011, and 2012 include bandwidth to Internet1 (also termed “commodity Internet”), Internet2, and National LambdaRail. Data for FY 2005 and FY 2007 are limited to Internet1 and Internet2. The response categories in the FY 2005 survey varied slightly from those in the FYs 2007–11 surveys; in the FY 2005 survey, the categories included “1–2.5 Gbps” and “2.6–9 Gbps.”

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities.

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network capabilities, either between existing campus buildings or from the campus to an external network. The percentage of academic institutions with these unused cables has increased steadily in recent years. The percentage of institutions with dark fiber to their Internet service provider has grown from 29% in FY 2005 to 47% in FY 2011. The percentage of institutions with dark fiber between their own buildings remained high throughout this period, increasing slightly from 86% in FY 2005 to 90% in FY 2011.

High-Performance Computing

Many academic research institutions manage their HPC resources through a distinct organizational unit within the institution that has a separate staff and budget. A total of 192 academic institutions reported ownership of centrally administered HPC resources in FY 2011.[24] This approach enables faculty to focus on their primary responsibilities instead of being diverted by administration and fundraising to support their own HPC. Central HPC administration can decrease overall operating expenses and create wider availability of computing resources.[25] However, many HPC resources, not included here, reside beyond direct institutional administration because they are supported by external funding sources.

Forty-seven percent of doctorate-granting institutions provided centrally administered HPC resources, compared to less than 9% of non-doctorate-granting institutions. Similar percentages of public doctorate-granting (48%) and private doctorate-granting (45%) institutions provided these resources. Clusters are the most common centrally administered HPC architecture used by academic institutions because they provide the most flexibility and cost efficiency for scaling in addition to their generally lower administrative costs. Over 97% of HPC-providing institutions employ cluster architectures (appendix table 5-13). HPC-providing institutions also use architectures such as massively parallel processors (11% of institutions), symmetric multiprocessors (19%), or other types of architectures (20%), all of which can be used in conjunction with or as an alternative to clusters.[26]

Colleges and universities often share their HPC resources with external organizations. In FY 2011, these partnerships most often involved other colleges or universities (72%). Sharing of HPC resources with other external users was fairly evenly distributed among government (21%), industry (18%), and nonprofit organizational (17%) partners. Public institutions were more likely to have external users of their HPC than were private institutions.

Data Storage

As the collection of massive data sets has increased in recent years, data storage and curation have become an increasingly critical issue. Data management plans are often required in funding proposals where large data sets will be used. Of the academic institutions with centrally administered HPC in FY 2011, 56% reported usable online storage greater than 100 terabytes.[27] A smaller share of public (21%) and private institutions (18%) provided greater than 500 terabytes of online storage.

As of FY 2011, 45% of institutions with centrally administered HPC reported no archival storage. Archival storage includes online and offline storage for files and data that do not support immediate access from HPC resources. This percentage changed little from FY 2009 (43%), yet it stands much higher than FY 2007 (29%).

Doctoral Scientists and Engineers in Academia

S&E doctorate holders employed at U.S. universities and colleges hold a central role in the nation's academic R&D enterprise. Through the R&D they undertake, S&E doctorate holders produce new knowledge and contribute to marketplace innovation. They also teach and provide training opportunities for young people who may then go on to earn S&E doctorates and themselves train the next generation of scientists and engineers.

This section examines trends in the demographic composition of the doctoral S&E academic workforce and its deployment across institutions, positions, and fields. Particular attention is paid to the component of the academic workforce that is more focused on research, including graduate assistants, those employed in postdoctoral positions, and researchers receiving federal support. A central message of this section is that, whether looking across 15–20 years or across four decades, the demographic composition of the academically employed S&E workforce, like the S&E workforce throughout the economy, has changed substantially. There have also been changes, although not as substantial, in how this workforce has been deployed across institutions, positions, and fields. Longer-term comparisons from 1973 to 2010 are made to illustrate fluctuations over multiple decades and trends that, once started, have not stopped. Shorter-term comparisons (from the early to mid-1990s to 2010) are made to illustrate what the past 15–20 years have brought forth.[28] Comparisons over the 7-year period from 2003 to 2010 are used in the discussion of minorities in the academically employed workforce because data prior to the early years of the 2000–09 decade are not directly comparable to data from 2003 to 2010.

Unless specifically noted, estimates of S&E doctorate holders in this section come from the Survey of Doctorate Recipients (SDR), a biennial NSF survey that is limited to individuals, including foreign-born individuals, who received their research doctorate in science, engineering, or health at a U.S. institution. Since foreign-trained doctorate holders are also an important component of the academic doctoral workforce, this section also draws from the National Survey of College Graduates (NSCG) to provide estimates of foreign-trained, academically employed doctorate holders, by gender and field of degree.

The SDR substantially undercounts academically employed postdocs, many of whom were trained outside the

United States. To provide more complete postdoc counts, this section supplements SDR data on postdocs with data on postdocs from the Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS), an annual survey jointly conducted by NSF and NIH. Data on graduate assistants are also provided from this survey. (See chapter 3 for more information on foreign-born doctorate holders working in the United States.)

Owing to the complex interrelationships among faculty and nonfaculty positions that jointly produce R&D outcomes, much of the discussion addresses the overall academic employment of U.S.-trained S&E doctorate holders, regardless of position or rank. However, at various points, full-time faculty and those who work outside of the full-time faculty population are discussed separately.

Trends in Academic Employment of Doctoral Scientists and Engineers

Academic employment of doctoral scientists and engineers grew over the past three decades and reached an estimated 359,000 in 2010. Of this total, the large majority—almost 295,000—were U.S. trained. Among these, there was a substantial increase over the employment numbers estimated in 2008 (appendix table 5-14). The change from 2008 reflects an increase in the overall population of doctoral scientists and engineers across the various sectors of the economy rather than a shift toward a higher proportion of doctoral scientists and engineers finding employment in the academic sector.

The United States is unlike many other countries in terms of the fraction of doctorate holders employed in academia. A comparison of 1990–2006 doctorate recipients in 14 countries for which data are available found that, in most of these countries, more than half of the doctorate holders were employed in academia, compared with 47% for the United States. Only the United States, Austria, and Belgium had substantial fractions of doctorate holders employed in the business sector, and the United States had one of the smallest fractions employed in government (Auriol 2010). In recent decades, growth in the number of doctoral scientists and engineers in the academic sector has been slower than the rate of growth in the business and government sectors, resulting in a decline in the academic sector's share of all S&E doctorates from 55% in the early 1970s to just under 50% in the mid-1990s to about 44% in 2010.

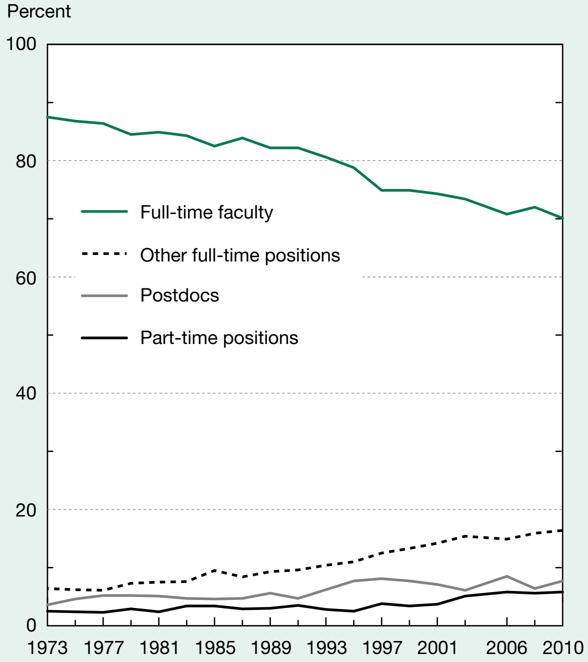
Academic Employment of S&E Doctorate Holders

The doctoral academic S&E workforce includes doctorate holders in S&E who are employed at 2-year or 4-year colleges or universities, including medical schools and university research institutes. This workforce is employed in the following positions: full and associate professors (senior faculty); assistant professors (junior faculty); postdoctoral researchers (postdocs); other full-time positions, such as instructors, lecturers, adjunct faculty, research associates, and administrators; and part-time positions of all kinds.

Full-time faculty positions as either senior or junior faculty continue to be the norm in academic employment, but S&E doctorate holders are increasingly employed in other full-time positions, as postdocs, and in part-time positions (figure 5-12). Over the past 40 years, and especially since the mid-1990s, average annual growth rates have been much higher for nonfaculty and part-time positions than for full-time faculty positions. The share of full-time faculty among all U.S.-trained, academically employed S&E doctorate holders fell from almost 90% in the early 1970s to about 80% by the mid-1990s and then dropped further, to about 70% in 2010 (appendix table 5-14). From the early 1970s to 2010, the share of other full-time positions rose from 6% to 16%, the share of postdocs increased from 4% to 8%, and the share of part-time positions increased from 2% to 6% of all academic S&E doctorate holders. There has also been a

Figure 5-12

SEH doctorate holders employed in academia, by type of position: 1973–2010



SEH = science, engineering, and health.

NOTES: Full-time faculty includes full, associate, and assistant professors plus instructors for 1973–95; for 1997–2010, full-time faculty includes full, associate, and assistant professors. Other full-time positions include such positions as research associates, adjunct appointments, lecturers, and administrative positions for all years plus instructors for 1997–2010. Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes. Data beginning with 2008 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the 1973–2010 Survey of Doctorate Recipients.

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decrease in the percentage of U.S.-trained doctorate holders in tenured positions (discussed below).

The proportion of full-time faculty among S&E doctorate holders in higher education gradually declined in all fields between 1973 and 2010. Growth in postdoc positions and other full-time and part-time positions helped to account for the declining share of full-time faculty positions (appendix table 5-14).

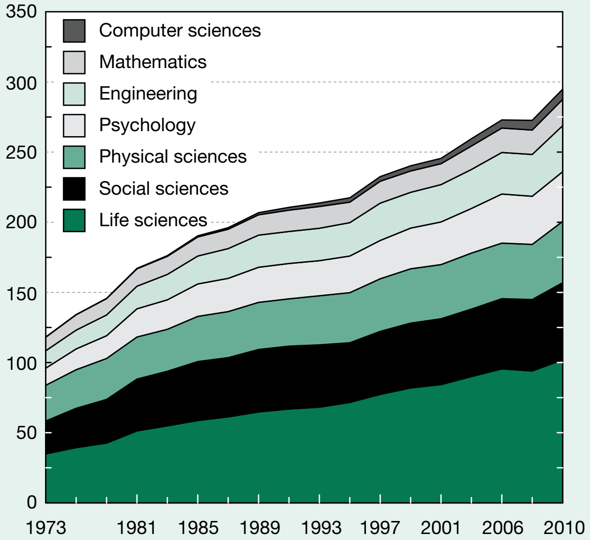
From the early 1980s through 2010, growth in the number of life scientists and psychologists with academic employment was consistently stronger than for doctorate holders in other S&E fields (figure 5-13). Growth in academic employment slowed in the early 1990s for social sciences, physical sciences, and mathematics but has increased since then in social sciences and mathematics (appendix table 5-14).

Trends in Tenure Status

Among U.S.-trained S&E doctorate holders working full-time in academia, the proportion that has achieved tenure has diminished since 1997, although the proportion in tenure-track positions has not. In 1997, tenured positions accounted for an estimated 53% of positions held by U.S.-trained S&E doctorate holders in academic employment; this decreased to 48% in 2010 as other positions grew as a share of overall doctoral academic employment.[29] The same percentage of positions in 1997 as in 2010 (just over 16%) was untenured but on a tenure track. Analysis of U.S. Department of Education data at all degree-granting institutions indicates larger decreases of about 10 percentage points over the past 15–20 years in tenured positions' share of academic employment (AAUP 2010). In addition, it is likely that a higher proportion of foreign-trained doctorate holders than U.S.-trained doctorate holders working in academia are in non-tenured and non-tenure-track positions. If so, the tenured proportion of the academic doctoral workforce (regardless of degree location) would be somewhat less than the 48% found among those who were trained in the United States (Stephan and Levin 2003).

Figure 5-13
SEH doctorate holders employed in academia, by degree field: 1973–2010

Thousands



SEH = science, engineering, and health.

NOTES: Data for computer sciences are not available before 1981. Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences. Data beginning with 2008 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the 1973–2010 Survey of Doctorate Recipients.

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In both 1997 and 2010, the distribution of tenure status across the fields of S&E varied (table 5-9). For those with doctoral degrees in life sciences, mathematical sciences, social sciences, psychology, and engineering, the percentage of tenured positions by field decreased from 1997 to 2010 by 4–9 percentage points, depending on the field. For those with a doctoral degree in physical sciences, there was less change between 1997 and 2010—about 50% were tenured in each year. For those with a degree in computer and information sciences, a larger percentage held tenured positions in 2010 (53%) than in 1997 (46%).

Tenure status also varied by age in 1997 and 2010 (table 5-10). In 2010, lower percentages of doctorate holders at each age group were tenured.[30] For example, 38% of those 40–44 years of age held tenured positions in 2010, compared with 47% in 1997. For those 50–64 years of age, there were even larger differences between 1997 and 2010 in tenure status by age. For example, 70% of those 60–64 years of age held tenured positions in 2010, while 85% of those in this age range held tenured positions in 1997. There was a much larger presence in the doctoral academic workforce of those ages 65–75 years in 2010 (25,100; 9%) than in 1997 (8,500;

Table 5-9
Tenure status by field of doctorate: 1997 and 2010
(Percent)

Field of doctorate	1997	2010
Mathematical sciences	70.3	64.2
Social sciences	63.0	58.5
Computer and information sciences	45.5	53.4
Engineering	58.6	49.7
Physical and related sciences	50.7	48.7
Psychology	50.4	42.4
Life sciences	43.6	39.5

NOTES: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, including medical schools and university research institutes.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013), of the Survey of Doctorate Recipients.

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4%), making it difficult to compare changes in tenure status in this age range over time.

The reduction from 1997 to 2010 in tenured positions' share of total positions occurred across most (but not all) Carnegie classifications (see the chapter 2 sidebar "Carnegie Classification of Academic Institutions" for a discussion of Carnegie classifications). In 1997, 47% of academically employed S&E doctorate holders at the most research-intensive institutions held tenured positions; this percentage decreased to just over 40% in 2010. Similar reductions occurred at less research-intensive doctorate-granting institutions and at master's-granting institutions. However, at medical schools, similar percentages of academically employed doctorate holders held tenured positions in 1997 (31%) and 2010 (29%). At baccalaureate institutions, a slightly higher share of academically employed doctorate holders held tenured positions in 2010 (60%) than in 1997 (58%).

Table 5-10

Tenure status of academically employed SEH doctorate holders, by age: 1997 and 2010

(Percent)

Age	1997	2010
All ages	52.6	47.8
< 30	D	D
30–34	4.9	2.7
35–39	24.9	20.7
40–44	46.9	38.0
45–49	63.0	56.1
50–54	72.0	63.5
55–59	78.3	67.6
60–64	84.6	69.6
65–75	80.0	76.1

D = suppressed to avoid disclosure of confidential information.

SEH = science, engineering, and health.

NOTE: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Survey of Doctorate Recipients.

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Women in the Academic S&E Workforce

The past 40 years have seen tremendous growth in the participation of women in the academic doctoral S&E workforce. In 1973, only about 11,000 U.S.-trained women were employed at this level. In 2010, by contrast, about 105,000 U.S.-trained women with S&E doctorates were employed in academia, nearly a 10-fold increase.[31] The number of U.S.-trained women with S&E doctorates employed in academia almost doubled over the past 15 years, rising from about 60,000 in 1997 to over 105,000 in 2010. In comparison, the number of U.S.-trained male S&E doctorate holders grew by just less than 10% over the same period and by about 80% over the four-decade period, from about 110,000 in 1973 to just under 200,000 in 2010 (appendix table 5-15).[32] An estimated 19,000 women were employed in academia as foreign-trained doctorate holders in S&E in 2010, along with an estimated 45,000 foreign-trained men.[33]

These differential rates of increase are reflected in the steadily rising share of women in the academic S&E workforce. Women constituted 36% of all U.S.-trained, academic S&E doctoral employment and 32% of full-time faculty in 2010, up from 9% and 7%, respectively, in 1973 (appendix table 5-15). Women's share of academic S&E employment increased markedly over time in all position categories, though to a lesser degree in part-time positions (table 5-11). Women have held a larger share of junior faculty positions than positions at either the associate or full professor rank. However, as a result of the

Table 5-11

Women as percentage of SEH doctorate holders employed in academia, by position: Selected years, 1973–2010

(Percent)

Position	1973	1983	1993	2003	2010[a]
All positions	9.1	15.0	21.9	30.3	35.7
Full-time senior faculty	5.8	9.3	14.2	22.8	28.0
Full-time junior faculty	11.3	23.5	32.2	39.7	44.2
Other full-time positions	14.5	23.1	30.2	34.8	41.7
Postdocs	14.3	30.1	30.8	38.0	39.0
Part-time positions	48.3	41.7	61.0	54.5	55.3

SEH = science, engineering, and health.

[a] Data for 2010 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

NOTES: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes. Senior faculty includes full and associate professors; junior faculty includes assistant professors and instructors in 1973, 1983, and 1993; in 2003 and 2010, junior faculty includes assistant professors. Other full-time positions include positions such as research associates, adjunct appointments, instructors (in 2003 and 2010), lecturers, and administrative positions. Part-time positions exclude those employed part time who are students or retired.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the 2003 and 2010 Survey of Doctorate Recipients.

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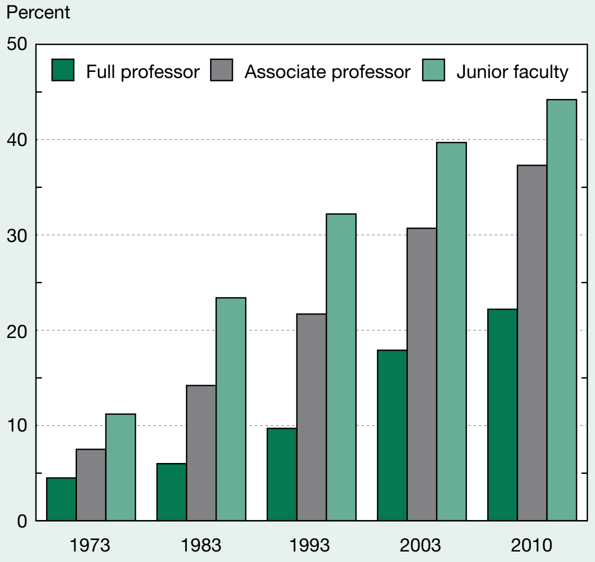
decades-long trend in the rising proportion of women earning doctoral degrees, coupled with their slightly greater propensity to enter academic employment, the share of women in all faculty ranks rose significantly between 1973 and 2010. In 2010, women constituted 22% of full professors, 37% of associate professors, and 44% of assistant professors (figure 5-14).

Compared with their male counterparts in the U.S.-trained academic doctoral S&E workforce, women were more heavily concentrated in the fields of life sciences, social sciences, and psychology, with correspondingly lower shares in engineering, physical sciences, mathematics, and computer sciences. Women's share of doctorate holders in each of these fields, however, grew during the 1973–2010 period (appendix table 5-15). The field distribution of foreign-trained female doctorate holders largely mirrored this distribution (table 5-12).

Figure 5-14

Women as percentage of SEH doctorate holders with full-time employment in academia, by academic rank: Selected years, 1973–2010



SEH = science, engineering, and health.

NOTES: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes, excluding those employed part time who are students or retired. Junior faculty includes assistant professors and instructors in 1973, 1983, and 1993; in 2003 and 2010, junior faculty includes assistant professors. Data for 2010 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years,when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of 2003 and 2010 Survey of Doctorate Recipients.

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Minorities in the Academic S&E Workforce

Although the number of U.S.-trained, academically employed S&E doctorate holders who are members of underrepresented minority groups (i.e., blacks, Hispanics, and American Indians or Alaska Natives) has increased over time, they remain a small percentage of the total (appendix table 5-16).[34] These groups constituted 8.3% of total academic employment and about the same percentage of full-time faculty positions in 2010, up from about 2% in 1973 and up from 7% (of full-time faculty positions) and 7.9% (of all positions) in 2003 (table 5-13). Underrepresented minority groups have a higher share of employment in other positions, which include part-time positions, than in the full-time faculty and postdoc employment categories. Compared to white S&E doctorate holders employed in academia, underrepresented minorities were concentrated in social sciences and less represented in physical sciences and life sciences (appendix table 5-16).

In both 2003 and 2010, a slightly higher percentage of women than men who are underrepresented minorities held faculty positions.[35] Female blacks held about 4.6% of faculty positions held by women in 2003 and about 5.1% of these positions in 2010. Male blacks were in about 2.9% of faculty positions held by men in 2003 and about 3.4% in 2010. Similarly, female Hispanics occupied about 4.3% of faculty positions held by women in 2003 and about 4.8% in 2010. Male Hispanics were in about 3.2% of faculty positions occupied by men in 2003 and about 3.9% in 2010. Male and female American Indians and Alaska Natives held about the same percentage of faculty positions in 2003 and 2010 (less than 1%).

The share of Asians or Pacific Islanders employed in the S&E academic doctoral workforce grew dramatically over the past three decades, rising from 4% in 1973 to 16% in

Table 5-12

Foreign-trained SEH doctorate holders employed in academia, by degree field and sex: 2010

Field	Total	Male	Female
Full-time positions			
All fields	61,000	43,000	18,000
Physical sciences	15,000	13,000	2,000
Computer and mathematical sciences	3,000	3,000	S
Life sciences	34,000	20,000	14,000
Social sciences and psychology	4,000	3,000	1,000
Engineering	5,000	4,000	1,000
Part-time positions			
All fields	3,000	2,000	1,000

S = suppressed for reasons of confidentiality and/or reliability.

SEH = science, engineering, and health.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the National Survey of College Graduates.

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2010.[36] Asians or Pacific Islanders were heavily represented among those with degrees in engineering and computer sciences, where they constituted 31% and 37%, respectively, of the S&E academic doctoral workforce in 2010. Among those with degrees in social sciences (9%) and psychology (6%), far smaller proportions were Asians or Pacific Islanders (appendix table 5-16). A larger share of Asians or Pacific Islanders than whites was employed at research universities and medical schools in 2010.

In both 2003 and 2010, a higher percentage of male Asians or Pacific Islanders held faculty positions than their female counterparts. Male Asians or Pacific Islanders were in about 12.0% of faculty positions occupied by men in 2003 and about 14.4% of these positions in 2010. Female Asians or Pacific Islanders held about 8.9% of faculty positions occupied by women in 2003 and about 12.1% in 2010. Both male and female Asians or Pacific Islanders increased their share of faculty positions from 2003 to 2010.

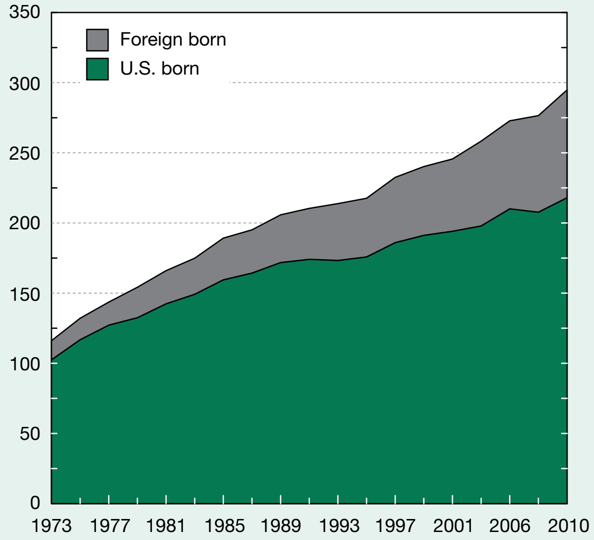
Foreign-Born U.S. S&E Doctorate Holders in the Academic Workforce

Academia has long relied on foreign-born doctorate holders, many of them with doctoral degrees from U.S. universities, to staff faculty and other academic positions. The following discussion is limited to foreign-born individuals with U.S. doctorates.

Academic employment of foreign-born, U.S.-trained S&E doctorate holders has increased continuously since the 1970s at a rate that has exceeded the growth in academic employment of U.S.-born S&E doctorate holders. As a result, the foreign-born share of the total academic employment of U.S. S&E doctorate holders increased from 12% in 1973 to about 26% in 2010 (figure 5-15) and reached particularly

Figure 5-15

SEH doctorate holders employed in academia, by birthplace: 1973–2010



SEH = science, engineering, and health.

NOTES: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research centers, excluding those employed part time who are students or retired. Data beginning with 2008 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the 2010 Survey of Doctorate Recipients.

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Table 5-13

Underrepresented minorities as percentage of SEH doctorate holders employed in academia, by position: Selected years, 1973–2010

(Percent)

Position	1973	1983	1993	2003	2010[a]
All positions	2.0	3.7	5.0	7.9	8.3
Full-time faculty	1.9	3.6	5.0	7.0	8.3
Postdocs	2.4	4.8	4.5	7.0	7.0
Other positions	2.9	4.1	5.3	7.3	8.6

SEH = science, engineering, and health.

[a] Data for 2010 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

NOTES: Underrepresented minorities include blacks, Hispanics, and American Indians or Alaska Natives. Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes. Faculty includes full, associate, and assistant professors plus instructors in 1973, 1983, and 1993. In 2003 and 2010, faculty includes full, associate, and assistant professors. Other positions include part-time positions and full-time positions such as research associates, adjunct appointments, instructors (in 2003 and 2010), lecturers, and administrative positions. Other positions exclude those employed part time who are students or retired.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the 2003 and 2010 Survey of Doctorate Recipients.

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high proportions in engineering (49%) and computer sciences (51%) (appendix table 5-17). In all fields, foreign-born doctorate holders were a larger share of postdoc employment than of full-time faculty employment. Overall, 49% of postdoc positions were held by foreign-born U.S. S&E doctorate holders, compared to 24% of full-time faculty positions.

Of the 46,000 U.S.-trained Asian or Pacific Islander S&E doctorate holders employed in academia in 2010, 10% were native-born U.S. citizens, 39% were naturalized U.S. citizens, and 51% were noncitizens. In 2010, Asians or Pacific Islanders represented 52% of the foreign-born S&E faculty employed full-time in the United States and nearly 70% of the foreign-born S&E doctorate holders with postdoc appointments. In contrast, only about 2% of native-born, full-time faculty and 5% of native-born postdocs were Asians or Pacific Islanders. (See chapter 3 for a discussion of foreign-born individuals in the S&E workforce.)

Age Composition of the Academic Doctoral Workforce

The trend toward relatively fewer full-time faculty positions and relatively more postdoc and other full-time and part-time positions is especially noteworthy because of the steady increase over the past 15–20 years in the share of full-time faculty positions that are held by those over 65 years of age.

In 1994, the Age Discrimination in Employment Act of 1967 (ADEA) became fully applicable to universities and colleges, prohibiting the forced retirement of faculty at any age. From this point through 2010, as more individuals born during the period of high birth rates from 1946 to 1964 (the "Baby Boomers") began to move through middle age into their 50s and 60s, the proportion of academically employed doctorate holders in the oldest age groups increased (table 5-14). In 2010, 20% of U.S.-trained, academically employed doctorate holders in S&E were between 60 and 75 years of age, double the percentage (10%) of those in this age range in 1995.[37] In 1995, full-time faculty ages 60–75 years held less than 2% of doctoral academic positions; this percentage increased to 7% in 2010. (See chapter 3 for a discussion of the age profile and retirement patterns of the S&E doctoral workforce in other institutional sectors.)

Table 5-14
Academically employed SEH doctorate holders, by age: 1995 and 2010
(Percent)

Age	1995	2010[a]
20–39	29.2	26.6
40–59	61.0	53.2
60–75	9.8	20.1

SEH = science, engineering, and health.

[a] Data for 2010 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Survey of Doctorate Recipients.

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Many of the older U.S.-trained, academically employed doctorate holders work at research-intensive universities. The percentage of doctorate holders working at the most research-intensive institutions who were between 60 and 75 years of age increased by 8 percentage points between 1995 and 2010, rising from just under 10% in 1995 to just under 18% in 2010. Meanwhile, the percentage of doctorate holders working at the most research-intensive institutions who were between 30 and 44 years of age decreased by 6 percentage points between 1995 and 2010. In 1995, over 50% of doctorate holders working at the most research-intensive institutions were between 30 and 44 years of age; in 2010, this percentage had fallen to less than 44%.

A comparison of the age distribution of full-time faculty positions at research universities and other universities and colleges shows that there has been a relatively sharp increase since the mid-1990s—when ADEA became applicable to the professoriate—in the percentage of these positions held by those ages 65–75 years. The data show that the share of those ages 65–75 years was rising well before the act became mandatory, dipped in the early 1990s at research universities (and leveled off at other institutions), and then rose steeply in most years from 1995 to 2010, particularly at the most research-intensive universities (figure 5-16; appendix table 5-18).

Academic Researchers

The interconnectedness of research, teaching, and public service activities in academia makes it difficult to assess the precise size and characteristics of the academic research workforce by examining the employment trends in academic positions. Individuals with the same academic job titles may be involved in research activities to differing degrees or not be involved in research. Therefore, self-reported research involvement is a better measure than position title for gauging research activity.[38] This section limits the analysis to academic S&E doctorate holders who reported that research is either their primary or secondary work activity (i.e., the activity that occupies the most or second-most hours of their work time during a typical work week).

Doctoral S&E Researchers

Since 1973, the number of U.S.-trained, academically employed S&E researchers grew from just over 80,000 to almost 200,000 (appendix table 5-19). In 2010, of those identified as such researchers, over 140,000 were employed in full-time faculty positions.[39]

Looking across all doctoral academic positions and across the past four decades, the proportion of academically employed S&E doctorate holders who identified research as their primary or secondary activity has fluctuated between about 60% and 75%. A similar pattern of fluctuation occurred for full-time faculty. In 2010, 67% of S&E doctorate holders in academia classified research as their primary or secondary activity.[40]

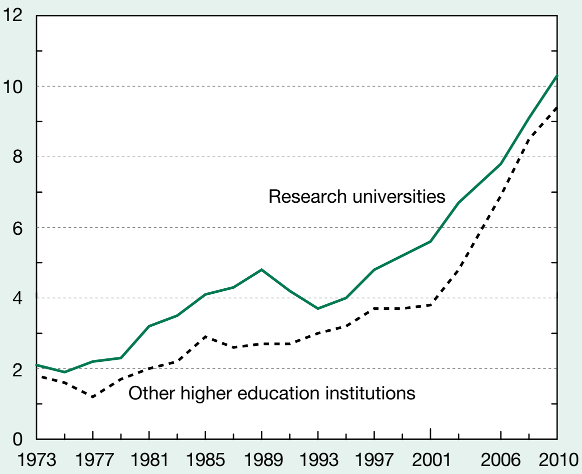
Looking across fields, the proportions of researchers among all academic S&E doctorate holders and all full-time faculty were higher in life sciences, engineering, and computer sciences than in social sciences and psychology (appendix table 5-19). In most fields, the share of academic S&E doctorate holders who reported research as their primary or secondary responsibility declined slightly between 1993 and 2010.

A different picture emerges when considering those who report research as their primary work activity. In contrast to the declining share of academic employees who reported research as their primary *or* secondary work activity, the share who reported research as their primary work activity generally increased throughout the period from 1973 to 2010.

Among full-time doctoral S&E faculty, the increased share of doctorate holders reporting research as their primary work activity reflects a shift in priority from teaching to research. Over the last four decades, the proportion of full-time faculty identifying research as their primary work activity climbed from 19% to 36%, while the share of faculty with teaching as their primary activity fell from 68% to 47% (figure 5-17).

Figure 5-16

Full-time faculty ages 65–75 at research universities and other higher education institutions: 1973–2010



NOTES: Faculty positions include full, associate, and assistant professors and instructors from 1973 to 1995; from 1997 to 2010, faculty positions include full, associate, and assistant professors. Data beginning with 2008 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, 1973–95 Survey of Doctorate Recipients, and special tabulations (2013) of the 1997–2010 Survey of Doctorate Recipients. See appendix table 5-18.

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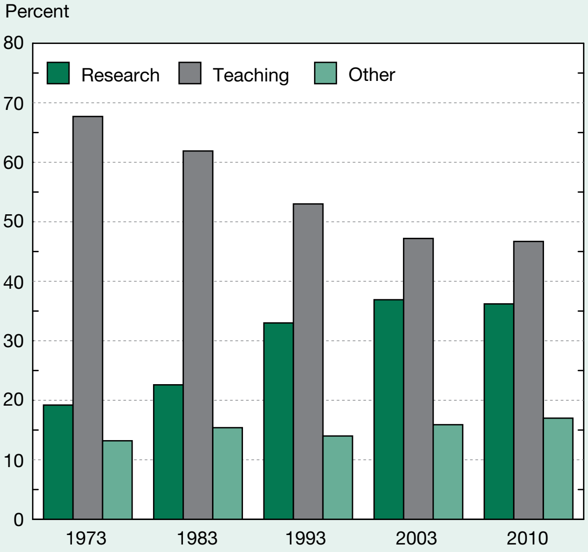
The balance of emphasis between teaching and research varied across the disciplines. A higher share of faculty with doctorate degrees in life sciences identified research as their primary work activity, and a higher share of faculty with doctorate degrees in mathematics and social sciences reported teaching as their primary activity. Since 1991, the proportion of doctorate holders who reported research as a primary work activity declined among computer scientists and life scientists but grew among mathematicians, psychologists, engineers, and social scientists (appendix table 5-19).

S&E Full-Time Faculty

In 2010, 37% of the S&E doctoral faculty who had earned their degree since 2007 identified research as their primary work activity, a slightly lower share than that reported by faculty who had earned S&E doctorate degrees 4–7 years earlier or 8–11 years earlier (both 41%) (table 5-15). The

Figure 5-17

Primary work activity of full-time doctoral SEH faculty: 1973–2010



SEH = science, engineering, and health.

NOTES: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes, excluding those employed part time who are students or retired. Full-time faculty includes full, associate, and assistant professors plus instructors for 1973, 1983, and 1993; for 2003 and 2010, full-time faculty includes full, associate, and assistant professors. Research includes basic or applied research, development, or design. "Other" includes a wide range of activities. Data for 2010 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the 2003 and 2010 Survey of Doctorate Recipients.

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comparable percentage for faculty 12 or more years from receipt of their degree is somewhat lower (34%). The higher share of primary researchers within the second and third cohorts, 4–11 years since receiving their doctorate, coincides with the period during which many faculty would be preparing to apply for tenure at their university and would have heightened motivation to complete research projects and publish results. For faculty members who received their doctoral degree 12 or more years ago, other responsibilities—such as mentoring younger faculty, advising doctoral students, and accepting major committee assignments or faculty leadership roles—may become primary work activities.

A similar pattern across career stages prevailed in most degree fields. Research was more frequently a primary work activity for faculty in engineering than for faculty in other fields.

Graduate Research Assistants

The close coupling of advanced training with hands-on research experience is a key feature of U.S. graduate education. Many of the nearly one-half million full-time S&E graduate students in 2011 conduct research as part of their academic studies (table 5-16).

The number of research assistants—full-time graduate students whose primary mechanism of financial support is a research assistantship—has grown faster than graduate enrollment, both overall and in most fields. Graduate research assistantships were the primary means of support for 27% of graduate students in 2011, up from 22% in the early 1970s.

Academic Employment in Postdoc Positions

About 44,000 S&E doctorate holders were employed in academic postdoc positions in 2011 (see sidebar, "Postdoctoral Researchers"). The estimate comes from the GSS, which reported a total of about 63,000 postdocs in 2011, with about two-thirds (over 44,000) holding doctorates in S&E and about one-third holding doctorates in non-S&E fields. SDR data indicate that the U.S.-trained component of academically employed postdocs with S&E degrees climbed from 4,000 in the early 1970s to 22,800 in 2010 (appendix table 5-14). During that time period, the share of postdocs increased from 4% to 8% of all U.S.-trained, academically employed S&E doctorate holders. Postdocs were much more prevalent in life sciences, physical sciences, and engineering than in social sciences, although there were increases across all fields in 2010. Growth from 2003 to 2010 was greatest in the proportion of U.S.-trained postdocs in physical sciences and engineering (figure 5-18; appendix table 5-14).

The demographic profile of U.S.-trained individuals employed in academic postdoc positions has changed dramatically over the past 40 years. In particular, the proportions of postdocs held by women, racial and ethnic minorities, and foreign-born individuals have climbed (table 5-17).

A temporary postdoc appointment is a common stop along the career path of S&E doctorate holders, particularly during their early career stages. In 2010, 41% of recently degreed, U.S.-trained S&E doctorate holders in academia were employed in postdoc positions, while 35% were employed in full-time faculty positions (appendix table 5-20). *Recently degreed* refers to those who received their doctorate within 1–3 years prior to the 2010 SDR. *Early career* refers to those who received their doctorate within 1–7 years prior to the 2010 SDR. A lower share (13%) of U.S.-trained, academically employed S&E doctorate holders 4–7 years beyond their doctoral degree was employed in academic postdoc positions; 60% held full-time faculty positions (appendix table 5-20).

In 2010, over three-fourths (78%) of recently degreed, U.S.-trained academic postdocs were employed at the most research-intensive universities (table 5-18). The postdoc

Table 5-15
SEH faculty reporting research as primary work activity, by years since doctorate and degree field: 2010
(Percent)

Years since doctorate	All fields	Computer and information sciences	Life sciences	Mathematics and statistics	Physical sciences	Psychology	Social sciences	Engineering
All years since doctorate	36.1	35.0	42.6	29.8	33.4	33.0	29.2	40.5
1–3	37.2	12.5	37.8	38.5	27.3	33.3	39.0	50.0
4–7	41.2	50.0	43.3	40.9	35.1	35.9	34.9	52.6
8–11	40.5	25.0	45.3	25.0	42.1	37.1	34.4	51.9
≥ 12	34.1	35.5	42.4	26.2	31.8	31.4	25.8	34.8

SEH = science, engineering, and health.

NOTES: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes, excluding those employed part time who are students or retired. Faculty includes full, associate, and assistant professors. Research includes basic or applied research, development, and design. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Survey of Doctorate Recipients.

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populations employed at medical schools and other universities and colleges included a larger pool of doctorate holders who had not recently earned their doctoral degree. The fields of life sciences and physical sciences have had the highest incidence of postdocs over the years (figure 5-18).

Recent data indicate that the economic downturn of the late 2000s may have influenced some early career doctorate holders to take academic postdoc positions when they would have preferred other employment. The percentages of postdocs citing "other employment not available" as a reason for accepting a postdoc position increased between 2008 and 2010, while most other reasons for obtaining a postdoc decreased (table 5-19). (The percentage of postdocs citing "obtaining training outside the PhD field" also increased.)

Table 5-16

Full-time SEH graduate students and graduate research assistants at universities and colleges, by degree field: Selected years, 1973–2011

	1973		1983		1993		2003		2011[a]	
Group and degree field	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent
Graduate students	161.6	100	252.0	100	329.6	100	398.0	100	457.3	100
Computer sciences	2.9	2	10.6	4	17.4	5	30.9	8	33.8	7
Life sciences	40.6	25	69.2	28	91.6	28	123.2	31	124.4	27
Mathematics	10.3	6	11.0	4	14.5	4	14.6	4	18.7	4
Physical sciences	28.9	18	37.2	15	41.9	13	41.9	11	49.3	11
Psychology	15.2	9	26.6	11	34.8	11	35.8	9	39.3	9
Social sciences	32.4	20	43.5	17	55.6	17	61.3	15	74.2	16
Engineering	31.3	19	53.9	21	73.8	22	90.4	23	107.2	23
Graduate research assistants	35.9	100	54.9	100	90.2	100	114.3	100	122.5	100
Computer sciences	0.7	2	1.4	3	3.8	4	7.5	7	8.3	7
Life sciences	9.4	26	16.5	30	28.0	31	35.5	31	37.7	31
Mathematics	0.7	2	0.8	2	1.4	2	1.8	2	2.1	2
Physical sciences	8.9	25	12.6	23	17.0	19	18.1	16	19.6	16
Psychology	1.9	5	3.0	5	4.6	5	5.6	5	5.6	5
Social sciences	4.0	11	5.0	9	7.4	8	8.4	7	7.6	6
Engineering	10.4	29	15.6	28	28.0	31	37.4	33	40.1	33

SEH = science, engineering, and health.

[a] Total includes fields not shown separately that were added or reclassified in the 2007 survey.

NOTES: Detail may not add to total because of rounding. Graduate research assistants are full-time graduate students with research assistantships as their primary mechanism of support. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Survey of Graduate Students and Postdoctorates in Science and Engineering.

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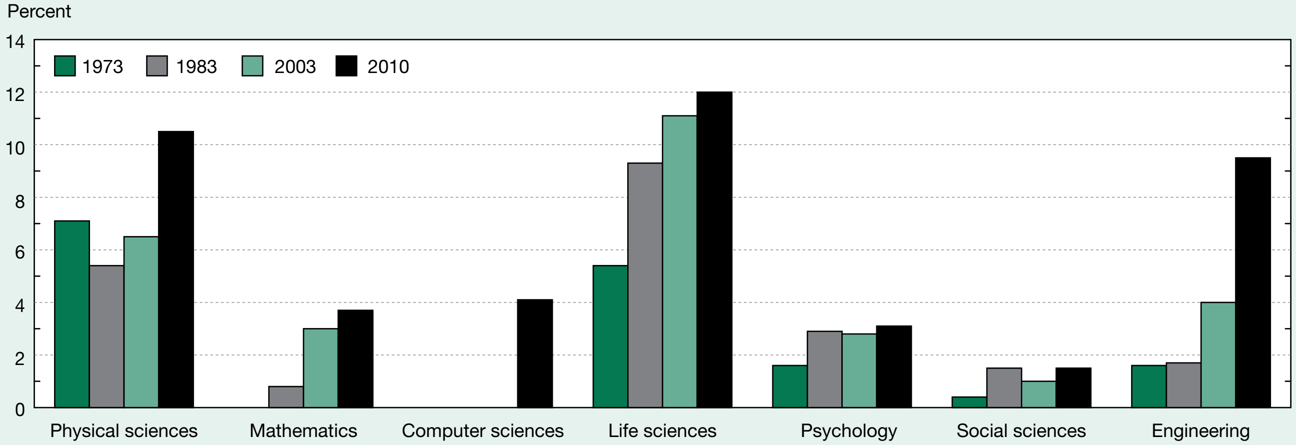
Postdoctoral Researchers

A postdoctorate (postdoc) is a temporary position in academia, industry, a nonprofit organization, or government that is taken after the completion of a doctorate. It serves as a period of apprenticeship for the purpose of gaining scientific, technical, and professional skills. Ideally, the individual employed in a postdoc position gains these skills under the guidance of an adviser, with the administrative and infrastructural support of a host institution, and with the financial support of a funding organization. However, the conditions of postdoc employment vary widely between academic and non-academic settings, across disciplines, and even within institutions, and formal job titles are an unreliable guide to actual work roles.

Postdoctoral researchers have become indispensable to the S&E enterprise and perform a substantial portion of the nation's research. Most have recently earned their doctoral degree, and so they bring a new set of techniques and perspectives that broadens their research teams' experience and makes them more competitive for additional research funding. In addition to conducting research, postdoctoral researchers also educate, train, and supervise undergraduate students engaged in research; help write grant proposals and papers; and present research results at professional society meetings (COSEPUP 2000).

Figure 5-18

SEH doctorate holders with academic employment in postdoc position, by degree field: Selected years, 1973–2010



SEH = science, engineering, and health.

NOTES: Some data were not available; other data were suppressed for reasons of confidentiality and/or reliability. Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes, excluding those employed part time who are students or retired. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences. Data for 2010 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the 2003 and 2010 Survey of Doctorate Recipients.

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Table 5-17

SEH doctorate holders with academic employment in postdoc position, by demographic group: Selected years, 1973–2010

(Percent distribution)

Demographic group	1973	1983	1993	2003	2010[a]
Sex					
Female	16.7	30.1	30.8	37.6	39.0
Male	83.3	69.9	69.2	62.4	60.5
Race/ethnicity					
White	85.7	81.9	68.4	63.1	54.9
Asian or Pacific Islander	11.9	13.3	27.1	30.6	36.6
Underrepresented minority	2.4	4.8	4.5	7.0	7.1
Place of birth					
United States	82.5	81.7	60.9	57.0	51.0
Foreign	17.5	18.3	39.1	43.0	49.0

SEH = science, engineering, and health.

[a] Data for 2010 include all U.S.-trained doctorate recipients who lived or worked in the United States on the survey date. These data correct for a slight undercount in prior years, when some U.S.-trained doctorate recipients who either planned to live abroad or were living abroad were excluded.

NOTES: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes, excluding those employed part time who are students or retired. Underrepresented minorities include blacks, Hispanics, and American Indians or Alaska Natives. Asian or Pacific Islander includes Pacific Islanders from 1973–93 but excludes them from 2003–10.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the 2003 and 2010 Survey of Doctorate Recipients.

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Federal Support of Doctoral Researchers in Academia

The federal government provides academic researchers with a substantial portion of overall research support. This support may include assistance in the form of fellowships, traineeships, and research grants. For example, faculty members often receive research grants while postdocs often are funded through fellowships. This section presents data from S&E doctorate holders in academia who reported on the presence or absence (but not magnitude or type) of federal support for their work. Comparisons are made over the approximately 40-year period between the early 1970s and 2010 and between the roughly two-decade-long period between the late 1980s or very early 1990s and 2010.[41]

Academic Scientists and Engineers Who Receive Federal Support

The share of S&E doctorate holders and researchers in academia who receive federal support has varied over time according to the level of research activity and the type of academic position held (appendix table 5-21). In general, a larger share of doctorate holders and researchers received federal support in the late 1980s and very early 1990s than

Table 5-18
SEH doctorate holders with academic employment in postdoc position, by Carnegie institution type and years since doctorate: 2010
(Percent distribution)

Institution type	Postdocs (thousands)	Years since doctorate 1–3	Years since doctorate 4–7	Years since doctorate ≥ 8
All institutions	22.8	100.0	100.0	100.0
Doctorate-granting, very high research	17.0	77.9	69.7	61.8
Other doctorate-granting institutions	2.4	9.4	13.8	7.7
Medical schools/medical centers	2.1	7.4	10.7	23.3
Other universities and colleges	1.3	5.3	5.8	7.2

SEH = science, engineering, and health.

NOTES: Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes, excluding those employed part time who are students or retired. Institutions are designated by the 2005 Carnegie classification code. For information on these institutional categories, see *The Carnegie Classification of Institutions of Higher Education*, http://classifications.carnegiefoundation.org/index.php.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) of the Survey of Doctorate Recipients.

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Table 5-19
Reasons for accepting postdoc position: 2008–10

Reason	2008 Total	2008 Percent	2010 Total	2010 Percent	2008–10 Population change (%)	2008–10 Distribution change (%)
All reasons						
Additional training in PhD field	12,200	67.6	14,800	65.2	21.3	-3.6
Training outside of PhD field	8,100	44.9	11,000	48.2	35.8	7.3
Work with person/at place	11,300	62.9	12,900	56.8	14.2	-9.7
Other employment not available	3,900	21.7	7,000	30.7	79.5	41.5
Postdoc expected in this field	13,900	76.9	17,000	75.1	22.3	-2.3
Some other reason	1,500	8.3	1,900	8.4	26.7	1.2
Most important reason						
Additional training in PhD field	4,000	22.3	4,300	19.0	7.5	-14.8
Training outside of PhD field	2,600	14.6	4,000	17.6	53.8	20.5
Work with person/at place	2,900	16.3	3,500	15.6	20.7	-4.3
Other employment not available	1,800	9.8	3,100	13.5	72.2	37.8
Postdoc expected in this field	5,800	32.0	6,800	29.8	17.2	-6.9
Some other reason	900	5.0	1,100	4.7	22.2	-6.0

NOTES: Data are for academically employed, U.S. trained postdocs. Numbers are rounded to the nearest 100. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics with National Opinion Research Center, special tabulations (2013) of the Survey of Doctorate Recipients.

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in either the early 1970s or in 2010. In 2010, 45% of all U.S.-trained S&E doctorate holders in academia and 56% of those for whom research was a primary or secondary activity reported federal government support for their work.[42] Looking across all fields, about the same percentage (45%) of U.S.-trained, academically employed doctorate holders received federal support in the early 1970s as in 2010. In the very early 1990s, however, a somewhat higher percentage (49%) received federal support. A somewhat smaller share of those for whom research was a primary or secondary responsibility received federal support in 1973 (52%) than in 1991 (58%) or 2010 (56%). The share of full-time faculty who received federal support from 1973 to 2010 fluctuated, rising from 42% in 1973 to 48% in 1991 and then dipping to 45% in 2010. A larger share of academic doctorate holders employed in nonfaculty positions received federal support in 1973 (60%) and in the very early 1990s (59%) than in 2010 (42%).

Federal support varied by the field in which the academically employed held their doctoral degree. Over the past 40 years, U.S.-trained doctorate holders in engineering, life sciences, and physical sciences have been more likely to report receiving federal support than doctoral degree holders in mathematics, psychology, or social sciences (appendix table 5-21). In mathematics, gradually larger shares of doctorate holders received federal support (27% in 1973; just over 34% in the very early 1990s and in 2010). In psychology and social sciences, by contrast, gradually smaller shares received federal support. For example, in 1973, 38% of doctorate holders in psychology and 26% of doctorate holders in the social sciences reported federal support. This decreased to 33% and 20%, respectively, in 2010.

Federal support is more prevalent in medical schools and in the most research-intensive universities (*very high research activity* institutions according to Carnegie classification) (appendix table 5-22). About 65% of S&E doctorate holders and full-time faculty employed in these institutions received federal support in 2010. The percentage with federal support was about 50% at *high research activity* institutions; at other universities and colleges, it ranged from about 15%–30%.

Federal Support of Early Career S&E Doctorate Holders

Federal support has been less available to early career S&E doctoral faculty than to more established faculty, and the percentage of early career S&E faculty with federal support has declined (appendix table 5-23). In 2010, less than 28% of recent doctorate recipients in full-time faculty positions received federal support, down from 38% two decades earlier. Of recent S&E doctorate recipients employed in postdoc positions in 2010, 72% received federal support, which was a substantial decline from the early 1990s (84%).

S&E doctorate holders employed as full-time faculty who had received their doctorate 4–7 years earlier were more likely to receive federal support than those with more recently earned doctorates, and the same was true of those employed in postdoc positions. As with recent doctorate recipients, the share of full-time faculty and postdocs 4–7 years beyond their doctorate who received federal support also declined from the early 1990s. The shares of early career full-time faculty and postdocs with federal support were generally higher in some fields (life sciences, physical sciences, and engineering) than in others (mathematics and social sciences).

Outputs of S&E Research: Articles and Patents

Chapter 2 of this volume discusses the human capital outputs of higher education in S&E. This section of the current chapter continues that theme by examining the intellectual output of S&E research. The section presents indicators derived from both published research articles and U.S. patents.

Researchers have traditionally published the results of their work in the world's peer-reviewed S&E journals. These *bibliometric* data (see sidebar, "Bibliometric Data and Terminology") are indicators of national and global scientific activity. For example, a count of the coauthorships on U.S. articles is an indicator of the partnerships involved in the U.S. scientific effort. Likewise, measures involving citations and patents can be indicators of international patterns of influence and of invention based on scientific research. Bibliometric indicators are calculated for different countries and—within the United States alone—for different sectors.

Overall, the indicators provide insight into five broad areas. The first section, "S&E Article Output," examines the quantity and national origin of S&E publications. The second section, "Coauthorship and Collaboration in S&E Literature," examines the national partnerships in these publications. The third section, "Trends in Citation of S&E Articles," examines various patterns of national scientific sharing and influence. The fourth section, "Citation of S&E Articles by USPTO Patents," examines the utilization of S&E literature by inventors. And, finally, the fifth section, "Academic Patenting," examines patenting and related activities in academia.

Discussions of regional and country indicators will examine patterns and trends in developed and developing countries, as classified by the World Bank. Countries classified by the World Bank as high income are considered *developed*; those classified as upper- and lower-middle income and as low income are considered *developing*.[43]

S&E Article Output

This section begins by describing and comparing the S&E article output of the United States to other regions, countries, and economies in the world. The article output of China and other developing countries has increased much more rapidly than that of the United States and other developed countries over the last 15 years. Although the United States remains

Bibliometric Data and Terminology

The article counts, coauthorships, and citations discussed in this section are derived from S&E articles, notes, and reviews published in a set of scientific and technical journals tracked by the Science Unit of Thomson Reuters in the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) (http://www.thomsonreuters.com/business_units/scientific/). Journal items excluded are letters to the editor, news stories, editorials, and other material whose purpose is not the presentation or discussion of scientific data, theory, methods, apparatus, or experiments.

Journal selection. This section uses a changing set of journals that reflects the current mix of journals and articles in the world. Thomson Reuters selects journals each year as described at http://www.thomsonreuters.com/products_services/science/free/essays/journal_selection_process/, and the selected journals become part of SCI and SSCI. The journals selected are notable for their relatively high citation rank within their S&E subfields; journals of only regional interest are excluded.

The number of journals analyzed by the National Science Foundation from SCI and SSCI was 4,093 in 1988 and 5,087 in 2012, an annual growth rate slightly less than 1.0%. These journals give good coverage of a core set of internationally recognized, peer-reviewed scientific journals. The coverage includes electronic-only journals and print journals with electronic versions. In the period 1988–2012, the database contained 16 million S&E articles, notes, and reviews. Over the same period, the average number of articles, notes, and reviews per journal per year increased from about 111 to 168, an annual growth rate of about 1.7%.

Article data. Except where noted, *author* means *departmental* or *institutional* author. Articles are attributed to countries or sectors by the country or sector of the institutional address(es) given in the articles, not by the national origins or the citizenship of the authoring scientists or engineers. If no institutional affiliation is listed, the article is excluded from the counts in this chapter.

Likewise, *coauthorship* refers to *institutional* coauthorship. An article is considered coauthored only if it shows different institutional affiliations or different departments of the same institution; multiple listings of the same department of an institution are considered one institutional author. The same logic applies to cross-sector and international collaboration.

Two methods of counting articles are used: *fractional* and *whole counts*. Fractional counting is used for article and citation counts. In fractional counting, credit for coauthored articles is divided among the collaborating institutions or countries based on the proportion of their participating departments or institutions. Whole counting is used for coauthorship data. In whole counting, each institution or country receives one credit for its participation in the article.

Data in the section “Article Output by Country” are reported by publication year through 2011 as recorded in the SCI and SSCI data files through late January 2013. These data are noted as “by year of publication.” Publication data in the remaining bibliometrics sections are reported through 2012. These data are noted as “by data file year.”

The region/country/economy breakouts are reported in appendix table 5-24. Data reported in this section are grouped into 13 broad S&E fields and 125 subfields (appendix table 5-25).

a major producer of S&E articles, its global share of article production has declined. This section then examines U.S. article output in academia, the largest producer of U.S. articles, and other institutional sectors.

Article Output by Country

A growing number of countries produce S&E articles. Over the period from 1988 to 2012, a total of 199 countries were authors on at least one S&E article (appendix table 5-24).[44]

The four major producers of the world’s S&E articles in 2011 were the European Union (EU; see “Glossary” for member countries) (31%), the United States (26%), China (11%), and Japan (6%).[45] Together, they accounted for 73% of the world’s S&E publications in 2011 (figure 5-19; appendix table 5-26). The EU, the United States, and Japan have been major producers for several decades. China emerged as a major producer in the mid-2000s. Overall, 47 countries—less than a quarter of those that produced S&E articles in 2011 (see appendix table 5-24)—accounted for 98% of global output (table 5-20).

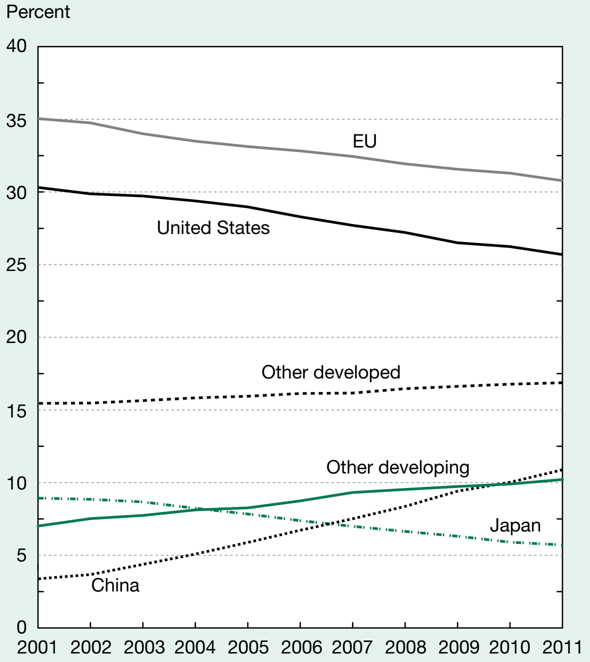
Between 2001 and 2011, the total world S&E article output grew at an average annual rate of 2.8% (table 5-20). The total for developing countries grew more than three times faster (9.9% average annual) than the world total. China propelled growth of developing countries (15.6%), resulting in its global share climbing from 3% to 11% (figure 5-19). The fifth-largest S&E article producer in 2001, China surpassed Japan in 2007 to become the third-largest S&E article producer, behind the EU and the United States (appendix table 5-26). China’s growth in S&E publication is concurrent with its enormous growth in GDP over the last decade, which is consistent with findings by many researchers that there is a high correlation between these two measures (Price 1969; Narin, Stevens, and Whitlow 1991).

Among other larger emerging economies, over the decade Brazil grew at a 6.4% average annual rate and India grew at a 7.6% average annual rate, resulting in their global shares increasing 1 percentage point to reach 2% and 3%, respectively (table 5-20). Rapid growth of S&E articles in Brazil, India, and China coincided with increased R&D expenditures and growth in S&E degrees awarded at the bachelor's-degree and doctoral-degree levels (see chapter 2, "Higher Education in Science and Engineering").

Smaller developing countries with rapid S&E article growth (11%–23% annual average) included Iran, Malaysia, Pakistan, Thailand, and Tunisia.

Developed economies' S&E article production grew more slowly (1.5%) than that of developing economies (9.9%) over the decade. U.S. growth in S&E article production was even slower (1.1%) than the average for all developed economies. The U.S. global share fell from 30% to 26%, mostly as a result of developing economies' more rapid growth.

Figure 5-19
S&E articles, by global share of selected region/country: 2001–11



EU = European Union.

NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on the basis of the proportion of its participating institutions). Counts for all six groups sum to the world total. Data for Bulgaria, Hungary, and Romania are included with the EU and not with developing economies.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-26.

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The EU, the world's largest producer, grew slightly more slowly (1.4%) than all developed countries. Among EU member countries, growth rates were slower for the three largest—France, Germany, and the United Kingdom—and generally much faster in Ireland, Portugal, and other smaller member countries. Although EU article production grew slightly faster than that of the United States, the EU's global share fell from 35% to 31% because of far more rapid growth of developing countries.

S&E article production of Japan, the fourth-largest producer, contracted (-1.7% annual average) over the decade. As a result, Japan's global share dropped from 9% to 6%, a far greater decline (35%) compared to the declines of the shares of the United States and the EU (15% and 12%). The weakening of Japan's position may reflect its lengthy economic stagnation despite recent increases in R&D expenditures and reform of its research universities.[46] Also among major developed nations, Russia saw its S&E article output decline (-1.0% annual average) over the decade.

Publication output by developed economies outside of the EU, the United States, and Japan grew much faster, primarily due to rapid growth (6%–9% annual average) in three Asian locations—South Korea, Taiwan, and Singapore.

The distribution of S&E article output by field provides an indication of the priority and emphasis of scientific research in different locations.[47] The S&E article portfolios of the four major producers—the EU, the United States, China, and Japan—have distinct differences (table 5-21; appendix tables 5-27–5-39). The United States is focused primarily on biological sciences and medical sciences, more so than the world at large; together, these fields account for 52% of U.S. 2011 articles. The United States also produces a higher proportion of S&E articles than the rest of the world in other life sciences, psychology, and social sciences, although this may be due in part to how Thomson Reuters selects journals to include in its database.[48]

Like the United States, the EU is also focused primarily on biological sciences and medical sciences. However, the EU has placed a greater emphasis than the United States on physics, chemistry, and engineering.

Japan's articles are fairly evenly divided among biological sciences, medical sciences, chemistry, and physics.

China's S&E portfolio is dominated by chemistry, physics, and engineering, with a far higher concentration in these fields than the three other major producers and most other countries. These fields largely fueled China's rapid growth in article output. Compared to the rest of the world, China and Japan put very little emphasis on publication in other life sciences, psychology, and social sciences.

Article Output by U.S. Sector

Six U.S. institutional sectors produce S&E articles: the federal government, industry, academia, FFRDCs, private nonprofit organizations, and state and local governments.[49]

Table 5-20

S&E articles in all fields, by country/economy: 2001 and 2011

Rank	Country/economy	2001	2011	Average annual change (%)	2011 world total (%)	2011 cumulative world total (%)
-	World	629,386	827,705	2.8	na	na
1	United States	190,597	212,394	1.1	25.7	25.7
2	China	21,134	89,894	15.6	10.9	36.5
3	Japan	56,082	47,106	-1.7	5.7	42.2
4	Germany	42,678	46,259	0.8	5.6	47.8
5	United Kingdom	45,588	46,035	0.1	5.6	53.4
6	France	30,602	31,685	0.3	3.8	57.2
7	Canada	21,945	29,114	2.9	3.5	60.7
8	Italy	22,093	26,503	1.8	3.2	63.9
9	South Korea	11,008	25,593	8.8	3.1	67.0
10	Spain	15,324	22,910	4.1	2.8	69.8
11	India	10,801	22,480	7.6	2.7	72.5
12	Australia	14,484	20,603	3.6	2.5	75.0
13	Netherlands	12,117	15,508	2.5	1.9	76.8
14	Taiwan	7,912	14,809	6.5	1.8	78.6
15	Russia	15,658	14,151	-1.0	1.7	80.3
16	Brazil	7,052	13,148	6.4	1.6	81.9
17	Switzerland	7,950	10,019	2.3	1.2	83.1
18	Sweden	10,022	9,473	-0.6	1.1	84.3
19	Turkey	4,151	8,328	7.2	1.0	85.3
20	Iran	1,035	8,176	23.0	1.0	86.3
21	Poland	5,629	7,564	3.0	0.9	87.2
22	Belgium	5,827	7,484	2.5	0.9	88.1
23	Israel	6,235	6,096	-0.2	0.7	88.8
24	Denmark	4,917	6,071	2.1	0.7	89.6
25	Austria	4,480	5,102	1.3	0.6	90.2
26	Finland	4,930	4,878	-0.1	0.6	90.8
27	Norway	3,215	4,777	4.0	0.6	91.4
28	Portugal	2,081	4,621	8.3	0.6	91.9
29	Singapore	2,434	4,543	6.4	0.5	92.5
30	Greece	3,204	4,534	3.5	0.5	93.0
31	Mexico	3,204	4,173	2.7	0.5	93.5
32	Czech Republic	2,571	4,127	4.8	0.5	94.0
33	Argentina	2,931	3,863	2.8	0.5	94.5
34	New Zealand	2,851	3,472	2.0	0.4	94.9
35	Ireland	1,588	3,186	7.2	0.4	95.3
36	South Africa	2,291	3,125	3.2	0.4	95.7
37	Egypt	1,463	2,515	5.6	0.3	96.0
38	Thailand	727	2,304	12.2	0.3	96.2
39	Hungary	2,398	2,289	-0.5	0.3	96.5
40	Malaysia	472	2,092	16.0	0.3	96.8
41	Chile	1,159	1,979	5.5	0.2	97.0
42	Ukraine	2,239	1,727	-2.6	0.2	97.2
43	Romania	927	1,626	5.8	0.2	97.4
44	Saudi Arabia	565	1,491	10.2	0.2	97.6
45	Croatia	696	1,289	6.3	0.2	97.8
46	Serbia	NA	1,269	na	0.2	97.9
47	Pakistan	279	1,268	16.3	0.2	98.1
48	Slovenia	851	1,239	3.8	0.1	98.2
49	Slovakia	924	1,099	1.8	0.1	98.3
50	Tunisia	352	1,016	11.2	0.1	98.5

na = not applicable; NA = not available.

NOTES: Countries/economies shown produced 1,000 articles or more in 2011. Countries/economies are ranked based on the 2011 total. Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by their year of publication and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on the basis of the proportion of its participating institutions). Detail does not add to total because of countries/economies not shown.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-26.

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This section describes patterns and trends in the sector distributions of U.S. article output.

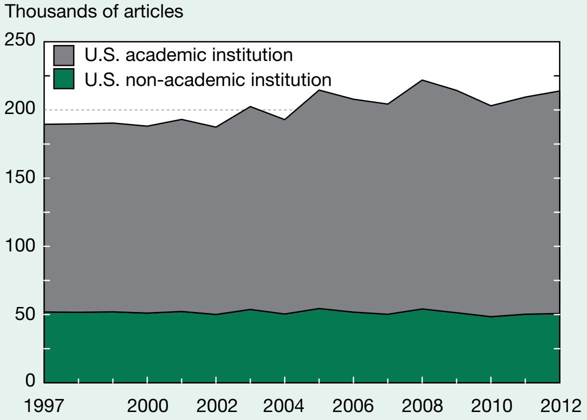
The U.S. academic sector is the largest producer of S&E articles, accounting for three-fourths of U.S. S&E article output. This sector was largely responsible for the slight growth of U.S. S&E article output over the last 15 years. The number of academic S&E articles rose from 138,000 to 163,000 between 1997 and 2012. As a result, academia's share of all U.S. articles rose from 73% to 76% (figure 5-20).

S&E publications in the non-academic sectors decreased slightly from 52,000 to 51,000 during this period. These sectors had divergent trends:

- Articles in the private nonprofit sector grew from 15,000 to 18,000 and at an even greater pace than the academic sector between 1997 and 2012 (appendix table 5-40). However, this sector's much smaller size resulted in a lesser impact on total U.S. growth.
- Articles in FFRDCs fluctuated between 5,000 and 6,000.[50]
- Industry and the federal government exhibited similar trends, starting the period at 14,000 articles and then declining, especially over the past 10 years. However, industry articles dropped further than federal government articles to end the period at 12,000, compared with 13,000 for the federal government.

Except for the FFRDCs, the research portfolios of the U.S. sectors are dominated by life sciences (biological sciences and medical sciences), with nearly half or more of all articles in these fields (table 5-22). The dominance of life

Figure 5-20
U.S. academic and non-academic S&E articles: 1997–2012



NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database and are assigned to U.S. institution(s) based on the institutional address(es) listed in the article. Articles are credited on a fractional count basis; for articles with institutional addresses from multiple countries/U.S. institutions, each country/U.S. institution receives fractional credit on the basis of the proportion of its participating institutions.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-40.

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Table 5-21
S&E research portfolios of selected regions/countries, by field: 2011
(Percent)

Field	World	United States	EU	China	Japan
All articles (*n*)	827,705	212,394	254,482	89,894	47,106
Engineering	10.7	7.1	9.0	16.9	11.0
Agricultural sciences	2.3	1.6	2.4	2.1	2.4
Astronomy	1.3	1.4	1.6	0.6	1.0
Biological sciences	19.5	23.3	19.3	14.8	20.7
Chemistry	13.9	8.2	12.8	24.9	17.3
Computer sciences	1.1	1.1	1.1	1.7	0.3
Geosciences	5.6	5.5	5.7	4.8	4.2
Mathematics	2.2	1.9	2.6	2.6	1.5
Medical sciences	22.1	28.3	24.0	10.6	21.3
Other life sciences	1.2	2.2	1.0	0.2	0.2
Physics	13.1	8.6	12.6	19.4	18.2
Psychology	2.8	4.8	2.9	0.4	0.8
Social sciences	4.1	6.0	4.9	0.9	1.0

EU = European Union.

NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by their year of publication and are assigned to the country on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries, each country receives fractional credit on the basis of the proportion of its participating institutions). See appendix table 5-24 for countries/economies included in the EU. Percentages may not add to 100% because of rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix tables 5-27—5-39.

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sciences is especially pronounced in the nonprofit sector, where 79% of the articles are in the biological sciences and medical sciences. With a much larger number of articles, academia has 49% of its S&E literature in life sciences. The research portfolio of FFRDCs is dominated by physics (36%), chemistry (19%), and engineering (16%), with far less concentration in life sciences (11%). This reflects the FFRDCs' more specialized and mission-oriented research programs in these and other physical sciences.

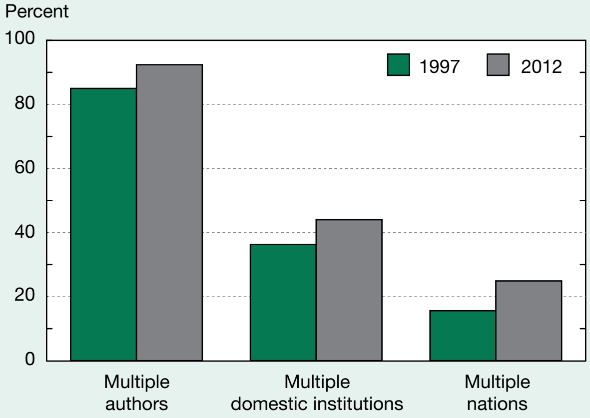
Coauthorship and Collaboration in S&E Literature

Collaborative S&E research facilitates knowledge transfer and sharing among individuals, institutions, and nations. It can be an indicator of interconnections among researchers in different institutional settings and the growing capacity of researchers to address complex problems by drawing on diverse skills and perspectives. Collaboration on S&E research publications over the last 15 years has been increasing, with higher shares of scientific articles with more than one named author and a higher proportion of articles with institutional and international coauthorships (figure 5-21). The largest increase was in international collaboration; the percentage of articles with authors from different countries rose from 16% to 25% between 1997 and 2012.

The following two sections explore the growth of collaborative publication.[51] The first section looks at international collaboration. The second section examines collaboration across institutional sectors—including academia, the federal

Figure 5-21

Share of world articles in all fields authored by multiple authors, institutions, and nations: 1997 and 2012



NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database. Articles by multiple authors are those with multiple persons authoring the article; articles by multiple domestic institutions and multiple nations have multiple institutional addresses listed on the article. Authors from different departments within the same institution are considered to be from different institutions.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-41.

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Table 5-22

Share of U.S. S&E articles, by sector and field: 2012

(Percent)

Sector	Federal government	Industry	Academic	FFRDCs	Private nonprofit	State/local government
All fields combined (*n*)	13,075	11,779	163,137	5,690	18,322	1,728
Engineering	6.0	13.8	7.0	15.9	1.2	3.8
Agricultural sciences	4.6	2.0	1.5	0.3	0.4	1.1
Astronomy	1.8	0.6	1.4	5.4	2.4	0.0
Biological sciences	29.7	22.7	22.7	8.9	24.6	24.9
Chemistry	4.7	12.4	8.4	18.7	2.0	0.9
Computer sciences	0.3	2.6	1.2	0.7	0.1	0.2
Geosciences	12.3	5.3	5.2	10.3	2.9	13.7
Mathematics	0.4	0.7	2.4	1.0	0.2	0.0
Medical sciences	26.3	24.5	25.8	2.5	54.3	43.5
Other life sciences	1.5	2.1	2.1	0.0	3.6	4.5
Physics	6.4	10.0	8.8	35.5	1.3	0.3
Psychology	2.6	1.5	6.0	0.0	2.7	4.0
Social sciences	3.5	1.7	7.4	0.6	4.2	3.2

NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a sector on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple sectors, each sector receives fractional credit on the basis of the proportion of its participating institutions).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-40.

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government, and industry—within the United States. (Data on sectors for other countries are not available.)

International Collaboration

International scientific collaborations reflect wider patterns of relationships among countries. Linguistic and historical factors (Narin, Stevens, and Whitlow 1991), geography, and cultural relations (Glänzel and Schubert 2005) play a role in these relationships. In recent years, coauthorships in Europe have risen in response to EU policies actively encouraging intra-European, cross-border collaboration. Strong ties among science establishments in Asia, though without the formal framework that characterizes Europe, have led to similar collaboration.

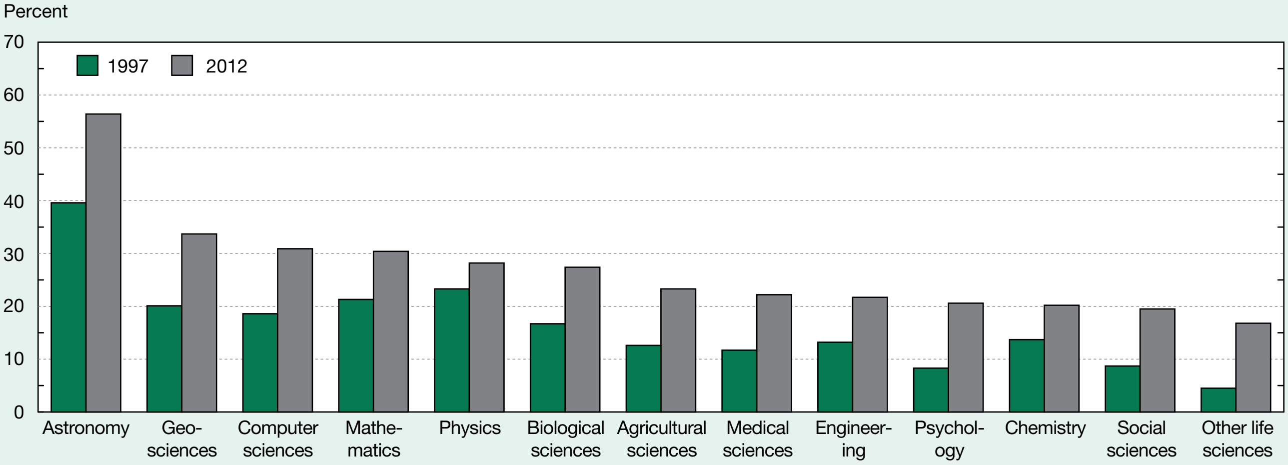
Rates of international collaboration by field. International collaboration on scientific articles, as measured by the shares of articles coauthored by institutional authors in different countries, has increased markedly over the last 15 years. S&E articles with coauthors from more than one country have grown to nearly one-fourth of the world's S&E articles, rising from 16% in 1997 to 25% in 2012. This is a slightly larger increase than the increase in purely domestic coauthorships during the same period (from 36% to 44%) (figure 5-21).

Researchers in different fields have different tendencies to collaborate internationally. Astronomy is the most international field, with over half of its articles internationally coauthored (56%) (figure 5-22). Geosciences, computer sciences, mathematics, physics, and biological sciences have relatively high rates of international collaboration, with shares in the range of 27%–34%. Fields with low rates of collaboration (17%–21%) include psychology, chemistry, social sciences, and other life sciences. Possible factors influencing variations among fields include the existence of formal international collaborative programs, expensive infrastructure (e.g., atomic colliders and telescopes) that results in cost sharing and collaboration among countries, the geographic scope (local versus international) of research fields, and path dependencies from earlier, relatively local ways of doing research.

International collaboration has risen across all scientific fields over the last 15 years. The two fields with the highest rates of international collaboration—astronomy and geosciences—had increases of 17 and 14 percentage points, respectively, in their shares between 1997 and 2012. Physics and chemistry had far lower gains of just 5 and 7 percentage points, respectively. Psychology and other life sciences had strong gains yet remain among the four fields with the least amount of international collaboration.

Rates of international collaboration by country/region. Countries vary widely in the proportion of their S&E articles that are internationally coauthored, ranging from 25% (Iran) to as much as 80% (Saudi Arabia) for articles in 2012 (appendix table 5-41; see also appendix tables 5-42–5-54 for individual fields). The shares of larger countries are generally lower (from 25% to 60%) than smaller countries (from 50% to 80%). The difference is likely because the bigger and more diversified scientific establishments in larger countries allow opportunities for collaborative scientific teams within their

Figure 5-22
Share of world's S&E articles with international collaboration, by S&E field: 1997 and 2012



NOTES: Data are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating institution or country is credited one count). Internationally coauthored articles may also have multiple domestic coauthors.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix tables 5-42–5-54.

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borders, whereas smaller countries do not have the research infrastructure or personnel to support such collaboration.

The U.S. international collaboration rate was 35% in 2012, significantly lower than France, Germany, and the United Kingdom (figure 5-23). However, because the United States has a higher share of articles with domestic coauthors, its overall proportion of coauthored articles is similar to that of the three EU countries.

The higher international collaboration rates of large EU member countries relative to the United States are likely due to their smaller science establishments, which increase the need for collaboration teams with international participation. In addition, the EU's Framework Programmes for Research and Technological Development and other programs designed to increase collaboration among EU member countries and with other countries likely boost their international collaboration.

Japan and China have even lower international collaboration shares than the United States (figure 5-23). One factor that may explain their low shares is that Asia does not have a formal framework like the EU to facilitate international collaboration. Another possible factor is that some Chinese and Japanese scientists may not speak English or publish their research in that language, which could limit their visibility in the international scientific community, where English is commonly used.

Rates of international collaboration have generally risen over the last decade, though to varying degrees (figure 5-23). The U.S. rate rose 10 percentage points to reach 35% between 2002 and 2012. Canada had a similar increase (from 40% to 50%) over the same period.

The increase has been even more dramatic for EU members and other European countries. The shares of France, Germany, and the United Kingdom increased by 12–16 percentage points to reach over 50%. The EU's Framework Programmes for Research and Technological Development, now in their seventh year, have likely been a major factor in these countries' increases.

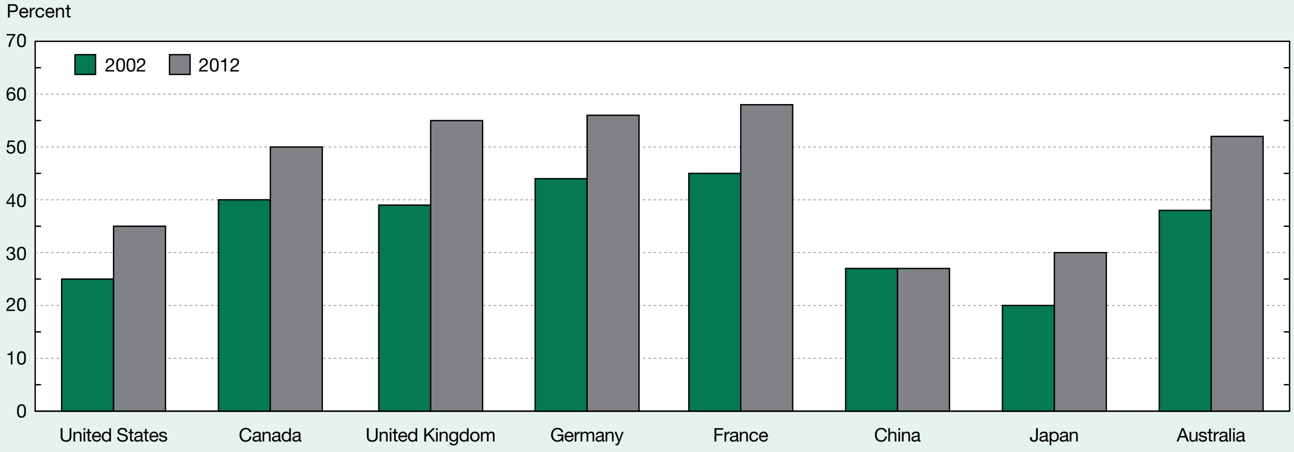
China is an exception to the general trend of increasing international collaboration. China's rate of international collaboration (27%) remained stable over the last decade during China's period of very rapid article growth. In contrast, Chinese domestic collaboration increased in this period: the proportion of its articles that had multiple domestic institutional authors rose by 11 percentage points, reaching 44% (appendix table 5-41).

Preferred collaboration partners. Different countries have different preferred partners for international scientific collaboration. The remainder of this section describes global partnership patterns, with particular emphasis on patterns of U.S. involvement in international collaboration.

The nation that most often coauthors with the United States is China, a collaborator on 16% of U.S. internationally coauthored articles (table 5-23).[52] As shown in figure 5-24, other countries that are important partners for the United States are the United Kingdom (14%), Germany (13%), Canada (11%), France (9%), Italy (7%), and Japan (7%). Canada and China are notable among these countries for having unusually high rates of U.S. participation in their own internationally coauthored articles (49% and 48%, respectively). For the other five countries, the comparable rates range from 29% to 37%.

For most countries, the percentage of U.S. internationally coauthored papers on which they are coauthors has

Figure 5-23
Share of S&E articles internationally coauthored, by selected country: 2002 and 2012



NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating institution or country is credited one count). Internationally coauthored articles may also have multiple domestic coauthors.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-41.

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stayed stable over the decade. China and Japan are exceptions. China's share of U.S. internationally authored articles tripled from 5% in 2002 to 16% in 2012, coinciding with its rapid expansion of article production. China swiftly moved up from the sixth-largest collaborating country in 2005 to the second-largest collaborating country in 2010 before becoming the largest in 2011. Japan's share of U.S. coauthored articles dropped from 10% to 7%, coinciding with its decline in article production.

Several countries that collaborate on relatively few U.S. internationally coauthored articles have very high U.S. participation in their own internationally coauthored articles. Three economies—Israel, South Korea, and Taiwan—have more than 50% of their international articles coauthored with the United States. Other countries with relatively large U.S. shares of their internationally coauthored articles include Mexico, Chile, Brazil, and Turkey.

Table 5-23

International coauthorship of S&E articles with the United States, by selected country/economy: 2002 and 2012

(Percent)

	U.S. share of country/economy's international articles		Country/economy's share of U.S. international articles	
Country/economy	2002	2012	2002	2012
World	43.8	43.0	na	na
China	36.8	47.5	5.1	16.2
United Kingdom	30.9	33.2	13.1	14.3
Germany	30.3	31.0	13.8	13.3
Canada	53.1	48.9	11.3	11.4
France	25.5	28.5	8.6	8.8
Italy	32.4	34.0	6.9	7.4
Japan	41.2	37.1	9.8	6.8
Australia	36.6	32.9	4.7	6.0
South Korea	55.1	53.9	3.7	6.0
Spain	26.9	29.5	3.9	5.8
Netherlands	29.6	33.7	4.4	5.6
Switzerland	31.6	33.4	4.0	4.8
Sweden	27.3	30.5	3.4	3.4
Brazil	37.0	41.5	2.5	3.2
Israel	52.8	55.6	3.5	2.8
India	34.3	34.2	1.9	2.7
Taiwan	55.4	52.3	1.9	2.7
Belgium	23.5	26.0	2.2	2.5
Russia	25.3	29.9	3.8	2.4
Denmark	29.8	32.3	2.0	2.3
Austria	24.8	28.9	1.5	2.0
Poland	26.2	32.2	1.9	2.0
Mexico	42.5	46.3	1.6	1.7
Norway	29.6	30.8	1.2	1.6
Finland	27.9	29.9	1.5	1.5
Singapore	30.0	31.7	0.7	1.5
Greece	27.7	37.7	0.9	1.5
South Africa	31.0	39.3	0.8	1.4
Turkey	39.7	40.3	0.9	1.3
Chile	40.4	45.1	0.8	1.3
Portugal	19.5	25.1	0.6	1.3
Czech Republic	21.1	29.3	0.8	1.2
New Zealand	37.4	34.1	1.1	1.2
Argentina	35.2	38.2	1.1	1.2
Ireland	23.4	30.1	0.5	1.0
Hungary	29.3	33.9	1.1	1.0

na = not applicable.

NOTES: Internationally coauthored articles have at least one collaborating institution from the indicated country/economy and an institution from outside that country/economy. Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating country/economy is credited one count). Countries/economies are ranked by the percentage of their share of the United States' international articles in 2012; countries/economies with less than 1% of the United States' 2012 international articles are omitted.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-56.

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An index of international collaboration is useful for highlighting rates of international scientific collaboration that differ substantially from chance (see sidebar, "Normalizing Coauthorship and Citation Data"). When collaborative authorship between two countries is exactly proportional to their overall rates of international collaborative authorship, the index value is 1; a higher index value means that a country pair has a stronger-than-expected tendency to collaborate, and a lower index value means the opposite.

U.S. collaboration with countries as measured by the index of international collaboration shows variable trends (table 5-24; appendix tables 5-55 and 5-56). In North America, the Canada-U.S. index shows a rate of collaboration that is slightly greater than would be expected, and the index has not changed much over the past 15 years. The U.S.-Mexico index is just about as would be expected and has been stable.

In scientific collaboration with EU member countries, the United States has a weaker-than-expected tendency to collaborate with the United Kingdom, Germany, and France despite a comparatively high volume of internationally coauthored articles. U.S. collaboration with these countries became slightly stronger between 1997 and 2012.

In contrast to EU member countries, U.S. collaboration with Asia has generally been stronger than expected. U.S. collaboration is relatively strong with China, South Korea, and Taiwan. However, U.S. collaboration with Japan is slightly weaker than expected despite a high volume of coauthored papers. Between 1997 and 2012, U.S.-Japan collaboration has shifted from as expected to weaker than expected.

Collaborations between Latin American countries are notably stronger than expected. The collaboration index of Mexico-Argentina is 3.88, far above expected levels. The collaboration index of Argentina-Brazil is even higher, at 5.81, one of the highest in the world, and was high, at 4.94, even 15 years ago.

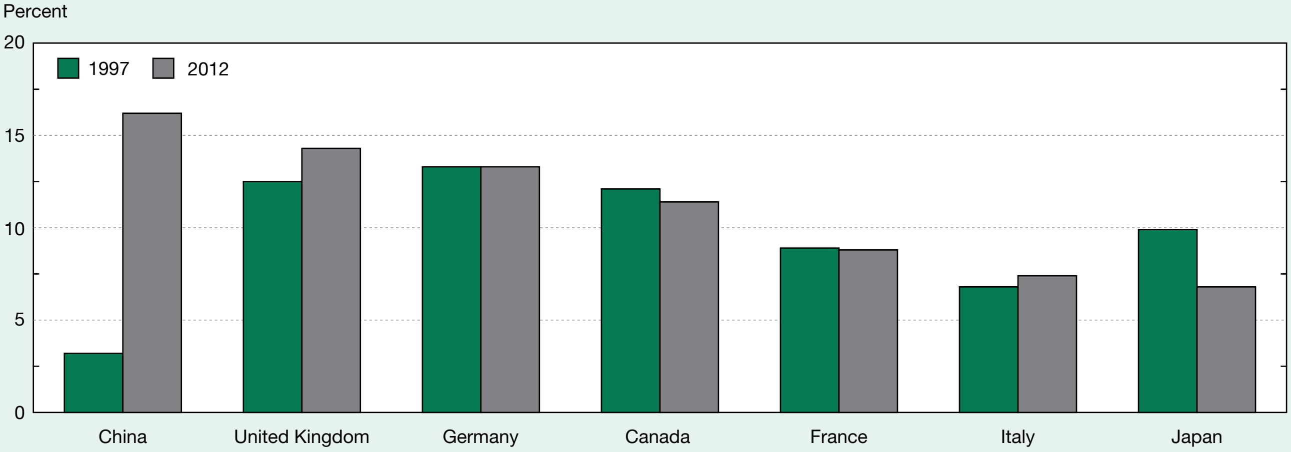
Among European countries, collaboration patterns are mixed, but most have increased between 1997 and 2012. Among the large publishing countries (Germany, the United Kingdom, and France), collaboration was less than expected in 1997 but grew to just about what would be expected in 2012. A particularly strong collaboration network has developed between scientists in Poland and the Czech Republic, with the index for their countries standing at 5.97 in 2012.

The Scandinavian countries increased their collaboration indexes with many countries elsewhere in Europe over the last 15 years (appendix table 5-55).[53] Within Scandinavia, the indexes are among the highest in the world (table 5-24).

Collaboration indexes within Asia and across the South Pacific between the large article producers are generally higher than expected, but some have declined between 1997 and 2012. The collaboration index of China-Japan declined from 1.61 to 1.23; the South Korea–Japan index fell from 2.20 to 1.93. The Australia–New Zealand collaboration index, although much higher than expected, fell from 4.33 to 3.65. Other partnerships strengthened during this period. The Australia-China collaboration shifted from slightly weaker to slightly stronger than expected. India's collaborations with both South Korea and Japan grew stronger between 1997 and 2012.

Figure 5-24

Selected country share of U.S. internationally coauthored articles: 1997 and 2012



NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database rather than their year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating institution or country is credited one count). Internationally coauthored articles may also have multiple domestic coauthors.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

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Normalizing Coauthorship and Citation Data

Data for coauthorships and citations can be misleading if they do not take into account the size of a country's scientific publication base. To aid interpretation, data should be normalized. The normalized measures used in this report have an expected value of 1.00. If the measure is higher than expected, it will be greater than 1.00; if less than expected, it will be less than 1.00.

Index of International Collaboration. Eliminating other factors (language, geography, etc.), one might expect a large share of a country's internationally coauthored articles to have coauthors from the United States simply due to the sheer size of the U.S. scientific base. Thus, if the United States is a coauthor on 43% of the world's internationally coauthored articles, one would expect 43% of China's internationally coauthored articles to have a U.S. partner. In fact, 47.5% of China's internationally coauthored articles in 2012 have a U.S. coauthor. Dividing the actual share by the expected share yields an index value of 1.10. Thus, China coauthors with the United States 10% more than expected. Index values for any country pair are always symmetrical, so the United States also coauthors with China 10% more than expected. The data for calculating the 2012 indexes in appendix table 5-55 are contained in appendix table 5-56.

Relative Citation Index. Similarly, normalizing citation counts by a country's publication output is essential for correct interpretation of the data. The expected share of citations that one country receives from another depends on the number of articles that the cited country produces. Using the U.S.-China example above, the United States authored 26.6% of all 2008–10 articles (appendix table 5-57). All other things being equal, if Chinese authors showed no preference for U.S. science, 26.6% of their references in 2012 articles would be to U.S. articles. In actuality, 22.9% of Chinese references are to U.S. articles. Dividing the number of Chinese references to U.S. articles by the expected number of references yields an index value of 0.86. The relative citation index is not symmetrical; that is, the index for China citing the United States is not equal to the index for the United States citing China (0.32).

Table 5-24
Index of international collaboration on S&E articles, by selected country/economy pair: 1997 and 2012
(International collaboration index)

Country/economy pair	1997	2012
North/South America		
Canada–United States	1.19	1.14
Mexico–United States	1.01	1.08
United States–Brazil	0.83	0.96
Argentina–Brazil	4.94	5.81
Mexico–Argentina	2.50	3.88
North Atlantic		
UK–United States	0.68	0.77
Germany–United States	0.67	0.72
France–United States	0.57	0.66
Canada–France	0.58	0.87
Europe		
France–Germany	0.75	1.06
France–UK	0.78	0.97
Germany–UK	0.70	0.98
Belgium–Netherlands	2.53	2.86
Italy–Switzerland	1.46	1.65
Poland–Czech Republic	1.76	5.97
Hungary–Germany	1.23	1.77
Germany–Czech Republic	1.30	1.63
Scandinavia		
Finland–Sweden	3.34	4.12
Norway–Sweden	4.38	4.61
Sweden–Denmark	2.74	3.88
Finland–Denmark	1.98	2.98
Pacific Rim		
Japan–United States	1.00	0.86
China–United States	0.79	1.10
South Korea–United States	1.38	1.25
Taiwan–United States	1.53	1.22
China–Canada	0.80	0.74
Japan–Canada	0.61	0.67
Asia/South Pacific		
China–Japan	1.61	1.23
South Korea–Japan	2.20	1.93
Australia–Singapore	2.22	1.48
Australia–China	0.92	1.11
Australia–New Zealand	4.33	3.65
India–Japan	0.78	1.06
India–South Korea	1.55	2.42

UK = United Kingdom.

NOTES: The international collaboration index shows the first country's rate of collaboration with the second country, divided by the second country's rate of international coauthorship. Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating country/economy credited one count).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-55.

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Collaboration among U.S. Sectors

U.S. coauthorship data at the sector level—academic, nonprofit, industry, FFRDCs, federal and state government—are indicators of collaboration among U.S. sectors and between U.S. sectors and foreign institutions. The academic sector, the largest article producer among U.S. sectors, is the center of U.S. sector and foreign collaboration. In 2012, the academic sector published 119,371 articles coauthored with other U.S. sectors and foreign institutions, three and a half times more than the 33,973 such articles published by the nonprofit sector, the second largest (table 5-25).

Although the largest producer of articles coauthored with other U.S. sectors and foreign institutions, academia has the lowest coauthored share of total articles, compared to other U.S. sectors.

Figure 5-25 shows the share of U.S. articles coauthored with foreign institutions, U.S. academic institutions, and other U.S. sectors (outside of self and academia). FFRDCs are notable for their very high level of foreign collaboration (46%) compared to a 31%–34% range for most other U.S. sectors. With a high concentration of FFRDCs being focused on physics research (36% of FFRDC articles, table 5-22), which often requires the use of globally shared instruments, a high degree of international collaboration can be expected. State and local governments have the lowest foreign collaboration shares but the highest share of collaboration with other U.S. sectors. Industry has the lowest collaboration share (57%) with academia, compared to 63% or higher for other U.S. sectors.

Over the last decade, collaboration with other U.S. sectors and with foreign institutions increased strongly in almost all sectors (table 5-25). In the academic sector, the number of articles coauthored with other U.S. sectors and foreign institutions increased by more than half, from 76,622 to 119,371. The largest increase was for articles coauthored with foreign institutions, which increased by 83% (from 41,978 to 76,907). As a result, articles with foreign coauthors increased their share of all U.S. academic articles, from 24% to 34%. U.S. academic articles coauthored with other U.S. sectors increased by 41% (from 43,587 to 61,329 articles).

The nonprofit sector had the largest increase in the number of coauthored articles with other U.S. sectors and foreign institutions (from 20,703 to 33,973, a 64% increase). Nonprofit articles coauthored with foreign institutions led the increase, more than doubling (from 6,337 to 13,740). The percentage of articles coauthored with foreign institutions increased their share from 22% to 34%.

Table 5-25

U.S. sector articles coauthored with other U.S. sectors and foreign institutions: 2002 and 2012

	U.S. sector					
Year	Academic	Federal government	Industry	FFRDCs	Private nonprofit	State/local government
2002						
All articles	176,756	24,824	23,485	9,502	28,372	3,868
Total coauthored	117,863	20,009	17,815	7,605	23,161	3,322
Total coauthored with another U.S. sector and/or foreign institution	76,622	18,592	16,456	7,275	20,703	3,209
Coauthored with another U.S. sector	43,587	16,051	13,372	5,671	18,124	3,073
Coauthored with academic sector	na	14,014	11,187	4,925	16,457	2,614
Coauthored with non-academic sector	43,587	5,543	5,305	1,762	5,544	1,455
Coauthored with foreign	41,978	5,749	5,557	3,609	6,337	494
2012						
All articles	226,753	29,099	25,268	13,316	40,672	4,550
Total coauthored	173,744	25,527	21,925	11,739	36,612	4,206
Total coauthored with another U.S. sector and/or foreign institution	119,371	24,057	20,555	11,269	33,973	4,103
Coauthored with another U.S. sector	61,329	21,244	16,651	9,128	29,883	3,941
Coauthored with academic sector	na	19,095	14,382	8,404	27,870	3,485
Coauthored with non-academic sector	61,329	8,367	7,535	2,768	9,595	2,037
Coauthored with foreign	76,907	9,006	8,712	6,172	13,740	917

na = not applicable.

FFRDCs = federally funded R&D centers.

NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a U.S. sector on the basis of the institutional address(es) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating institution type is credited one count in each qualifying group). The sum of articles coauthored with various sectors could exceed the total number of articles coauthored with another sector and/or foreign sector due to articles coauthored by multiple sectors. Articles from joint or unknown U.S. sectors are not shown.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

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Articles with at least one author from industry grew the least over the time period, less than 8%, and in turn had the smallest increase in articles coauthored with other U.S. sectors and foreign institutions (25%).

Much of the growth of industry-coauthored articles was with foreign institutions; foreign coauthorships increased by 57%. Articles coauthored with the academic sector rose by only 29%, the smallest increase among sectors coauthoring with academia.

Trends in Citation of S&E Articles

Citations indicate influence, and they are increasingly international in scope.[54] When scientists and engineers cite the published papers resulting from prior S&E research, they are formally crediting the influence of that research on their own work.

Citations are generally increasing with the volume of S&E articles. (For the analysis of citations from articles to articles, citation counts are limited to a fixed 3-year citation window that begins 4 years and ends 2 years prior to the year of the citing article.[55]) As cited by 1992 articles, an earlier S&E article received, on average, 1.85 citations. In contrast, an S&E article cited by 2012 articles received, on average, 2.47 citations (figure 5-26). Articles with U.S. authors tended to receive more citations than others, but that gap has narrowed slightly in the most recent 4 years.

The next sections examine two aspects of article citations in a global context: the overall rate of citation of a country's scientific publications, and the share of the world's most highly cited literature authored by different countries. The discussion of article citations will conclude with an examination of citations to articles authored by researchers at U.S. academic institutions and in other U.S. sectors.

International Citation Patterns

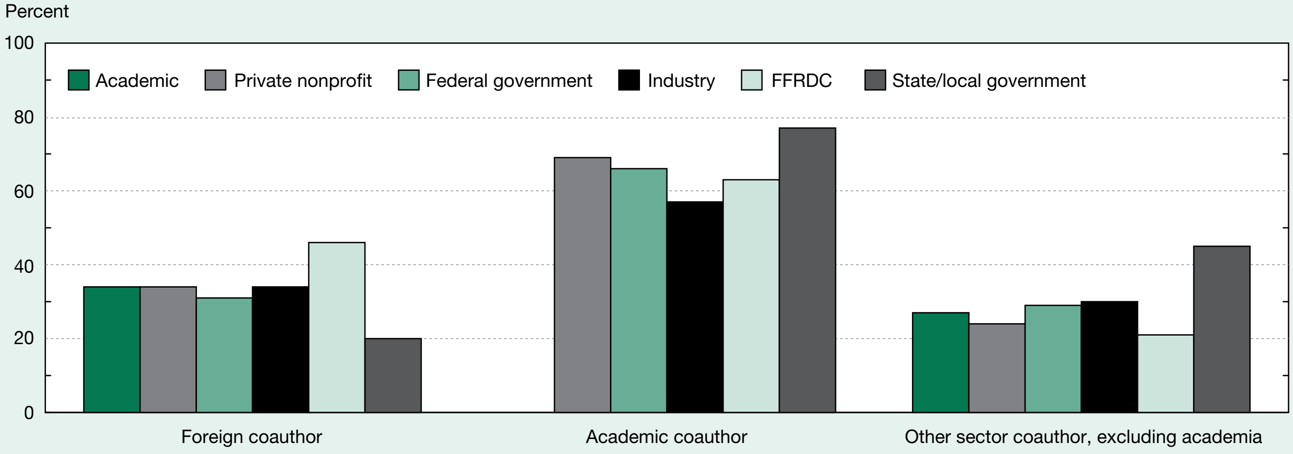
Like the indicators of international coauthorship discussed earlier, cross-national citations are evidence that S&E research is increasingly international in scope. Citations to a country's articles that come from articles authored outside that country are referred to as international citations. Between 1992 and 2012, the international share of citations increased in all but one of the world's major S&E article–producing countries.

China is the exception. In 1992, 69% of citations to Chinese S&E articles came from outside China; by 2012, the proportion had dropped to 49% (figure 5-27). This suggests that China's expanding S&E article output is being used mostly *within* China. However, changes in the composition of the Thomson Reuters database probably also play a role in accounting for this trend.[56] The trend toward domestic citations is also related to the unusually large role of domestic articles in Chinese output growth; the lack of international coauthors may explain, in part, the relatively low rate of international citations.

The relative citation index normalizes cross-national citation data for variations in publication output, much like the collaboration index (see sidebar, "Normalizing Coauthorship and Citation Data"). The expected value is 1.0, but unlike the collaboration index, citation indexes are

Figure 5-25

Share of U.S. sector articles coauthored with foreign institutions, academia, and other U.S. sectors: 2010



FFRDC = federally funded R&D center.

NOTES: Article counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a sector on the basis of the institutional address(es) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating institution type is credited one count in each qualifying group). The sum of shares may exceed 100 due to articles coauthored by multiple sectors. Articles from joint or unknown sectors are not shown. Articles with authors from a single sector are omitted.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

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not symmetric. When country A cites an article by country B, this does not mean that country B is also citing an article by country A. Table 5-26 shows the relative citation index for the year 2012 for major publishing locations in four regions: North America, the EU, Asia, and South America. These data show the following:

- U.S. articles are most highly cited by articles from Canada (1.29) and the United Kingdom (1.15).
- U.S. authors cite Chinese articles much less than expected (0.32).
- Mexico is heavily cited by South American countries, ranging from 22% to 44% more than expected (index values from 1.22 to 1.44); likewise, Mexican authors cite South American articles more than they cite articles from other areas of the world.
- Inter-European influence is strong, with most country pairs exhibiting index values greater than 1.0. Asian authors show similar interconnectedness, with the exception of Japan.

These data indicate the strong influence that geographic, cultural, and language ties have on citation patterns.

U.S. articles are more influential than those produced by the world's other major publishing regions or countries. They receive 31% more citations than expected. U.S. index values for physics and chemistry are especially high, at 1.49 and 1.43, respectively, but in every field, U.S. articles are disproportionately cited (see figure 5-28).[57]

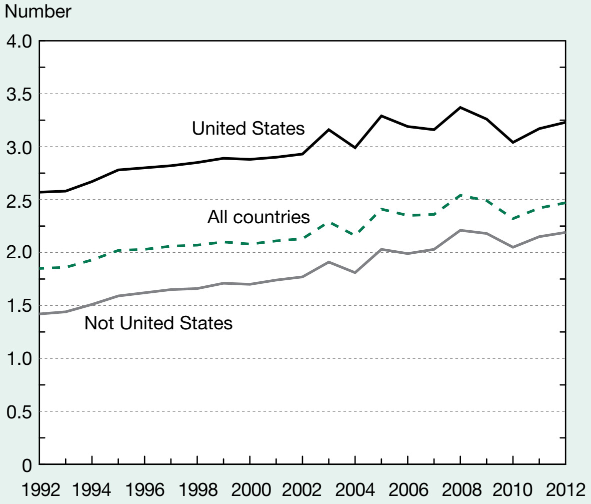
Trends in Highly Cited S&E Literature by Country

Another indicator of the performance of a national or regional S&E system is the share of its articles that are highly cited. High citation rates generally indicate that an article has a relatively great impact on subsequent research.

World citations to U.S. research articles show that, in all broad fields of S&E, U.S. articles continue to have the highest citation rates. In both 2002 and 2012, as displayed in appendix table 5-58, the U.S. share of articles in the 99th citation percentile was higher than its share in the 95th percentile, and these were higher than its share in the 90th

Figure 5-26

Average citations per S&E article, by country of author: 1992–2012



NOTES: Article/citation counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than year their of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/ economies, each country/economy receives fractional credit on the basis of the proportion of its participating institutions). Citation counts are based on a 3-year period with a 2-year lag (e.g., citations for 2012 are references made in articles in the 2012 data tape to articles in the 2008–10 data tapes).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2011) from Thomson Reuters, SCI and SSCI, http:// thomsonreuters.com/products_services/science/.

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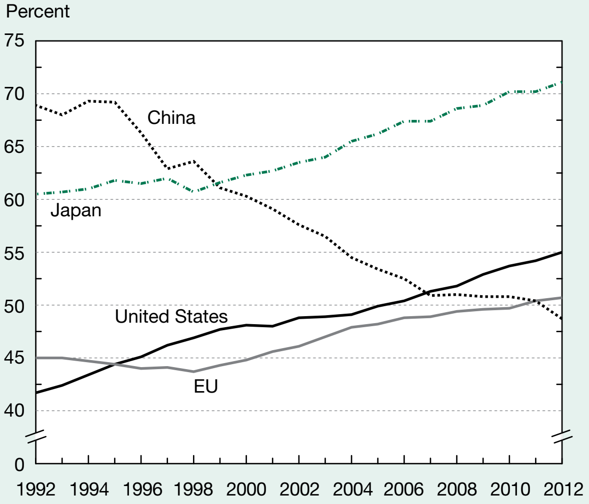
Figure 5-27

Share of selected region/country citations that are international: 1992–2012



EU = European Union.

NOTES: Article/citation counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database rather than their year of publication, and are assigned to a country/region on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/ regions, each country/region receives fractional credit on the basis of the proportion of its participating institutions). See appendix table 5-24 for countries included in the EU, which in this figure is treated as a single country. Citation counts are based on a 3-year period with a 2-year lag (e.g., citations for 2012 are references made in articles in the 2012 data tape to articles in the 2008–10 data tapes).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http:// thomsonreuters.com/products_services/science/.

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Table 5-26
Relative citation index, by selected country/economy pair: 2012

	Cited country/economy												
	North America			European Union			Asia				South America		
Citing country/ economy	United States	Canada	Mexico	France	Germany	UK	China	Japan	South Korea	Taiwan	Argentina	Brazil	Chile
North America													
United States	2.15	0.96	0.35	0.72	0.84	0.97	0.32	0.53	0.40	0.34	0.36	0.31	0.46
Canada	1.29	5.57	0.46	0.86	0.87	1.16	0.39	0.50	0.41	0.39	0.46	0.38	0.59
Mexico	0.99	0.90	27.04	0.96	0.84	0.95	0.62	0.52	0.54	0.59	1.37	1.17	1.52
European Union													
France	1.02	0.87	0.45	5.35	1.15	1.13	0.39	0.63	0.41	0.35	0.58	0.40	0.70
Germany	1.08	0.82	0.34	1.05	4.24	1.14	0.36	0.64	0.39	0.30	0.43	0.31	0.55
UK	1.15	1.00	0.36	0.94	1.06	4.17	0.30	0.51	0.33	0.29	0.37	0.32	0.50
Asia													
China	0.86	0.65	0.46	0.71	0.78	0.64	3.43	0.83	1.11	1.06	0.43	0.44	0.37
Japan	0.99	0.65	0.31	0.81	0.95	0.79	0.56	5.16	0.74	0.56	0.31	0.27	0.31
South Korea	1.04	0.64	0.34	0.64	0.74	0.68	1.03	1.02	7.45	1.29	0.36	0.37	0.45
Taiwan	0.95	0.71	0.43	0.65	0.73	0.68	1.12	0.90	1.51	11.37	0.41	0.40	0.41
South America													
Argentina	0.91	0.87	1.44	1.03	0.93	0.87	0.44	0.48	0.40	0.40	39.73	1.68	2.98
Brazil	0.84	0.79	1.22	0.87	0.75	0.83	0.53	0.50	0.49	0.53	1.92	13.93	1.07
Chile	1.02	0.90	1.31	1.13	1.05	1.06	0.42	0.46	0.41	0.37	2.74	1.19	55.46
World	1.31	1.01	0.56	1.03	1.13	1.15	0.84	0.82	0.75	0.68	0.65	0.60	0.67

UK = United Kingdom.

NOTES: Article/citation counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered database, rather than their year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on the basis of the proportion of its participating institutions). Citation counts are based on a 3-year period with a 2-year lag (e.g., citations for 2012 are references made in articles in the 2012 data tape to articles in the 2008–10 data tapes).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

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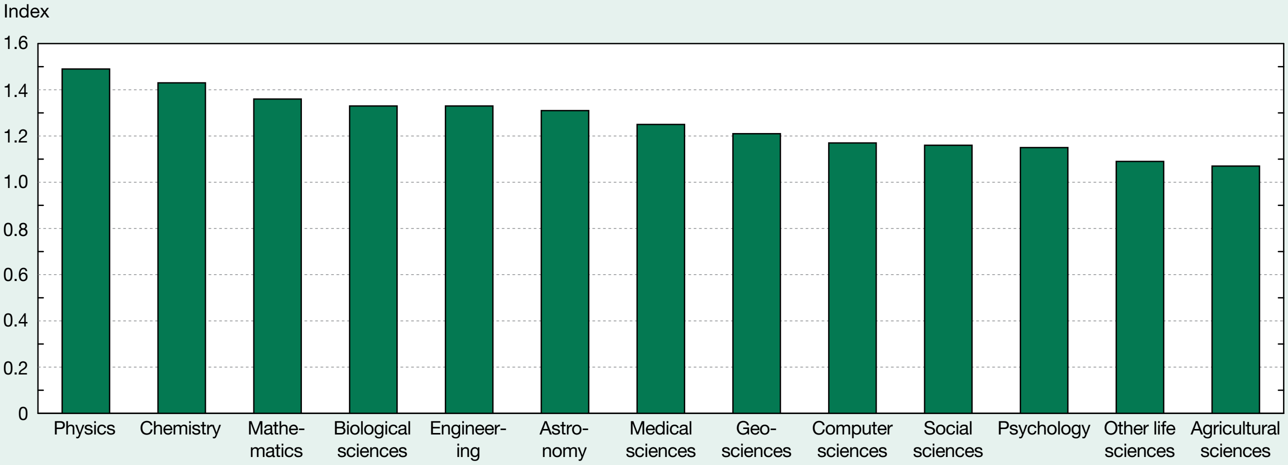
Figure 5-28
Relative citation index to the United States, by scientific field: 2012



NOTES: Article/citation counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database rather than their year of publication. Citation counts are based on a 3-year period with a 2-year lag (e.g., citations for 2012 are references made in articles in the 2012 data tape to articles in the 2008–10 data tapes).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

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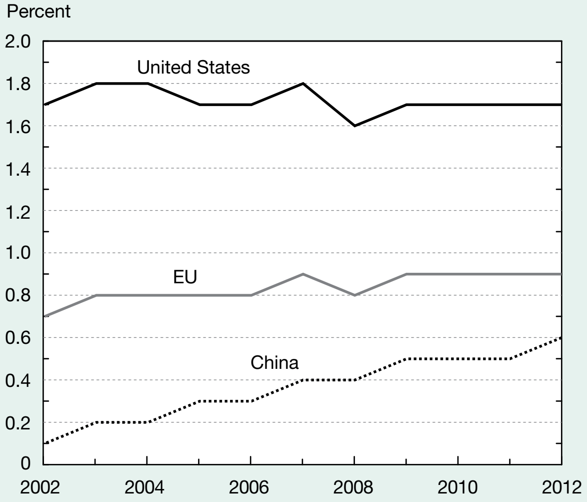
percentile.[58] In 2012, although the United States authored 27% of the world's total of 2.4 million articles in the cited period shown, the United States authored 46% of the articles in the 99th citation percentile.

U.S. publications uniquely display the preferred citation pattern: the higher the citation percentile, the higher the share of U.S. articles in the citation percentile. In contrast, EU articles are found disproportionately in the middle citation percentiles, while Chinese and Japanese articles are found disproportionately in the lower citation percentiles (see appendix table 5-58). Nevertheless, as the U.S. share of all articles produced declined between 2002 and 2012, its share of articles in the 99th percentile (i.e., the top 1%) of cited articles also declined, particularly in some fields. Shares in the top percentile increased for the EU and China but dropped slightly for Japan.

Between 2002 and 2012, 1.6%–1.8% of U.S.-authored S&E articles have appeared in the world's top 1% of cited articles, compared with 0.7%–0.9% of articles from the EU (figure 5-29). The share of China's articles in the top 1% remained behind the United States and the EU but increased from 0.1% to 0.6% over the period.

Figure 5-29
Share of U.S., EU, and China S&E articles that are in the world's top 1% of cited articles: 2002–12



EU = European Union.

NOTES: Article/citation counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/regions, each country/region receives fractional credit on the basis of the proportion of its participating institutions). See appendix table 5-24 for countries included in the EU, which in this figure is treated as a single country. Citation counts are based on a 3-year period with a 2-year lag (e.g., citations for 2012 are references made in articles in the 2012 data tape to articles in the 2008–10 data tapes).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-57.

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The high citation of U.S. articles has changed little over the past 10 years, remaining much higher than expected when compared to the overall U.S. share of world articles (figure 5-30; appendix table 5-57). Between 2002 and 2012, the EU index of highly cited articles for all fields combined rose slightly, to almost 1.0. The Japanese index remained the same and well below the expected value. China's index rose substantially from 0.1 in 2002 to 0.6 in 2012, the same as Japan's index.

U.S. articles are highly cited across all broad scientific fields, with indexes ranging from 1.3 to 2.2. The U.S. indexes across all these fields showed little change between 2002 and 2012. The greatest gain in the index of highly cited articles was in engineering, which grew from 1.7 to 2.0. The indexes for two fields—chemistry and social sciences—declined slightly (appendix table 5-57).

The EU's articles are more highly cited than expected in two fields, agriculture (1.2) and physics (1.2) for 2012. The EU's index values are what would be expected in two fields—astronomy and chemistry.

China is less highly cited than expected in all science fields except computer sciences, chemistry, and geosciences. Impressively, China's index in computer sciences leaped from 0.2 in 2002 to 1.3 in 2012. Chinese geosciences articles experienced a similar rise from 0.2 to 1.1, while the index for chemistry has now just reached the expected value of 1.0.

Japan's production of highly cited articles is lower than expected across all fields, although its index increased substantially in astronomy.

U.S. Cross-Sector Citation Trends

The relative citation index (described in the section on "International Citation Patterns") can also be used to examine the influence that each U.S. sector has on U.S. S&E literature. Figure 5-31 shows the relative citation index values for each of the six sectors of U.S. institutions and how they have changed over the past 20 years. U.S. academic articles are at the citation level that would be expected and have maintained this level over the entire time period. State and local governments, industry, and FFRDCs historically have produced the U.S. articles with the lowest citation rates. Index values for industry articles have gradually declined over time. In contrast, articles authored at FFRDCs have shown a marked improvement since 2008, rising above the expected value of 1.0 by 2011 and finally ending the period as the second most highly cited U.S. sector.

Articles authored at federal government institutions always have been cited within the United States more than expected. Although the index value declined almost to 1.0 in the 1990s, it has since risen to 1.09. The U.S. articles with the relative greatest impact are those by nonprofit organizations. Counter to the federal government trend, index values rose over the 1990s to 1.29 but have been in decline in the past 10 years, dropping to 1.14 by 2012.

Citation of S&E Articles by USPTO Patents

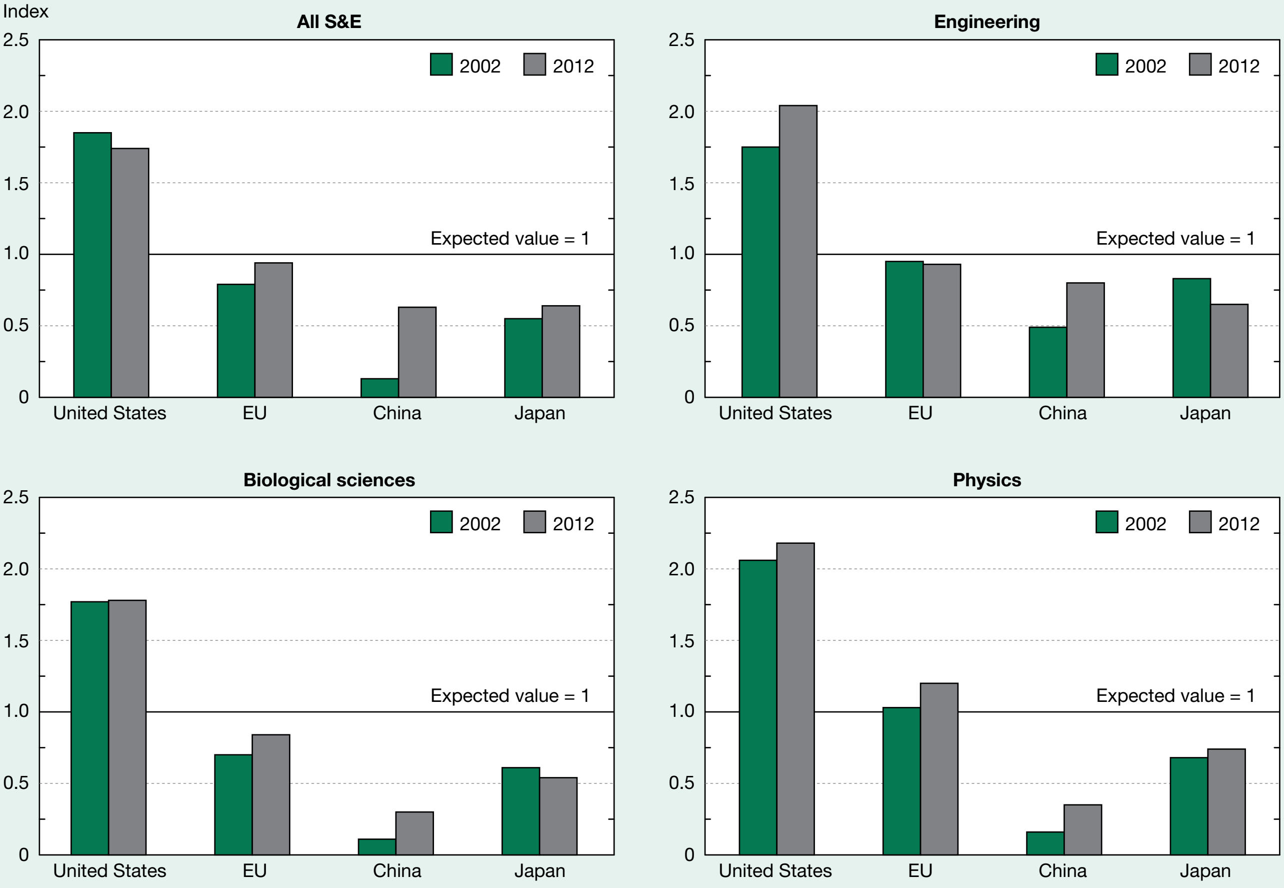
Citations to the S&E literature on the cover pages of issued patents are one indicator of the contribution of research to the development of inventions.[59] To measure trends consistently, the analysis limits the cited article years to a specific moving window, just as is done for references from articles to articles. Unlike article-to-article citations, however, patents reference much older research, largely due to the length of time that passes from patent application to patent grant (i.e., *pendency*). Therefore, indicators in this section are based on an 11-year citation window after a 5-year lag. For example, citations from 2012 are references from patents issued in 2012 to articles published from 1997–2007.

According to this indicator, research links to invention increased sharply in the late 1980s and early 1990s (Narin, Hamilton, and Olivastro 1997). At the same time, patenting activity by academic institutions was increasing rapidly, as were patent citations to S&E literature produced across all sectors (NSB 2008:5-49–5-54).

After a slowdown in the late 1990s and early 2000s, referencing from patents to scientific literature is once again increasing. Of utility patents awarded to both U.S. and foreign assignees, 12% cited S&E articles in 2003, and this figure grew to 15% in 2012 (appendix table 5-59). In addition, the share of patent citations to foreign S&E articles has increased, coinciding with a growth in the percentage of U.S. utility patents awarded to foreign assignees and the share of world articles authored outside the United States. Starting in 2009, U.S. patents cited more foreign articles than U.S. articles.

Citations to U.S. articles in 2012 USPTO patents were dominated by articles in biological sciences (48%) and

Figure 5-30
Index of highly cited articles, by selected S&E field and region/country: 2002 and 2012



EU = European Union.

NOTES: Article/citation counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles/citations are classified by the year they entered the database, rather than their year of publication, and are assigned to a country/region on the basis of the institutional address(es) listed in the article. See appendix table 5-24 for countries included in the EU. Citation counts are based on a 3-year period with a 2-year lag (e.g., citations for 2012 are references made in articles in the 2012 data tape to articles in the 2008–10 data tapes). The index of highly cited articles is a country's share of the world's top 1% cited articles divided by its share of world articles for the cited-year window.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-57.

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medical sciences (23%), along with chemistry (11%), engineering (7%), and physics (7%). These five fields account for 96% of the total (figure 5-32; appendix table 5-60). The patents citing U.S. articles are concentrated in three technology areas—pharmaceuticals, chemicals, and biotechnology—that together make up 63% of the total (figure 5-32).

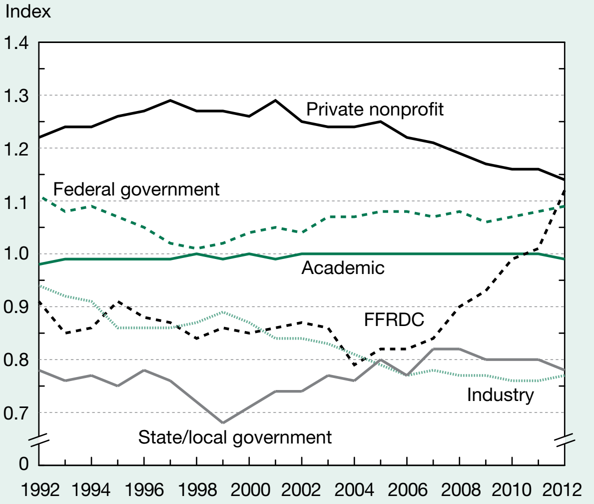
The proportion of U.S. articles cited in U.S. patents that were authored by industry and federal government dropped between 2003 and 2012, largely because citations to academic articles increased (appendix table 5-59). Citations to academia grew from 59% to 65% of total citations to U.S. articles in that time period. This trend was stronger in some fields than in others. It was especially pronounced in engineering (from 50% to 68%), mathematics (from 71% to 89%), physics (from 51% to 68%), and psychology (from 67% to 83%). Despite the increasing proportion of citations to academic articles overall, citations to academic agricultural science articles actually decreased (from 67% to 63%) (appendix table 5-60).

Articles from other sectors receive far fewer citations in patents, but this varied by field (figure 5-33). After academia, industry articles capture the next-largest share of citations in every major field except medical sciences, ranging from 12% (medical sciences) to 22% (engineering). In medical sciences, nonprofit articles garner 16% of patent citations.

Energy and Environment–Related Patent Citations

Clean energy and energy conservation and related technologies—including biofuels, solar, wind, nuclear, energy efficiency, pollution prevention, smart grid, and carbon sequestration—are closely linked to scientific R&D and have become a policy focus in the United States and other countries. NSF developed a method for identifying patents

Figure 5-31
Within-U.S. article citations: Relative citation index, 1992–2012



FFRDC = federally funded R&D center.

NOTES: Article/citation counts are from the set of journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles are classified by the year they entered the database, rather than their year of publication, and are assigned to a sector on the basis of the institutional address(es) listed in the article. Articles/citations are credited on a fractional-count basis (i.e., for articles with collaborating institutions from multiple countries/sectors, each country/sector receives fractional credit on the basis of the proportion of its participating institutions). Citation counts are based on a 3-year period with a 2-year lag (e.g., citations for 2012 are references made in articles in the 2012 data tape to articles in the 2008–10 data tapes).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from Thomson Reuters SCI and SSCI, http://thomsonreuters.com/products_services/science/.

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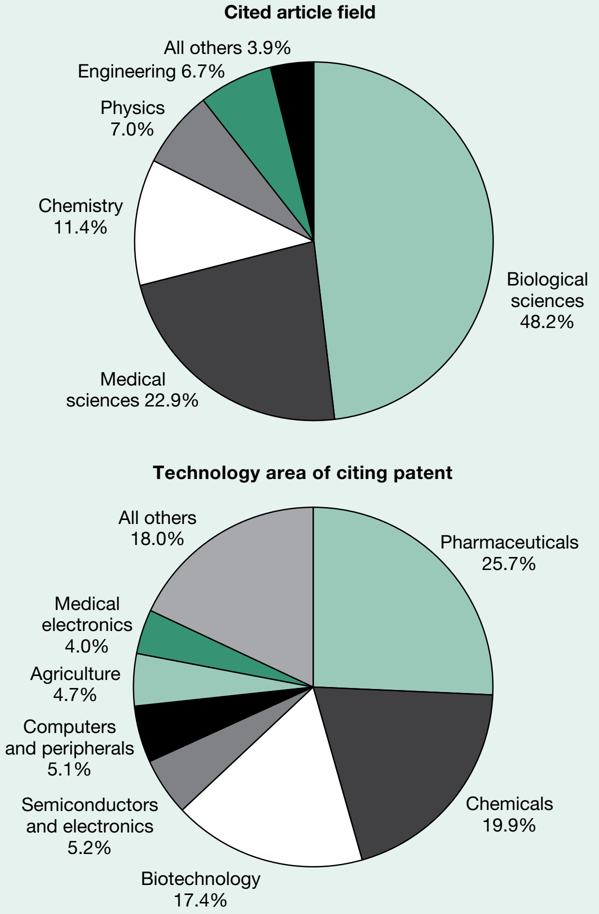
Figure 5-32
Citations of U.S. S&E articles in U.S. patents, by selected S&E article field and technology area: 2012



NOTES: Citations are references to S&E articles in journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Citation counts are based on an 11-year window with a 5-year lag (e.g., citations for 2012 are references in U.S. patents issued in 2012 to articles published in 1997–2007).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data, and Thomson Reuters, SCI and SSCI, http://www.thomsonreuters.com/products_services/science/. See appendix table 5-60.

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with potential application in these technologies. (See sidebar "Identifying Clean Energy and Pollution Control Patents" for details on the filters.)

Chapter 6 of this volume presents extensive data on the patents in four technology areas related to clean energy—alternative energy, pollution mitigation, smart grid, and energy storage—including the nationality of their inventors. (See chapter 6, "Industry, Technology, and the Global Marketplace," section "Patenting of Clean Energy and Pollution Control Technologies.") This section reports on the citations in those patents to the S&E literature, using those citations to indicate the linkages between S&E R&D and the potential for practical use of the results of those R&D projects in new inventions and technologies.[60] The citation data are based on patents issued between 2003 and 2012.

U.S. patents in these four areas of clean energy technology cite more foreign literature than U.S. literature (appendix table 5-61). In contrast, patents in all technology areas have consistently cited more U.S. literature than foreign literature (appendix table 5-59).

Within citations to U.S. literature, articles authored by the academic sector accounted for the most citations (70%) among U.S. sectors in 2012. Industry and FRRDCs were the next largest, accounting for 12% and 10% of citations, respectively. Between 2003 and 2012, academia's share of citations to U.S. literature increased from 59% to 70%. Industry's share fell from 22% to 12%.

Four broad S&E fields dominate the citations to S&E literature in these four patent areas: chemistry, physics, engineering, and biological sciences. The range of S&E fields cited indicates that these developing technologies rely on a wide base of S&E knowledge.

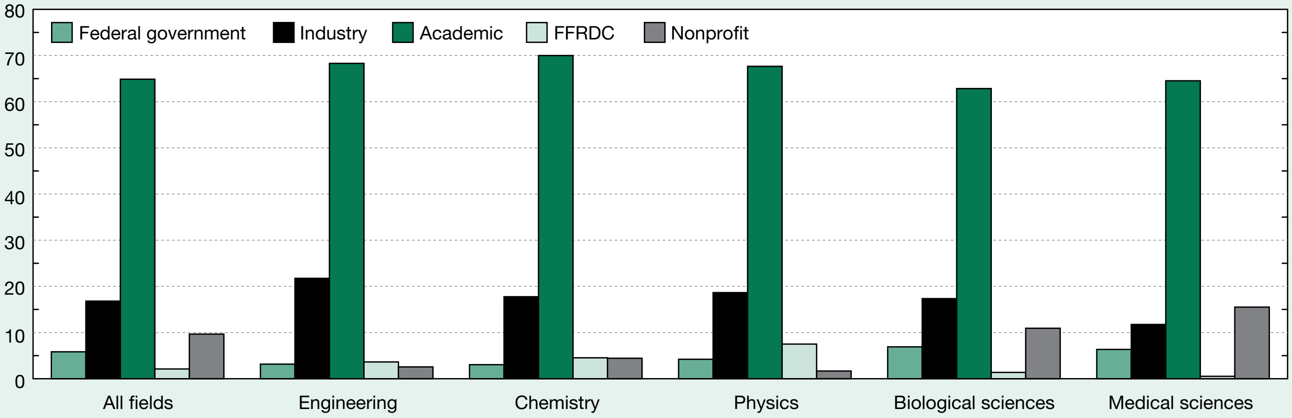
The S&E fields cited by these patents are shown in table 5-27. These four categories of energy and environment–related patents show somewhat different patterns of reliance on S&E literature. In both energy storage and smart grid, referencing is concentrated in a single field. For energy storage patents, over half of all citations are to chemistry articles; for smart grid patents, engineering is similarly dominant. Alternative energy and pollution mitigation citations are more evenly distributed across the four fields; for both of these technologies, however, chemistry is the most heavily cited field, receiving roughly one-third of all citations.

Using patent citations as an indicator, the data show that chemistry research contributes heavily to invention in all areas of green technology with the exception of smart grid, where engineering dominates. Geoscience articles, which in this taxonomy include environmental sciences, are prominent as well, but only in pollution mitigation.

Academic Patenting

Academic institutions whose research leads to intellectual property attempt to protect and benefit from the fruits of their labor through patents and associated activities. The majority of U.S. universities did not become actively involved in managing their own intellectual property until late in the 20th century, when the Bayh-Dole Act of 1980 gave

Figure 5-33
Citation of U.S. S&E articles in U.S. patents, by selected S&E field and article author sector: 2012
Percent



FFRDC = federally funded R&D center.

NOTES: Citations are references to U.S. S&E articles in journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Citations are classified on a fractional-count basis (i.e., for cited articles with collaborating institutions from more than one sector, each sector receives fractional credit on the basis of the proportion of its participating institutions). Citation counts are based on an 11-year window with a 5-year lag (e.g., citations for 2012 are references in U.S. patents issued in 2012 to articles published in 1997–2007). Fields with less than 5% of 2012 citations to U.S. articles are omitted. Joint and unknown sectors are not shown.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data, and Thomson Reuters, SCI and SSCI, http://www.thomsonreuters.com/products_services/science/. See appendix table 5-60.

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Identifying Clean Energy and Pollution Control Patents

Using a combination of U.S. Patent Classification and International Patent Classification codes and text strings, the National Science Foundation developed algorithms to identify U.S. Patent and Trademark Office–issued patents with potential application in four broad, green technology areas. The four technology areas and their main subcategories are listed below. The search codes used to locate relevant patents are available at http://www.patentboard.com/OurResearch/PatentFilters/tabid/115/Default.aspx, which documents the process used in identifying relevant patents.

Alternative energy production	Energy storage	Energy management (smart grid)	Pollution mitigation
Bioenergy	Batteries	Advanced components	Recycling
Geothermal	Flywheels	Sensing and measurement	Air
Hydropower	Superconducting magnetic energy systems	Advanced control methods	Solid waste
Nuclear	Ultracapacitors	Improved interfaces and decision support	Water
Solar	Hydrogen production and storage	Integrated communication	Environmental remediation
Wave/tidal/ocean	Thermal energy storage		Cleaner coal
Wind	Compressed air		Carbon and greenhouse gas capture and storage
Electric/hybrid vehicles			
Fuel cells			

colleges and universities a common legal framework for claiming ownership of income streams from patented discoveries that resulted from their federally funded research. Other countries implemented policies similar to the Bayh-Dole Act by the early 2000s, giving their academic institutions (rather than inventors or the government) ownership of patents resulting from government-funded research (Geuna and Rossi 2011). To facilitate the conversion of new knowledge produced in their laboratories to patent-protected public knowledge that potentially can be licensed by others or form the basis for a startup firm, many U.S. research institutions established technology management/transfer offices (AUTM 2009).

The following sections discuss overall trends in university patenting and related indicators through 2011 and 2012.

Trends and Patterns in Academic Patenting

USPTO granted 8,700 patents to U.S. and foreign universities and colleges in 2012, 3.4% of USPTO patents granted to all U.S. and foreign inventors (figure 5-34). U.S. universities and colleges were granted 5,100 USPTO patents, with foreign universities receiving 3,600.

Patenting by academic institutions has increased markedly over the last two decades—from 1,800 in 1992 to 8,700 in 2012—resulting in their share of all USPTO patents doubling from 1.8% to 3.4%. Patenting by U.S. institutions outpaced overall growth of USPTO patents in the 1990s, resulting in their share of all patents increasing from 1.6% in 1992 to 2.4% in 1999. Although the number of U.S. academic patents continued to grow from 2000 to 2012, the U.S. university and college share of all USPTO patents declined slightly (appendix table 5-62). In contrast, USPTO patents granted to foreign universities and colleges grew much more rapidly than those granted to U.S. universities and colleges in the 2000–12 period. U.S. patents to foreign universities and colleges grew sixfold to reach 3,600 patents; their share of all USPTO patents rose from 0.4% in 2000 to 1.4% in 2012 (figure 5-34).[61]

Patenting by U.S. and foreign universities and colleges in another major patent office, the European Patent Office (EPO), shows a similar trend of increasing activity (figure 5-35). The academic share of all patents granted by EPO increased from 0.9% in 1992 to 2.4% in 2012. After steadily increasing in the 1990s and early 2000s, the number of EPO patents granted to U.S. universities and colleges has remained flat at approximately 500–600 patents since 2003. In contrast, patenting by foreign universities and colleges grew more rapidly in the 2000s, and they surpassed U.S. universities in 2007.

The top 200 R&D-performing institutions dominate among U.S. universities and university systems receiving patent protection, with 98% of the total patents granted to U.S. universities between 1997 and 2012 (appendix table 5-62).[62] Among these institutions, 19 accounted for more than 50% of all patents granted to the top 200 (some of these were multicampus systems, like the University of California and the University of Texas). The University of California system received 11.3% of all U.S. patents granted to U.S. universities over the period, followed by the Massachusetts Institute of Technology, with 4.2%.

Biotechnology patents accounted for the largest share (25%) of U.S. university patents in 2012 (appendix table 5-63). Biotechnology has been the largest technology area for U.S. academic patenting since 1991. Pharmaceuticals, the next-largest technology area, has had a declining number of patents over the past decade, dropping from an average of 491 a year in 1998–2002 to 369 a year in 2008–12 (figure 5-36). Medical equipment shows a similar, but much smaller, decline. The other major technology areas have been increasing. Patents for semiconductors have made the greatest increase, from around 90 patents per year in 1993–97 to around 210 in 2008–12.

Commercialization of U.S. Academic Patents

Universities commercialize their intellectual property by granting licenses to commercial firms and supporting start-up firms formed by their faculty. Data from the Association of University Technology Managers (AUTM) indicate continuing growth in a number of such patent-related activities. Invention disclosures filed with university technology management/transfer offices describe prospective inventions and are submitted before a patent application is filed. These grew from 12,600 in 2002 to 19,700 in 2011 (notwithstanding small shifts in the number of institutions responding

Table 5-27
Patent citations to S&E articles, by selected patent technology area and article field: 2003–12

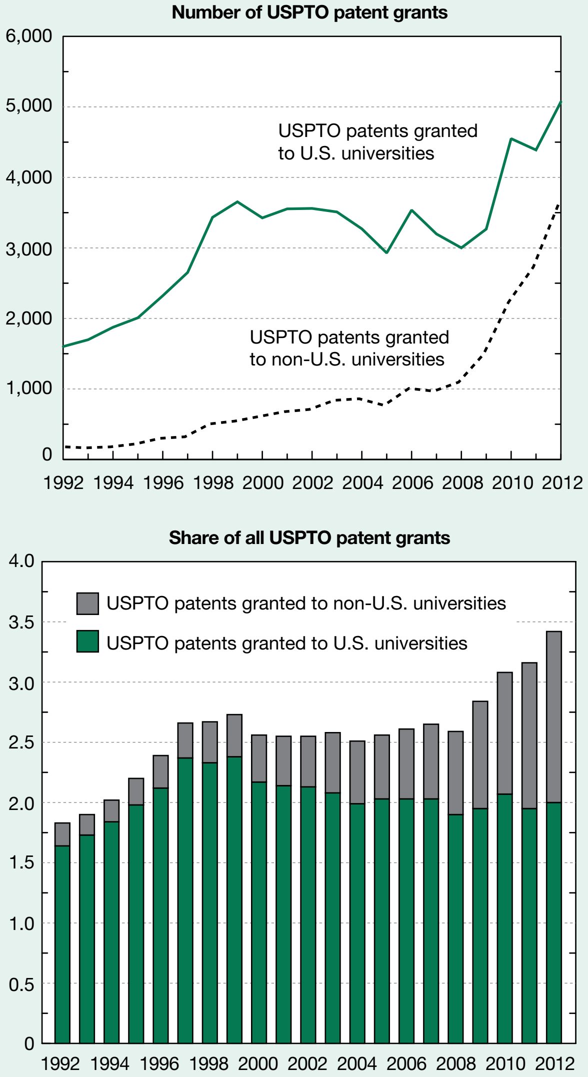
Technology/field	Citations (*n*)	Percent
Alternative energy	24,800	100.0
Chemistry	7,611	30.7
Physics	6,004	24.2
Engineering	5,285	21.3
Biological sciences	5,017	20.2
Geosciences	400	1.6
Agricultural sciences	365	1.5
All others	118	0.5
Energy storage	7,278	100.0
Chemistry	3,771	51.8
Engineering	1,555	21.4
Physics	1,164	16.0
Biological sciences	685	9.4
All others	103	1.4
Smart grid	1,695	100.0
Engineering	900	53.1
Physics	595	35.1
Computer sciences	85	5.0
Biological sciences	37	2.2
Geosciences	31	1.8
All others	47	2.8
Pollution mitigation	8,578	100.0
Chemistry	2,943	34.3
Engineering	1,817	21.2
Geosciences	1,605	18.7
Biological sciences	1,500	17.5
Physics	326	3.8
Agricultural sciences	243	2.8
All others	144	1.7

NOTES: Citations are references to S&E articles in journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Citation counts are based on an 11-year window with a 5-year lag (e.g., citations for 2012 are references in U.S. patents issued in 2012 to articles published in 1997–2007). Patents may appear in more than one technology area; thus, citation counts may overlap slightly. See sidebar "Identifying Clean Energy and Pollution Control Patents" for details on these technology areas.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data, and Thomson Reuters, SCI and SSCI, http://www.thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2014

Figure 5-34
USPTO patents granted to U.S. and non-U.S. academic institutions: 1992–2012

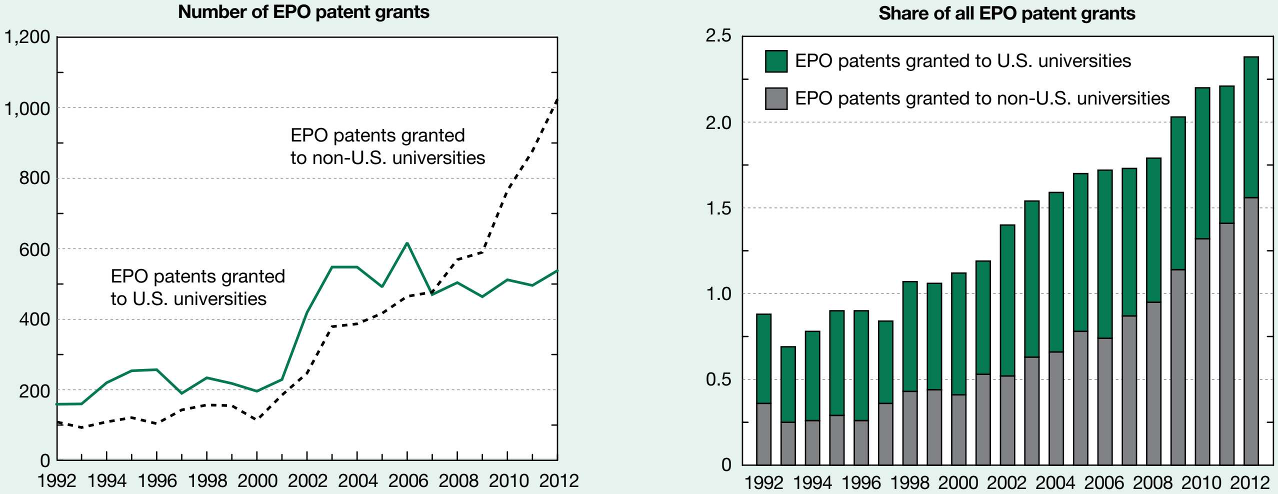


USPTO = U.S. Patent and Trademark Office.

SOURCE: The Patent Board,™ special tabulations (2013) of Proprietary Patent database. See appendix table 5-62.

Science and Engineering Indicators 2014

Figure 5-35
EPO patents granted to U.S. and non-U.S. academic institutions: 1992–2012

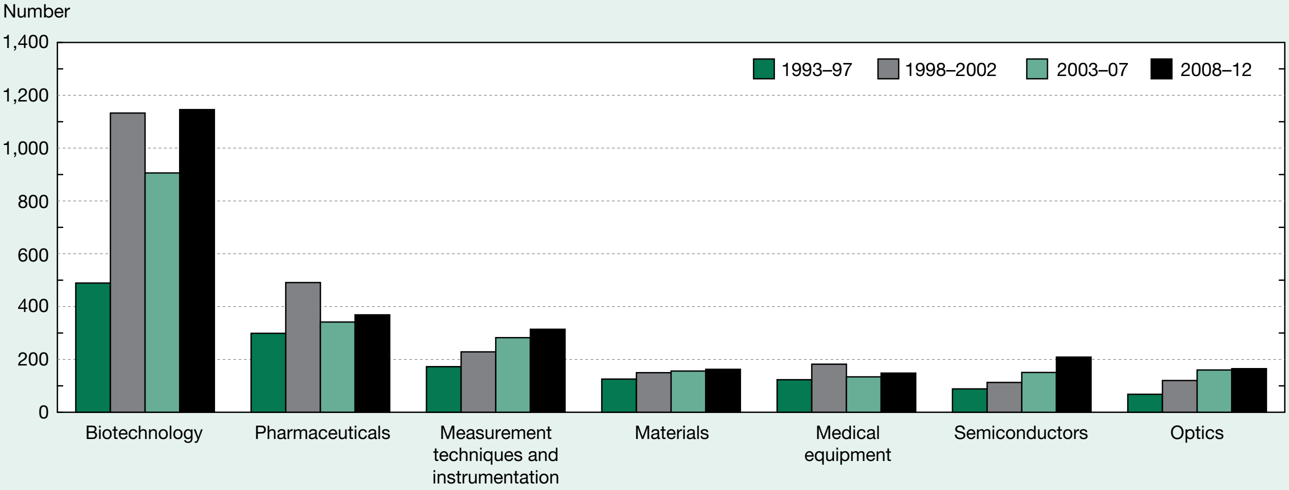


EPO = European Patent Office.

SOURCE: The Patent Board,™ special tabulations (2013) of Proprietary Patent database.

Science and Engineering Indicators 2014

Figure 5-36
U.S. academic patents, by technology area: Selected 5-year averages, 1993–2012



NOTES: Data include institutions affiliated with academic institutions (e.g., university and alumni organizations, foundations, and university associations). Universities vary in how patents are assigned (e.g., to boards of regents, individual campuses, or entities with or without affiliation with the university). The Patent Board™ technology areas constitute an application-oriented classification system that maps the thousands of International Patent Classes (IPCs) at the main group level into 1 of 35 technology areas. If a patent has more than one IPC, only the primary IPC is considered in mapping.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data. See appendix table 5-63.

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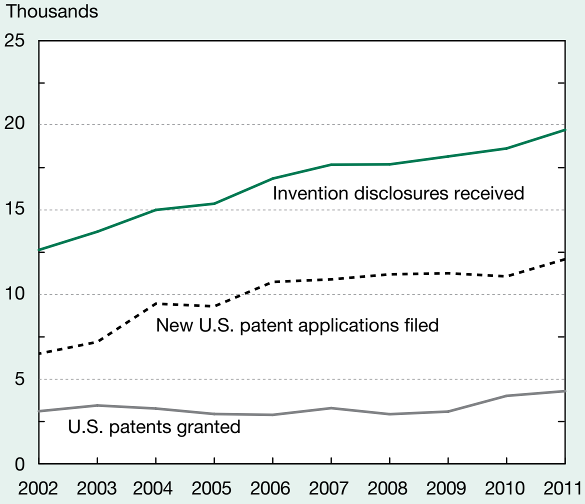
to the AUTM survey over the same period) (figure 5-37). Likewise, new U.S. patent applications filed by AUTM university respondents also increased, nearly doubling from 6,500 in 2002 to 12,100 in 2011. However, U.S. patents *awarded* to AUTM respondents stayed flat over the period, rising only in the last 2 years and reflecting a similar rise in the number of patents granted to all assignees (see appendix table 5-62).[63]

Despite the economic slowdown of the past 5 years, the number of new startup companies formed continued to rise, as did the number of past startups still operating; AUTM survey respondents reported a low of 348 startup companies formed in 2003 and a maximum of 617 in 2011, with a total of extant startup companies in 2011 of 3,573 (appendix table 5-64). Licenses and options that generated revenues also increased over the period. Active licenses increased steadily from 18,800 in 2001 to 33,300 in 2011.

Most royalties from licensing agreements accrue for relatively few patents and the universities that own them, and many of the AUTM respondent offices report no income. (Thursby and colleagues [2001] report that maximizing royalty income is not the dominant objective of university technology management offices.) At the same time, large one-time payments to a university can affect the overall trend in university licensing income. In 2011, the 157 institutions that responded to the AUTM survey reported a total of $1.5 billion in net royalties from their patent holdings. This is essentially the same amount reported for the last 3 years. Perhaps as a result of the nation's economic downturn, this number is down sharply from the high value of $2.1 billion reported in 2008 (appendix table 5-64).

Figure 5-37
U.S. university patenting activities: 2002–11



SOURCE: Association of University Technology Managers (AUTM), AUTM Licensing Surveys: 2002–11. See appendix table 5-64.

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Conclusion

The nation's universities and colleges play a key role in U.S. R&D by providing the following services:

- Educating and training S&E students in research practices and other advanced skills
- Performing a large share of the nation's basic research
- Building and operating world-class research facilities and supporting the national research cyberinfrastructure
- Producing intellectual output through published research articles and patents

Over the past several decades, academic spending on R&D has continued to increase, with funding from ARRA being a major source of support since 2009. The federal government has long provided the majority of funding for academic S&E R&D. Other important sources of academic R&D funding are universities and colleges themselves, state and local governments, businesses, and nonprofit organizations.

Academic R&D expenditures have long been concentrated within a relatively small number of universities and colleges. For over 20 years, less than 12 schools each year have received about one-fifth of total academic R&D funding, about 20 schools have received close to one-third of this funding, and about 100 have received four-fifths of the total. (The identities of the universities in each group have varied over time.)

For decades, more than half of all academic R&D spending has been in the broad field of life sciences. Since the mid-1990s, about one-third of all U.S.-trained, academically employed S&E doctorate holders received their degree in life sciences (in 2010, over 50% of their foreign-trained counterparts had doctorates in life sciences). The dominance of life sciences is also seen in physical infrastructure, where two subfields of life sciences—biological sciences and biomedical sciences—account for the bulk of growth in research space and where the largest share of new university research construction has been undertaken to advance health and clinical sciences. Life sciences are also heavily featured in academic R&D output: biological sciences and medical sciences accounted for over 50% of U.S. S&E articles in 2011.

Academic R&D is increasingly collaborative. More articles are authored by researchers from different university departments, from multiple universities, or from universities in different countries. Similarly, academic collaboration with researchers in other sectors of the U.S. economy—such as federal, state, or local government; business; or FFRDCs—has been increasing. Three-quarters of all U.S. articles, many of them authored by U.S. universities and colleges, now have coauthors from multiple institutions and countries. Collaboration rates between the United States and Canada are higher than would be expected, based on publishing output, thus suggesting the importance of geographic proximity and a common language. Collaboration rates are also relatively high between the United States and Asia (in particular, China, South Korea, and Taiwan), reflecting, in part, ties formed through large numbers of students from Asian locations having studied for advanced S&E degrees in the United States. In another indicator of growing research collaboration, R&D funds passed through universities to other universities or to non-academic institutions grew more rapidly over the last decade than total academic R&D funding.

Working conditions for S&E doctorate holders within the nation's universities and colleges as well as access to federal funds for research have undergone changes over the past 20–30 years. Although full-time faculty positions in the professoriate continue to be the norm in academic employment, S&E doctorate holders are increasingly employed in part-time and nontenured positions. Since 1995, despite an aging academic doctoral workforce, there has been a decrease in the percentage of doctorate holders with tenured positions. The share of academic researchers receiving federal support, including early career S&E faculty, has declined since 1991.

Higher education has also experienced notable changes in demographic diversity. In particular, the share of academic doctoral positions held by white, male, native-born citizens has declined. Women represent a growing share of academic doctoral employment in S&E, as do the foreign born and foreign trained. The share of Asians employed in the S&E academic doctoral workforce has grown dramatically over the past three decades, while the shares held by blacks, Hispanics, and American Indians or Alaska Natives have grown much more slowly; these latter groups remain underrepresented in the academic doctoral workforce.

There have been further shifts in the degree to which the academic doctoral workforce is focused on research activities versus teaching. Compared with the early 1990s, there has been an increase in the proportion of the academic doctoral workforce, including full-time faculty, that reports research as its primary work activity. By contrast, there has been a decline since the early 1990s in the share of the workforce that reports teaching as its primary work activity. Of those in the academic doctoral workforce reporting research as their primary activity, two-thirds are employed at the nation's most research-intensive academic institutions. Those who primarily teach are more evenly dispersed across academia.

The United States has a strong position in the global academic R&D enterprise. With major input from the academic sector, the United States is the largest single-country producer of S&E articles, not far behind the entire EU. The global shares of the United States, the EU, and other developed countries have declined as China has become the world's third-largest producer of S&E articles over the last decade. However, the United States continues to have a disproportionately high global share of the most-cited S&E articles, indicating that U.S. academic R&D continues to be highly influential for subsequent research around the globe.

Academic R&D increasingly advances marketplace technologies. U.S. universities continue to commercialize their research, as evidenced in the growth in the number of U.S. patent applications and invention disclosures and in the formation of startup companies. This growing commercialization of U.S. science is particularly important in biological sciences, which have spawned new discoveries in pharmaceuticals, chemicals, and biotechnology. In addition, U.S. patents most frequently cite academic-authored articles within all U.S. articles, underscoring the important linkage of academic R&D to invention.

Notes

1. The academic R&D totals presented here exclude expenditures at the federally funded research and development centers (FFRDCs) associated with universities. Those expenditures are tallied separately and discussed in chapter 4. Nevertheless, the FFRDCs and other national laboratories (including federal intramural laboratories) play an important role in academic research and education, providing research opportunities for students and faculty at academic institutions, often by providing highly specialized, shared research facilities.

2. For this discussion, the terms *universities and colleges, higher education,* and *academic institutions* are used interchangeably.

3. Gross domestic product implicit price deflators were used to convert current dollars to constant 2005 dollars.

4. From 2005 to 2008, prior to the enactment of the American Recovery and Reinvestment Act of 2009, academic R&D expenditures increased by an annual average rate of 1.5% after adjusting for inflation.

5. For a more complete discussion of these concepts, see the chapter 4 "Glossary."

6. Starting in 2010, the Higher Education Research and Development Survey asked institutions to categorize their R&D expenditures as either basic research, applied research, or development; prior surveys had asked how much total S&E R&D the institution performed and requested an estimate of the percentage of their R&D expenditures devoted to basic research. By only mentioning basic research, the survey question may have caused some respondents to classify a greater proportion of their activities in this category. The 2010 question provided definitions and examples of the three R&D categories to aid institutions in making more accurate assignments. In debriefing interviews, institutional representatives cited the changes in the survey question as the most important factor affecting their somewhat lower estimates of the amount of basic research institutions performed. The explicit inclusion of clinical trials and research training grants and the addition of non-S&E R&D may also have contributed.

7. Data on non-S&E R&D expenditures have been collected by the National Science Foundation since FY 2003. However, the response rates on these items for the years prior to 2006 make trend analysis unreliable.

8. The academic R&D reported here includes separately budgeted R&D and related recovered indirect costs and also

institutional estimates of unrecovered indirect costs associated with externally funded R&D projects, including committed cost sharing. *Indirect costs* are general expenses that cannot be associated with specific research projects but pay for things that are used collectively by many research projects at an academic institution. Two major components of indirect costs exist: (1) *facilities-related costs,* such as the construction, maintenance, and operation of facilities used for research; and (2) *administrative costs,* including expenses associated with financial management, institutional review boards, and environment, health, and safety management. Some indirect costs are recovered as a result of indirect-cost proposals that universities submit based on their actual costs from the previous year. *Unrecovered indirect costs* are calculated as the difference between an institution's negotiated indirect cost rate on a sponsored project and the amount it recovers from the sponsor. *Committed cost sharing* is the sum of the institutional contributions required by the sponsor for specific projects (*mandatory cost sharing*) and the institutional resources made available to a specific project at the discretion of the grantee institution (*voluntary cost sharing*).

9. The Higher Education Research and Development Survey collects aggregate data not separated by field on universities' estimates of basic research, applied research, and development.

10. Statistics on R&D performance can differ depending on whether the reporting is by R&D performers—in this case, academic institutions—or R&D funders. Reasons for this difference are discussed in the chapter 4 sidebar, "Tracking R&D: The Gap between Performer- and Source-Reported Expenditures."

11. Institutionally financed research includes both organized research projects fully supported with internal funding and all other separately accounted-for funds for research. This category does not include funds spent on research that are not separately accounted for, such as estimates of faculty time budgeted for instruction that is spent on research. Funds for institutionally financed R&D may also derive from general-purpose state or local government appropriations; general-purpose awards from industry, foundations, or other outside sources; endowment income; and gifts. Universities may also use income from patents and licenses or revenue from patient care to support R&D. (See this chapter's section "Commercialization of U.S. Academic Patents" for a discussion of patent and licensing income.)

12. Federal grants, contracts, and awards from other sources that are passed through state and local governments to academic institutions are credited to the original provider of the funds.

13. The federally financed share of academic S&E R&D expenditures dipped slightly in 2012; in part, this is because universities and colleges spent more American Recovery and Reinvestment Act of 2009 funds in 2011 (about $4.2 billion) than in 2012 (about $2.4 billion).

14. In 1991, the Office of Management and Budget capped reimbursement of administrative costs at 26% of total direct costs. As a result, actual unrecovered indirect costs at both public and private universities may be somewhat higher than the amounts reported on the Higher Education Research and Development Survey.

15. During the early years of the 2000 decade, survey questions on pass-through funding were voluntary, with relatively high nonresponse (11% in 2000 versus 4% in 2009).

16. Research space here is defined as the space used for sponsored R&D activities at academic institutions and for which there is separate budgeting and accounteing. Research space is measured in net assignable square feet (NASF). This is the sum of all areas on all floors of a building assigned to, or available to be assigned to, an occupant for a specific use, such as research or instruction. NASF is measured from the inside faces of walls. Multipurpose space that is partially used for research is prorated to reflect the proportion of time and use devoted to research.

17. The S&E fields used in the National Science Foundation Survey of Science and Engineering Research Facilities are based on the National Center for Education Statistics Classification of Instructional Programs (CIP)—which is updated every 10 years (the current version is dated 2010). The S&E fields used in the FY 2011 Survey of Science and Engineering Research Facilities reflect the 2010 CIP update. Both the FY 2007 and FY 2009 surveys reflect the 2000 CIP standard. For a comparison of the subfields in the FY 2005 and FY 2007 surveys, see the detailed statistical tables for S&E Research Facilities: FY 2007. No major impacts on these data resulted from the CIP 2010 update.

18. The science and technology field and subfield definitions were updated to the 2000 Classification of Instructional Programs starting with the FY 2007 Survey of Science and Engineering Research Facilities. Some of the observed declines in research space for health and clinical sciences and for physical sciences between FY 2005 and FY 2007 could reflect definition changes.

19. *Institutional sources* includes an institution's operating funds, endowments, private donations, tax-exempt bonds and other debt financing, and indirect costs recovered from federal and nonfederal sources.

20. Only projects whose prorated cost was estimated to be $250,000 or more for at least one field of S&E were included.

21. Because of rising capitalization thresholds, the dollar threshold for inclusion in the equipment category has changed over time. Generally, university equipment that costs less than $5,000 would be classified under the cost category of "supplies."

22. The "bricks and mortar" section of the Survey of Science and Engineering Research Facilities asks institutions to report their research space only. Therefore, the reported figures do not include space used for other purposes, such as instruction or administration. In the "Computing and Networking Capacity" section of the survey, respondents are asked to identify all of their cyberinfrastructure resources,

regardless of whether these resources were used for research or other functions.

23. Research-performing academic institutions are defined as colleges and universities that grant degrees in S&E and expend at least $1 million in R&D funds. Each institution's R&D expenditures are determined through the National Science Foundation Higher Education Research and Development Survey.

24. Academic institutions provided data on all computing systems with peak theoretical performance of 1 teraflop or faster. This defined the threshold for high-performance computing in the "Computing and Networking Capacity" section of the Survey of Science and Engineering Research Facilities. A *teraflop* is a measure of computing speed equal to 1 trillion floating point operations per second (FLOPS). FLOPS reflect the number of multiplications that a computer processor can perform within 1 second.

25. These points have been cited as rationales for centralizing cyberinfrastructure and high-performance computing at several institutions (University of Arizona 2013; UCSD 2009; Bose et al. 2010).

26. Clusters use multiple commodity systems, each running its own operating system with a high-performance interconnect network to perform as a single system. Massively parallel processors use multiple processors within a single system with a specialized high-performance interconnect network. Each processor uses its own memory and operating system. Symmetric multiprocessors use multiple processors sharing the same memory and operating system to work simultaneously on individual pieces of a program.

27. *Usable storage* is the amount of space for data storage that is available for use after the space overhead required by file systems and applicable redundant array of independent disks configurations is removed. Online storage includes all storage providing immediate access for files and data from high-performance computing systems of at least 1 teraflop. Storage can be either locally available or made available via a network.

28. In the discussion covering the age composition of the academic doctoral workforce, comparisons are made between 1995 and 2010 because the Age Discrimination in Employment Act of 1967 applied to the professoriate starting in 1994. In the section on federal support of doctoral researchers, comparisons are made between 1973, the very early 1990s, and 2010 because of the availability of relatively comparable data for these years. In all discussions of full-time faculty, comparisons are made between 1997 and 2010 because comparable data on senior and junior faculty groupings are available for these years.

29. These other positions included positions at universities and colleges where no tenure system exists and there are various non-tenure-track positions.

30. In addition, individuals ages 70–75 years grew as a share of the total doctoral academic workforce from 1995 to 2010. In 1995, less than 1% of the doctoral academic workforce was between 70 and 75 years of age; this increased to 2.4% in 2010.

31. Despite these gains, the number of academically employed, U.S.-trained female S&E doctorate holders in 2010 (105,000) was nearly identical to the number of their male counterparts four decades earlier (107,000).

32. Because a larger share of foreign-trained doctorate holders working in U.S. universities and colleges are men (70% in 2010 versus 64% of the U.S.-trained doctorate holders), using the Survey of Doctorate Recipients as a measure of female participation in the doctoral academic workforce results in a slight overcount of women's presence.

33. For some fields—in particular, life sciences and psychology—the National Survey of College Graduates (NSCG) estimates are somewhat higher than the Survey of Doctorate Recipients (SDR) estimates because SDR employs a more restrictive definition of research doctorate. As a result, some complications exist in comparing NSCG estimates of foreign-trained S&E doctorate holders with SDR estimates of the U.S.-trained S&E doctorate holders.

34. Analysis of trends in minority and underrepresented minority representation in the U.S.-trained academic doctoral workforce is complicated by changes in the Survey of Doctorate Recipients question about race and ethnicity starting in 2001. Specifically, since 2001, respondents have been allowed to report more than one race. Because of this change, data from 2001 to 2010 are not directly comparable to earlier years' data (Milan 2012).

35. Estimates of the percentage of underrepresented minorities by gender in the U.S.-trained academic doctoral workforce are based on small samples and are particularly sensitive to sampling error.

36. Asians or Pacific Islanders include Native Hawaiians and Other Pacific Islanders.

37. Some academically employed S&E doctorate holders were older than 75 years of age in 1995 and in 2010, but the Survey of Doctorate Recipients does not report on this because it drops respondents from the survey sample after they have reached 75 years of age. It is generally believed that individuals over age 75 years hold a small but growing share of doctoral academic employment.

38. The Survey of Doctorate Recipients presents respondents with a list of work activities and asks them to identify the activities that occupied the most hours and second most hours during their typical work week. This measure was constructed slightly differently prior to 1993, and the data are not strictly comparable across the two periods. Prior to 1993, the survey question asked the respondent to select their primary and secondary work activity from a list of activities. Beginning in 1993, respondents were given the same list and asked on which activity they spent the most hours and on which they spent the second most hours.

39. University-reported data from the Higher Education Research and Development Survey indicate that approximately 154,000 personnel paid from R&D salaries and

wages were designated as principal investigators in academic FY 2012.

40. A higher share (just under 90%) of the nation's foreign-trained academic doctoral personnel classified research as their primary or secondary work activity in 2010.

41. Data on federal support of academic researchers for 1985 and 1993–97 cannot be compared with results for the earlier years or with those from 1999 to 2010 because of changes in the survey question. In 1985, the question focused on 1 month and, from 1993 to 1997, on 1 week. In most other survey years, the reference was to the entire preceding year. Since the volume of academic research activity is not uniform over the entire academic year, a 1-week (or 1-month) reference period seriously understates the number of researchers supported at some time during an entire year.

42. A somewhat larger share of the nation's foreign-trained academic doctoral personnel working full-time (66%) received federal support in 2010.

43. For more information on the World Bank economic classification of countries, see http://data.worldbank.org/about/country-classifications/country-and-lending-groups.

44. Countries with indexed S&E articles can change their borders over time. Data on Hong Kong, for example, were formerly reported separately but are now included in totals for China. See appendix table 5-24 for a list of the locations represented in the data.

45. Statements that a country "authors" a certain number of articles are somewhat imprecise, especially given the growing rates of international collaboration discussed later in this chapter. See the sidebar "Bibliometric Data and Terminology" for more information on how S&E article production and collaboration are measured.

46. See Eades et al. (2005) for a discussion of recent reforms in Japan's higher education system. Japan's R&D expenditures increased by 14% to reach 17.4 trillion yen between 2000 and 2008, according to the Organisation for Economic Co-operation and Development (http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm).

47. Publication traditions in broad S&E fields differ somewhat. For example, although all fields publish journal articles, computer scientists often publish their findings in conference proceedings, and social scientists often write books and also publish in journals. Proceedings and books are poorly covered in the data currently used in this chapter.

48. Social science journals tend to focus on local issues, have less international author diversity, and publish in a language other than English more often than natural sciences journals—all criteria for exclusion from the Thomson Reuters databases. The lower concentration of articles in social sciences, other life sciences, and psychology in foreign countries may be partially attributed, then, to journal coverage. For further details on Thomson's journal selection process, see http://www.thomsonreuters.com/products_services/science/free/essays/journal_selection_process/.

49. The U.S. sector identification in this chapter is quite precise; to date, sector identification has not been possible for other countries.

50. The 16 federally funded research and development centers (FFRDCs) sponsored by the Department of Energy (DOE) dominated S&E publishing by this sector. Across all fields of S&E, DOE-sponsored labs accounted for 83% of the total for the sector in 2005 (NSB 2008). Scientists and engineers at DOE-sponsored FFRDCs published 96% of the sector's articles in chemistry, 95% in physics, and 90% in engineering (see "S&E Articles From Federally Funded Research and Development Centers" [NSB 2008:5-47]). Nine other federal agencies (including the Departments of Defense, Energy, Health and Human Services, Homeland Security, Transportation, and Treasury; the National Aeronautics and Space Administration; the Nuclear Regulatory Commission; and the National Science Foundation) also sponsor another 23 FFRDCs (NSF/SRS 2009).

51. Coauthorship is a broad, though limited, indicator of collaboration among scientists. Previous editions of *Indicators* discussed possible underlying drivers for increased collaboration, including scientific advantages of knowledge sharing and instrument sharing, decreased costs of travel and communication, and national policies (NSB 2006). Katz and Martin (1997), Bordons and Gómez (2000), and Laudel (2002) analyze limitations of coauthorship as an indicator of research collaboration. Despite these limitations, other authors have continued to use coauthorship as a collaboration indicator (Adams et al. 2005; Gómez, Fernández, and Sebastián 1999; Lundberg et al. 2006; Wuchty, Jones, and Uzzi 2007; Zitt, Bassecoulard, and Okubo 2000).

52. Readers are reminded that the number of coauthored articles between any pair of countries is the same; each country is counted once per article in these data. However, countries other than the pairs discussed here may also appear on the article.

53. Finland is included here as one of the Scandinavian countries; Iceland is not.

54. "Influence" is used here broadly; even citations that criticize or correct previous research indicate the influence of that previous research on the citing article.

55. For example, 2012 citation rates are from references in articles in the 2012 data file to articles contained in the 2008–10 data files of the Thomson Reuters Science Citation Index and Social Sciences Citation Index databases. Analysis of the citation data shows that, in general, the 2-year citing lag captures the 3 peak citation years for most fields, with the following exceptions: in astronomy and physics, the peak citation years are generally captured with a 1-year lag; in computer sciences, psychology, and the social sciences, the peak citation years are generally captured with a 3-year lag.

56. Some part of this percentage decrease may reflect the increase in Chinese journals in the Science Citation Index and Social Sciences Citation Index databases used in this chapter. Since more Chinese authors in these journals are available to cite their Chinese coauthors, international citations to Chinese-authored articles are declining as a share of total citations. However, accounting for the "nationality" of a journal is not straightforward, and the data file used by the National Science Foundation (NSF) excludes journals that are primarily of regional interest. NSF's estimate of "Chinese" journals shows an increase of 75% over the past decade, compared to an increase of 334% for Chinese-authored articles.

57. Because different S&E fields have different citation behaviors, these indicators should be used with caution. For example, articles in life sciences tend to list more references than, for example, articles in engineering or mathematics. Thus, a country's research portfolio that is heavily weighted toward life sciences (e.g., the United States) may receive proportionately more citations than a country whose portfolio is more heavily weighted toward engineering or mathematics.

58. *Percentiles* are specified percentages below which the remainder of the articles fall. Thus, the 99th percentile identifies the number of citations 99% of the articles failed to receive. Across all fields of science, 99% of articles from 2008 to 2010 failed to receive at least 21 citations in 2012. Matching numbers of citations with a citation percentile is not precise because all articles with a specified number of citations must be counted the same. Therefore, the citation percentiles discussed in this section and used in appendix tables 5-57 and 5-58 have all been counted conservatively, and the identified percentile is in every case higher than specified (i.e., the 99th percentile is always greater than 99%, the 95th percentile is always greater than 95%, and so forth). Actual citations/percentiles per field vary widely because counts were cut off to remain within the identified percentile. For example, using this method of counting, the 75th percentile for engineering contained 2008 to 2010 articles with 3–4 citations from 2012 articles, whereas the 75th percentile for astronomy contained articles with 6–10 citations. A country whose research influence was high would have greater proportions of articles in the higher-citation percentiles, whereas a country whose influence was low would have greater proportions of articles in lower-citation percentiles.

59. Patent citations to S&E research discussed in this section are limited to the citations found on the cover pages of successful patent applications. These citations are entered by the patent examiner and may or may not reflect citations given by the applicant in the body of the application. Patent cover pages also contain references to scientific and technical materials not contained in the article data used in this chapter (e.g., other patents, conference proceedings, industry standards). Analyses of the data referred to in this section found that nonjournal references on patent cover pages accounted for 19% of total references in 2008. The journals/articles in the Science Citation Index and Social Sciences Citation Index databases used in this chapter—a set of relatively high-impact journals—accounted for 83% of the journal references, or 67% of the total science references, on the patent covers.

60. In this discussion, patent data are patents granted by the U.S. Patent and Trademark Office to all assignees, not just U.S. assignees. S&E publication data are for all publications in all U.S. sectors and for all country authors.

61. Patent-based data must be interpreted with caution. Year-to-year changes in the data may reflect changes in U.S. Patent and Trademark Office processing times (so-called "patent pendency" rates) and attempts to reduce the backlog of patent applications that build up from time to time. Likewise, industries and companies have different tactics and strategies for pursuing patents and otherwise protecting intellectual property, and these also may change over time.

62. The institutions listed in appendix table 5-62 are slightly different from those listed in past volumes, and data for individual institutions may be different. In appendix table 5-62, an institution is credited with a patent even if it is not the first assignee, and therefore some patents may be double counted. Several university systems are counted as one institution, and medical schools may be counted with their home institution. Universities also vary in how they assign patents (e.g., to boards of regents, individual campuses, or entities with or without affiliation with the university).

63. Other than for general trends, the patent counts reported by Association of University Technology Managers respondents in figure 5-37 and appendix table 5-64 cannot be compared with the patent counts developed from U.S. Patent and Trademark Office data as in appendix tables 5-62 and 5-63.

Glossary

Doctoral academic S&E workforce: Includes those with a research doctorate in science, engineering, or health who are employed in 2- or 4-year colleges or universities, including medical schools and university research institutes, in the following positions: full and associate professors (referred to as *senior faculty*); assistant professors (referred to as *junior faculty*); postdoctorates (postdocs); other full-time positions, such as instructors, lecturers, adjunct faculty, research associates, and administrators; and part-time positions of all kinds.

European Union (EU): As of June 2013, the EU comprised 27 member nations: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Croatia joined the EU in July 2013. Unless otherwise noted, Organisation for Economic Co-operation and Development data on the EU include all 28 members; data on the EU from other sources are limited to the 27 nations that were members as of June 2013.

Federally funded research and development center (FFRDC): R&D organization exclusively or substantially financed by the federal government, either to meet particular R&D objectives or, in some instances, to provide major facilities at universities for research and associated training purposes. Each FFRDC is administered either by an industrial firm, a university, or a nonprofit institution.

File year: Year in which an S&E article entered Thomson Reuters' S&E publication database, which may be later than the year in which the S&E article was published.

Fractional counting: Method of counting S&E publications in which credit for coauthored articles is divided among the collaborating institutions or countries based on the proportion of their participating departments or institutions. For example, the United States and China would each be credited half of a count for an article with a U.S. coauthor and a Chinese coauthor.

Index of highly cited articles: A country's share of the top 1% most-cited S&E articles divided by the country's share of all cited S&E articles. An index greater than 1 means that a country has a disproportionately higher share in highly cited articles; an index less than 1 means the opposite.

Index of international collaboration: A country's share of another country's internationally coauthored articles divided by the other country's share of all internationally coauthored articles. An index greater than 1 means that a country pair has a stronger-than-expected tendency to collaborate; an index less than 1 means the opposite.

Net assignable square feet (NASF): Unit for measuring research space. NASF is the sum of all areas on all floors of a building assigned to, or available to be assigned to, an occupant for a specific use, such as research or instruction. NASF is measured from the inside face of walls.

Relative citation index: A country's share of another country's cited S&E articles divided by the other country's share of all cited S&E articles. An index of greater than 1 means that the country has a higher-than-expected tendency to cite the other country's S&E literature; an index less than 1 means the opposite.

Research space: The budgeted and accounted for space used for sponsored R&D activities at academic institutions. Research space is the net assignable square feet of space in buildings within which research activities take place. Research facilities are located within buildings. A building is a roofed structure for permanent or temporary shelter of persons, animals, plants, materials, or equipment. Structures are included as research space if they are (1) attached to a foundation; (2) roofed; (3) serviced by a utility, exclusive of lighting; and (4) a source of significant maintenance and repair activities.

Underrepresented minority: Demographic category including blacks, Hispanics, and American Indians or Alaska Natives, groups considered to be underrepresented in academic institutions.

Whole counting: Method of counting S&E publications in which each institution or country receives one credit for its participation in the article. Whole counting is used for coauthorship data. For example, the United States and China would each be credited one count for an article with a U.S. and Chinese coauthor.

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Chapter 6
Industry, Technology, and the Global Marketplace

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Highlights

Knowledge- and Technology-Intensive Industries in the World Economy

Knowledge- and technology-intensive (KTI) industries have been a major and growing part of the global economy. The United States has the highest KTI share of gross domestic product (GDP) of any large economy.

- Ten KTI industries, consisting of five service industries and five high-technology (HT) manufacturing industries, represented 27% of world GDP in 2012. Among the KTI industries, the commercial knowledge-intensive (KI) services—business, financial, and communications—have the highest share (16% of GDP). The public KI services, education and health, have a 9% share. The five HT manufacturing industries—aircraft and spacecraft; communications and semiconductors; computers; testing, measuring, and control instruments; and pharmaceuticals—have a 2% share.
- The U.S. economy had the highest concentration of KTI industries among major economies (40% of U.S. GDP). The KTI concentrations for the European Union (EU) and Japan were considerably lower at 29%–30%.
- Major developing countries have lower KTI shares than developed countries. The KTI shares in Brazil, China, and India were 19%–21%. Turkey had the highest KTI share (23%) among larger developing countries.

Productivity growth in the world's developing countries since 2000 has been much faster than in developed countries.

- Labor productivity growth in developing countries accelerated from 2% in the early 2000s to 6% in the mid-2000s before falling to 4% in the latter half of the 2000s. China and India led productivity growth of developing countries, growing 10% and 6%, respectively, between 2003 and 2012.
- Labor productivity growth in the United States and other developed countries slowed from 2% in the early 2000s to negative growth during the global recession before rising to 1%.

Worldwide Distribution of Knowledge- and Technology-Intensive Industries

The United States is the largest global provider of commercial KI services and HT manufactured goods.

- The United States has the largest global share (32%) in commercial KI services industries (business, financial, and communications). The EU is the second-largest global provider (23%).
- China's commercial KI services industries have been growing rapidly, but from a low base. China's global share reached 8% in 2012 to tie with Japan as the third-largest global provider.
- In HT manufacturing, the United States has a global share of 27%, closely followed by China. China's HT industries have grown exponentially from a global share of 4% in 2000 to 24% in 2012.

U.S. KTI industries generally fared better than those of the developed economies in the EU and Japan in the aftermath of the recession.

- The U.S. commercial KI services industries did better than their EU competitors following the 2008–09 global recession. U.S. value-added output in these industries grew 9% in 2010–12, whereas value added in the EU was stagnant.
- U.S. HT manufacturing industries fared better than those in the EU or Japan following the 2008–09 global recession. U.S. value-added output grew 2% in 2010–12, while value-added output of the EU and of Japan remained flat or declined.

U.S. KTI industries are a major part of the U.S. economy, and they have mostly recovered from the recession.

- U.S. commercial KI services industries employ one of every seven U.S workers (18 million) and pay higher-than-average wages. These industries have a higher-than-average share of skilled workers and fund about one-fourth of U.S. business R&D.
- Although U.S. HT manufacturing industries are much smaller than commercial KI services, they fund nearly one-half of U.S. business R&D. These industries employ 1.8 million workers and have an even higher share of highly skilled workers than commercial KI services.
- The value-added outputs of U.S. commercial KI services and HT manufacturing in 2012 are higher than their levels prior to the recession. However, employment in U.S. commercial KI services and HT manufacturing industries remains below its pre-recession levels.

Trade and Other Globalization Indicators

The EU is the world's largest exporter of commercial KI services, followed by the United States. Both the EU and the United States have substantial surpluses.

- The EU's commercial KI services exports more than doubled to reach $432 billion between 2004 and 2011, with its surplus widening to $127 billion.
- U.S. exports of commercial KI services grew as fast as the EU's to reach $235 billion between 2004 and 2011; the U.S trade surplus climbed from $25 billion to $52 billion.
- Commercial KI services exports of developing countries grew much faster than developed countries, but from a much lower base. In these services, China and India have the largest export shares (4%–5% each) among developing countries. India's trade surplus widened from $11 billion in 2004 to $51 billion in 2011.

In HT manufactured goods, China is the world's largest exporter, followed by the EU and the United States.

- China, the world's second-largest manufacturer of electronic products, is the world's largest exporter of HT products, with a surplus of over $200 billion. China imports components and inputs from the United States, the EU, and Asia for final assembly in China.

- The U.S. share of global HT exports remained stable for much of the 2000s. However, the U.S. trade deficit in HT products widened from $50 billion to $130 billion during this period.
- The U.S. trade deficit in HT goods is almost entirely due to information and communications technologies (ICT) products—communications, computers, and semiconductors. In other HT manufactured goods, notably aircraft and spacecraft, the United States has a substantial trade surplus.

A separate measure of U.S. trade in advanced technology products (ATP) shows patterns similar to those found in internationally comparable HT product trade data.

- In 2012, the United States exported $305 billion of ATP and imported $396 billion of ATP products. The $92 billion deficit of ATP trade is largely due to trade in ICT products, primarily with China. The United States has a substantial surplus in trade of aerospace products.

U.S. overseas investment in foreign KTI industries exceeds foreign investment in U.S. KTI industries.

- In the commercial KI services industries, the stock of U.S. overseas investment was $1 trillion in 2012. The EU is the largest recipient, followed by Asia, which in these data includes Australia and New Zealand. The stock of foreign direct investment in the United States in these industries was $600 billion, with the EU as the largest investor.
- In computer and electronics manufacturing, which includes three HT manufacturing industries, the stock of U.S. overseas investment was $102 billion. Asia, which in these data includes Australia and New Zealand, and the EU are the two largest destinations. The stock of foreign direct investment in these industries in the United States was $61 billion, with the EU and Asia and the Pacific regions being the two largest investors.

Innovation-Related Indicators of the United States and Other Major Economies

U.S. firms in commercial KTI industries reported much higher incidences of innovation than firms in other industries.

- Five HT manufacturing industries—aircraft; computers; communications; testing, measuring, and control instruments; and pharmaceuticals—reported rates of product innovation that were at least double the U.S. manufacturing sector average.
- In the U.S. nonmanufacturing sector, software firms were the leading innovators, with 69% of companies reporting the introduction of a new product or service compared to the 9% average for all nonmanufacturing companies. Innovation is two to three times higher than the nonmanufacturing average in computer systems design; data processing, hosting, and related services; and scientific R&D services.

The U.S. Patent and Trademark Office (USPTO) granted U.S. inventors 127,000 patents in 2012, not quite half of all USPTO patents granted worldwide.

- The share of patents granted by USPTO to U.S. inventors declined from 53% in 2003 to 48% in 2012.
- The United States has a higher concentration relative to other major economies in USPTO patenting activity in several advanced and science-based technologies, including ICT, automation, biotechnology, and pharmaceuticals.

The United States has a similar share to the EU and Japan in triadic patents, which are considered an indicator of higher-value inventions.

- Triadic patents are patents sought for protection in the world's largest markets—the United States, the EU, and Japan.
- The U.S. share of triadic patents has remained constant during the 2000s at 27%–30%.

Investment and Innovation in Clean Energy Technologies

More of the world's investment in clean energy technologies occurred in developing countries than in developed countries in 2012. More commercial investment in clean energy technologies occurred in China than in any other country.

- Clean energy investment in China, largely in solar and wind technologies, rose exponentially over the last decade to reach $61 billion in 2012.
- Commercial investment in clean energy was between $27 billion and $29 billion in the United States and the EU in 2012. Commercial investment in the EU is down sharply due to the EU's economic difficulties and cutbacks in government support for clean energy production and investment.
- Worldwide venture capital investment in clean energy technologies was estimated at $4 billion in 2012. The United States is the largest recipient, accounting for more than 80% of all investment. Three technologies—energy smart and efficiency, solar, and biofuels—dominate venture capital investment.
- Worldwide venture capital investment rose rapidly, more than quadrupling from $1 billion to $4 billion from 2004 to 2012.

The United States and Japan were the largest investors in 2012 public research, development, and demonstration (RD&D) for clean energy technologies.

- Expenditures of most OECD countries on RD&D investment for clean energy and nuclear technologies were an estimated $13 billion in 2010.
- U.S. public RD&D investment in clean energy technologies jumped from $1.5 billion in 2004 to spike at $7.0 billion in 2009 due to one-time stimulus funding under the American Recovery and Reinvestment Act of 2009. In 2011, U.S. public RD&D dropped to $4.0 billion, still $2.5 billion higher than its level in 2004.

Introduction

Chapter Overview

Policymakers in many countries increasingly emphasize the central role of knowledge, particularly research and development and other activities that advance science and technology (S&T), in a country's economic growth and competitiveness. This chapter examines the downstream effects of these activities on the performance of the United States and other major economies in the global marketplace.

This chapter covers two main areas. The first is knowledge- and technology-intensive (KTI) industries in both the service and manufacturing sectors. KTI industries are 10 categories of industries classified by the Organisation for Economic Co-operation and Development (OECD 2001, 2007) that have a particularly strong link to S&T:[1]

- Five knowledge-intensive (KI) services industries incorporate high technology (HT) either in their services or in the delivery of their services. Three of these—financial, business, and communications services (including computer software and R&D)—are generally commercially traded. The others—education and health services—are publicly regulated or provided and remain relatively more location bound.
- Five HT manufacturing industries spend a large proportion of their revenues on R&D and make products that contain or embody technologies developed from R&D. These are aircraft and spacecraft, pharmaceuticals, computers and office machinery, semiconductors and communications equipment (treated separately in the text), and scientific (medical, precision, and optical) instruments.[2] Trends in aircraft and spacecraft and pharmaceuticals are particularly sensitive to government policies. Aircraft and spacecraft trends are affected by funding for military aircraft, missiles, and spacecraft and by different national flight regulations. National regulations covering drug approval, prices, patent protection, and importation of foreign pharmaceuticals can affect pharmaceuticals.

This report gives special attention to KTI industries in information and communications technology (ICT). ICT combines the HT manufacturing industries of computers and office machinery, communications equipment, and semiconductors with the KI services of communications and computer programming (a subset of business services). ICT industries are important because they provide the infrastructure for many social and economic activities, facilitating innovation and economic growth.[3]

Industries that are less KTI, however, remain very important in the world economy and therefore receive some attention in the chapter (see sidebar, "Industries That Are Not Knowledge or Technology Intensive").

The globalization of the world economy involves the rise of new centers of KTI industries.[4] Although the United States continues to be a leader in these industries, China, India, Brazil, and other developing economies have vigorously pursued national innovation policies in an effort to become major producers and exporters of KTI goods and services. Advances in S&T have enabled companies to spread KTI activity to more locations around the globe and to develop strong interconnections among geographically distant entities.

The second major focus of the chapter is innovation. Because innovation is closely associated with technologically led economic growth, the analysis of innovation in the chapter emphasizes the role of KTI industries. The measurement of innovation is an emerging field, and current data and indicators are limited. However, activities related to the commercialization of inventions and new technologies are regarded as important components of innovation indicators. Such activities include patenting, the creation and financing of new HT firms, and investment in intangible goods and services.

In recent years, innovations aimed at developing improved technologies for generating clean and affordable energy have become increasingly important in both developed and developing countries or economies. Clean energy has a strong link to S&T. Like ICT, energy is a key element of infrastructure, the availability of which can strongly affect prospects for growth and development. For these reasons, the chapter pays special attention to energy technologies.

Several themes cross-cut the various indicators examined in the chapter:

- The HT manufacturing industries are the most globalized among the KTI industries. Two HT manufacturing industries—communications; semiconductors and computers—have the most complex global value chains, where China is the dominant locale for final production. Three industries—aircraft and spacecraft; testing, measuring, and control instruments; pharmaceuticals—are less globally integrated, with final production largely located in developed countries.
- Globalization is increasing rapidly in the commercial KI services industries but remains substantially less than in the HT manufacturing industries. Data on trade and U.S. foreign investment suggest that these industries have substantial linkages among developed economies. Industries in developed economies also contract out some of their activities to developing economies.
- Although KTI activity has increased in Brazil, India, Indonesia, Turkey, and other developing countries, China plays a unique role in this arena. Despite a per capita income comparable to that in other developing countries, China's economic activity in several KTI industries has grown unusually quickly and is now comparable to or exceeds that of the United States, the European Union (EU; see "Glossary" for member countries), and Japan.
- KTI industries remain concentrated in developed countries despite much more rapid growth by China and other developing countries. Developed countries account for

Industries That Are Not Knowledge or Technology Intensive

Science and technology (S&T) are used in many industries besides high-technology (HT) manufacturing and knowledge-intensive (KI) services. Service industries not classified as KI services—which include the wholesale and retail, restaurant and hotel, transportation and storage, and real estate industries—may incorporate advanced technology in their services or in the delivery of their services. Manufacturing industries not classified as HT by the Organisation for Economic Co-operation and Development (OECD) may use advanced manufacturing techniques, incorporate technologically advanced inputs in manufacture, and/or perform or rely on R&D. Industries not classified as either manufacturing or services—agriculture, construction, mining, and utility—also may incorporate recent S&T in their products and processes. For example, agriculture relies on breakthroughs in biotechnology, construction uses knowledge from materials science, mining depends on earth sciences, and utilities rely on advances in energy science.

In the non-KI services industries—real estate; restaurants and hotels; transport and storage; and wholesale and retail—patterns and trends of the four largest producers—the United States, the EU, Japan, and China—were similar to those in HT manufacturing and commercial KI services (table 6-A). The United States and the EU, the

Table 6-A

Global value added for selected industries, by selected region/country/economy: 1997, 2006, and 2012

(Percent distribution)

Service industry and region/country/economy	1997	2006	2012
Agriculture			
Global value added (current $billions)	1,140	1,461	2,879
China	15.3	20.6	28.8
EU	19.5	15.6	10.3
Japan	6.6	4.4	3.8
United States	9.5	8.4	5.9
Construction			
Global value added (current $billions)	1,610	2,585	3,657
China	4.0	6.2	16.3
EU	27.2	31.1	22.4
Japan	21.3	10.6	10.6
United States	21.5	25.2	15.3
Mining			
Global value added (current $billions)	573	1,713	3,038
China	4.8	8.2	17.4
EU	11.7	7.4	3.9
Japan	1.2	0.2	0.1
United States	16.6	13.4	9.4
Real estate			
Global value added (current $billions)	2,686	4,283	5,667
China	1.7	3.2	8.3
EU	29.3	32.7	27.8
Japan	17.3	12.1	13.1
United States	34.3	34.8	31.9
Restaurants and hotels			
Global value added (current $billions)	732	1,202	1,708
China	3.3	5.5	10.2
EU	28.2	31.6	25.9
Japan	17.5	10.9	11.3
United States	30.1	32.0	27.6
Transport and storage			
Global value added (current $billions)	524	855	1,255
China	3.8	6.0	10.4
EU	30.5	34.6	26.8
Japan	14.2	8.6	9.3
United States	23.9	20.2	16.7
Utilities			
Global value added (current $billions)	708.2	1,032.8	1,487.8
China	4.0	9.5	20.5
EU	25.0	26.5	20.9
Japan	21.4	14.0	11.7
United States	26.7	24.8	19.7
Wholesale and retail			
Global value added (current $billions)	3,713	5,607	8,042
China	3.0	4.5	10.7
EU	24.9	26.1	20.5
Japan	18.5	11.3	9.9
United States	30.0	30.4	23.7

EU = European Union.

NOTES: Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database (2013).

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three-quarters of global production of commercial KI services industries, the largest category of KTI industries.

- KTI industries in developing countries have fared better than those in developed countries in the aftermath of the 2008–09 global recession. Among the KTI industries in the developed countries, those in the United States rebounded more robustly from the economic downturn than those in other developed economies.

Chapter Organization

The chapter focuses on the United States, the EU, Japan, and the large and rapidly developing economy of China. Other major developing countries, including Brazil, India, and Indonesia, also receive significant attention. The timespan is from the late 1990s to the present.

This chapter is organized into five sections. The first section discusses the prominent role of KTI industries in regional and national economies around the world.

Industries That Are Not Knowledge or Technology Intensive—continued

two largest providers, had modest declines in their global shares of value added between 1997 and 2012. Japan's share declined more sharply. China's global share grew rapidly to reach near or at Japan's share in restaurants and hotels, transport and storage, and wholesale and retail during this period.

Non-HT manufacturing industries are divided into three categories, as classified by the OECD: medium-high technology, medium-low technology, and low technology.* In these industries, patterns and trends were somewhat divergent from those in HT manufacturing (table 6-B). China's global share of value added grew rapidly between 1997 and 2012, and it became the world's largest manufacturer in the three non-HT manufacturing segments. The global shares of the United States and EU declined sharply in contrast to their relatively more stable positions in HT manufacturing. Japan's share also declined sharply in all three segments.

The positions of the United States, the EU, China, and Japan in nonmanufacturing and nonservices industries—agriculture, construction, and mining—are fairly similar to their positions in KTI industries (table 6-A). China's global share grew rapidly between 1997 and 2012, and it became the world's largest producer in agriculture and mining. The global shares of the United States and EU fell moderately. Japan had a steeper decline in these industries.

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* Medium-high technology includes motor vehicle manufacturing and chemicals production, excluding pharmaceuticals; medium-low technology includes rubber and plastic production and basic metals; and low technology includes paper and food product production.

Table 6-B
Global value added for manufacturing industries, by selected technology level and selected region/country/economy: Selected years, 1997–2012
(Percent distribution)

Manufacturing technology level and region/country/economy	1997	2003	2006	2009	2012
Medium high					
Global value added (current $billions)	1,467	1,643	2,139	2,357	3,480
China	3.4	7.0	11.6	23.1	28.2
EU	33.2	33.9	32.4	28.0	23.0
Japan	20.2	16.8	14.3	11.8	11.6
United States	23.4	23.7	20.3	15.3	14.4
Medium low					
Global value added (current $billions)	1,346	1,482	2,212	2,418	3,512
China	3.8	7.8	12.9	24.0	31.1
EU	28.9	29.6	25.8	22.1	16.2
Japan	19.5	15.1	11.3	9.8	9.6
United States	23.5	22.4	20.2	14.9	13.4
Low					
Global value added (current $billions)	1,454	1,594	1,955	2,371	2,969
China	4.6	8.1	13.4	20.4	29.1
EU	30.2	30.0	27.9	25.1	19.3
Japan	15.7	13.4	10.0	9.6	9.1
United States	23.4	24.1	20.6	17.9	13.9

EU = European Union.

NOTES: Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. The technology level of manufacturing is classified by the Organisation for Economic Co-operation and Development on the basis of R&D intensity of output. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database (2013).

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The second section describes the global spread of KTI industries and analyzes regional and national shares of worldwide production. It discusses shares for the KTI industry group as a whole, for KI services and HT manufacturing overall, and for particular services and manufacturing industries within these groups. Because advanced technology is increasingly essential for non-HT industries, some data on these industries are also presented.

The third section examines indicators of increased interconnection of KTI industries in the global economy. Data on patterns and trends in global trade in KTI industries make up the bulk of this section. The section also presents data on U.S. trade in advanced technology products (ATP), examining trends in U.S. trade with major economies and in key technologies. Data on domestic and foreign production and on employment in U.S. multinational companies (MNCs) in KTI industries are presented as indicators of the increasing involvement of these economically important firms in cross-border activities. To further illustrate the effects of globalization on the United States, the section presents data on U.S. and foreign direct investment abroad, showing trends by region and for individual KTI industries.

The fourth section presents innovation-related indicators. It examines countries' shares in all patents granted by the United States in various technology areas. It next examines countries' shares of high-value patents. It presents innovation-related data on U.S. industries from the National Science Foundation's (NSF's) Business R&D and Innovation Survey (BRDIS). A discussion of U.S. HT small businesses includes data on the number of HT small business startups and existing firms, employment, and venture capital and Small Business Innovation Research (SBIR) investment by industry.

The last section presents data on clean energy and energy conservation and related technologies, which have become a policy focus in developed and developing nations. These energy technologies, like KTI industries, are closely linked to scientific R&D. Production, investment, and innovation in these energies and technologies are rapidly growing in the United States and other major economies.

Data Sources, Definitions, and Methodology

This chapter uses a variety of data sources. Although several are thematically related, they have different classification systems. The sidebar "Comparison of Data Classification Systems Used" describes these systems and aims to clarify the differences among them. The discussion of regional and country patterns and trends includes examination of developed and developing countries using the World Bank's per capita income classification. Countries classified by the World Bank as *high income* are developed countries, while those classified in the other income levels—*upper middle income, lower middle income,* and *low income*—are classified as developing. In this chapter, "country" and "economy" are used interchangeably in these discussions.

Knowledge- and Technology-Intensive Industries in the World Economy

The first section of this chapter examines the role of KTI industries in the global economy. (For an explanation of KTI industries, please see "Chapter Overview.") Data on value added in these industries can be used to examine their growing importance in the global economy, the United States, and other major economies. (For a discussion of value added and other measures of economic activity, see sidebar, "Industry Data and Terminology"). For context, selected data are presented on wealth, productivity growth, and ICT infrastructure of selected economies, with a focus on the United States and other economies in which KTI industries play a particularly large or rapidly growing role.

Growth of Knowledge- and Technology-Intensive Industries in the World and Major Economies

KTI industries—commercial KI services, public KI services, and HT manufacturing—are a major part of the global economy, making up 27% of world gross domestic product (GDP) (appendix tables 6-1–6-3). Among the KTI industries, the commercial KI services—business, financial, and communications—have the highest share (16% of GDP) (appendix table 6-4).

The public KI services—education and health—are the second largest (9%) (appendix tables 6-3, 6-5, and 6-6).[5] The HT manufacturing industries—aircraft and spacecraft, communications, computers, pharmaceuticals, semiconductors, and testing, measuring and control instruments—are much smaller, with a 2% share (appendix table 6-7).

The KTI share of the world economy remained roughly constant between 1997 and 2012 (appendix tables 6-2 and 6-3). Among the KTI categories, the commercial KI services share gained 1 percentage point to reach 16% (appendix table 6-4). The expansion of commercial KI services reflects the continued shift in developed economies to services and the tendency for businesses and other organizations to purchase various services rather than maintain organizational units to provide them. This has spurred the growth of the business services industry. In developing economies, rapid economic growth and higher per capita income have stimulated demand for various services, including the commercial KI services of communications and financial services.

The share of public KI services stayed stable at 9% between 1997 and 2012 (appendix tables 6-3, 6-5, and 6-6). The growth of education and health care in line with world GDP growth has occurred due to increased demand for and access to education and health care services, the aging of populations in many countries, and other demographic factors and technological advances, such as online education and electronic medical records. The share of HT manufacturing declined 1 percentage point to reach 2% (appendix table 6-7).

Comparison of Data Classification Systems Used

Topic	Data provider	Variables	Basis of classification	Coverage	Methodology
Knowledge-intensive (KI) service and high-technology (HT) manufacturing industries	IHS Global Insight, World Industry Service database (proprietary)	Production, value added	Industry basis using International Standard Industrial Classification	KI services—business, financial, communications, health, and education services HT manufacturing—aircraft and spacecraft, pharmaceuticals, office and computer equipment, communications, and scientific and measuring equipment	Uses data from national statistical offices in developed countries and some developing countries and estimates by IHS Global Insight for some developing countries
Trade in commercial KI services	World Trade Organization	Exports and imports	Product basis using Extended Balance of Payments Services Classification	KI services—business, financial, communications, and royalties and fees	Uses data from national statistical offices, International Monetary Fund, and other sources
Trade in HT goods	IHS Global Insight, World Trade Service database (proprietary)	Exports and imports	Product basis using Standard International Trade Classification	Aerospace, pharmaceuticals, office and computing equipment, communications equipment, and scientific and measuring instruments	Uses data from national statistical offices and estimates by IHS Global Insight
U.S. trade in advanced-technology products	U.S. Census Bureau	Exports and imports	Product basis using Harmonized Commodity Description and Coding System, 10 technology areas classified by U.S. Census	Advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications, life sciences, nuclear technology, optoelectronics, and weapons	Data collected from automated reporting by U.S. Customs
Globalization of U.S. multinationals	U.S. Bureau of Economic Analysis (BEA)	Value added, employment, and inward and outward direct investment	Industry basis using North American Industrial Classification System (NAICS)	Commercial KI services—business, financial, communications HT manufacturing—aerospace, pharmaceuticals, office and computer equipment, communications, and scientific and measuring equipment	BEA annual surveys of U.S. multinationals and U.S. subsidiaries of non-U.S. multinationals
U.S. industry innovation activities	National Science Foundation, Business R&D and Innovation Survey	Innovation activities	U.S. businesses with more than five employees	Industries classified on industry basis using NAICS	Survey of U.S.-located businesses with more than five employees using nationally representative sample

Continued on following page

Comparison of Data Classification Systems Used—continued

U.S. Patent and Trademark Office (USPTO) patents	The Patent Board	Patent grants	Inventor country of origin, technology area as classified by The Patent Board	More than 400 U.S. patent classes, inventors classified according to country of origin and technology codes assigned to grant	Source of data is USPTO
Triadic patent families	Organisation for Economic Co-operation and Development (OECD)	Patent applications	Inventor country of origin and selected technology area as classified by OECD	Broad technology areas as defined by OECD, inventors classified according to country of origin	Sources of data are USPTO, European Patent Office, and Japanese Patent Office
Venture capital	Dow Jones VentureSource	Investment, technology area, country of investor origin	Technology areas as classified by Dow Jones classification system	Twenty-seven technology areas, investment classified by venture firms' country location	Data collected by analysts from public and private sources, such as public announcements of venture capital investment deals

Industry Data and Terminology

The data and indicators reported here permit the tracing and analysis of broad patterns and trends that shed light on the spread and shifting distribution of global knowledge- and technology-intensive (KTI) capabilities. The industry data used in this chapter derive from a proprietary IHS Global Insight database that assembles data from the United Nations (UN) and the Organisation for Economic Co-operation and Development to cover 70 countries in a consistent way. IHS estimates some missing data for some of the developing countries, including China. Data for developing countries may not be available on a timely basis or for specific industries.

The industry data follow the International Standard Industrial Classification, a UN system for classifying economic activities. Firms are classified according to their primary activity; a company that primarily manufactures pharmaceuticals, for example, but also operates a retail business would have all of its economic activity counted under pharmaceuticals.

Production is measured as value added. Value added is the amount contributed by an economic entity—country, industry, or firm—to the value of a good or service. It excludes purchases of domestic and imported supplies as well as inputs from other countries, industries, or firms.

Value added is measured in current dollars. For countries outside the United States, value added is recorded in the local currency and converted at the prevailing nominal exchange rate. Industry data are reported in current dollar terms because most KTI industries are globally traded and because the majority of international trade and foreign direct investment is dollar denominated. However, current dollars are an imperfect measure. Economic research has found a weak link between nominal exchange rates of countries' currencies that are globally traded and differences in their economic performance (Balke, Ma, and Wohar 2013). In addition, the exchange rates of some countries' currencies are not market determined.

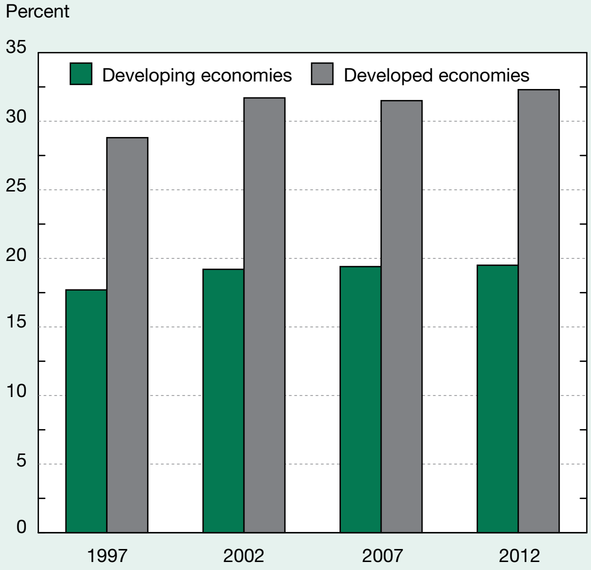
Value added is also an imperfect measure. It is credited to countries or regions based on the reported location of the activity, but globalization and the fragmentation of supply chains mean that the precise location of an activity is often uncertain. Companies use different reporting and accounting conventions for crediting and allocating production performed by their subsidiaries in foreign countries. Moreover, the value added of a diversified company's activity is assigned to a single industry based on the industry that accounts for the largest share of the company's business. However, a company classified as manufacturing may include services, and a company classified in a service industry may include manufacturing or may directly serve a manufacturing company. For China and other developing countries, industry data may be estimated by IHS Global Insight or may be revised frequently because of rapid economic change or improvements in data collection by national statistical offices. Thus, value-added trends should be interpreted as broad and relatively internally consistent indicators of the changing distribution of where economic value is generated, and small differences and changes should not be overemphasized.

Patterns and Trends of Knowledge- and Technology-Intensive Shares of Developed Economies

The KTI share of developed economies is much higher than that of developing economies due to their much larger share of KI services (figure 6-1; appendix tables 6-2 and 6-3). KTI shares vary widely among developed economies:

- The United States has the largest KTI share of any large developed economy (40%), followed by Australia (39%) and the United Kingdom (36%) (figure 6-2). These countries have larger shares in KI services, particularly in commercial KI services (22%–28%). The commercial KI services' shares of Australia and the United States are due, in part, to their higher shares in financial services (14% and 8%, respectively) relative to other developed economies (appendix tables 6-3 and 6-8). Some research suggests that the large size of financial sectors in the United States and other developed economies has fostered slowed economic growth and greater economic instability (Palley 2007:2–3).
- The EU, Japan, Canada, and South Korea have KTI shares of 29%–30%, with considerably smaller shares than the United States in commercial KI services (14%–18% versus 24%) (figure 6-2). The EU and South Korea have smaller shares of financial services (5%–7%) compared to Australia and the United States.

Figure 6-1
KTI industries' share of GDP of developed and developing economies: Selected years, 1997–2012



GDP = gross domestic product; KTI = knowledge and technology intensive.

NOTES: Output of KTI industries on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. KTI industries include knowledge-intensive (KI) services and high-technology (HT) manufacturing industries classified by the Organisation for Economic Co-operation and Development. KI services include business, financial, communications, education, and health. Commercial KI services include business, financial, and communications services. HT industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Developed countries are classified by the World Bank as high income. Developing economies are classified by the World Bank as higher- and lower-middle income and low income.

SOURCE: IHS Global Insight, World Industry Service database (2012). See tables 6-2 and 6-3.

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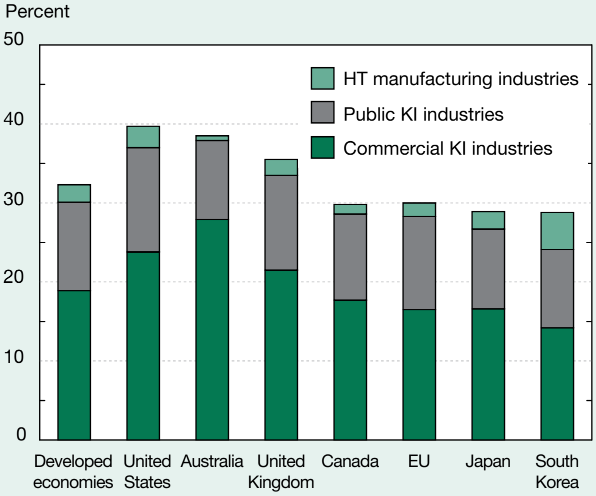
Between 1997 and 2012, the KTI share of developed economies grew from 29% to 32% due to increases in the commercial and public KI services (figure 6-1; appendix tables 6-2–6-6). The HT manufacturing share fell from 3% to 2% (appendix table 6-7). The context for this development is the continued shift from manufacturing to services in developed economies.

Trends in the KTI share varied somewhat among the developed economies:

- The KTI shares of the United States, the United Kingdom, and Australia rose 6–9 percentage points from 1997 to 2012 to reach 39%–40% in Australia and the United States and 36% in the United Kingdom (figure 6-2; appendix

Figure 6-2
Output of KTI industries as a share of GDP of selected developed economies: 2012



EU = European Union; GDP = gross domestic product; HT = high technology; KI = knowledge intensive; KTI = knowledge and technology intensive.

NOTES: Output of KTI industries on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. KTI industries include KI services and HT manufacturing industries classified by the Organisation for Economic Co-operation and Development. KI services include business, financial, communications, education, and health. Commercial KI services include business, financial, and communications services. Public KI services include education and health. HT manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and measuring, testing, and control instruments. Developed economies are classified by the World Bank as high income.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix tables 6-3–6-7.

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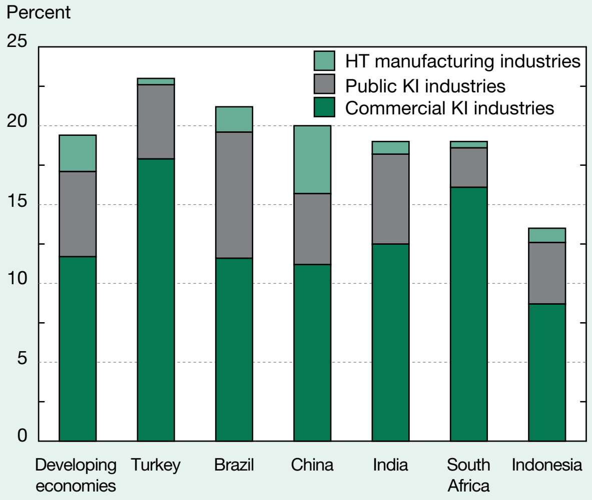
tables 6-2 and 6-3). In the United States, the increase in the KTI share occurred largely from a rise in the share of financial services (from 7% to 8%) and public KI services (from 11% to 13%) (appendix tables 6-5, 6-6, and 6-8).

- The EU's and Japan's KTI shares rose 3 percentage points to reach 30% and 29%, respectively.
- South Korea's share rose 6 percentage points to reach 29%.

Patterns and Trends of Knowledge- and Technology-Intensive Shares of Developing Economies

The KTI share of developing economies is much lower than that of developed economies due to smaller shares of KI services (figure 6-1). The KTI shares of individual developing countries vary widely, reflecting considerable differences in their stage of development and level of per capita income (figure 6-3; appendix tables 6-2 and 6-3). Among the larger developing countries, Turkey, which has a relatively high per capita income, has the highest KTI share (23%). Five countries—Brazil, China, India, Mexico, and South Africa—have KTI shares of 19%–21%. Indonesia has the lowest KTI share of any large developing economy (14%).

Figure 6-3
Output of KTI industries as a share of GDP for selected developing economies: 2012



GDP = gross domestic product; HT = high technology; KI = knowledge intensive; KTI = knowledge and technology intensive.

NOTES: Output of KTI industries is on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. KTI industries include KI services and HT manufacturing industries classified by the Organisation for Economic Co-operation and Development. KI services include business, financial, communications, education, and health. Commercial KI services include business, financial, and communications services. Public KI services included education and health. HT manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and measuring, testing, and control instruments. Developing economies are classified by the World Bank as higher- and lower-middle income and low income.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix tables 6-3–6-7.

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The KTI share of developing countries as a group edged up from 18% to 20% between 1997 and 2012 (figure 6-1). The commercial KI share grew slightly from 11% to 12%. The shares of public KI services and KI services were flat, as were shares of HT and non-HT manufacturing (figure 6-4). The shares of agriculture, construction mining, and utilities grew substantially in many of these countries, reflecting the continuing importance of resource extraction to their economies and growing domestic and global demand for food, energy, and minerals.

Trends of individual developing countries varied widely (figure 6-3):

- Turkey's KTI share had the largest increase among larger developing countries, rising 7 percentage points to reach 23%; most of the increase occurred in commercial KI services.
- Mexico's KTI share gained 5 percentage points to reach 21% due to increases in commercial KI services. Its HT manufacturing share fell from 2% to 1% (appendix tables 6-2–6-4 and 6-7).
- China's KTI share grew by 3 percentage points to reach 20% due entirely to a rise in its HT manufacturing share as it became the primary location for global production of electronic products.
- India's KTI share rose from 16% to 19% due an increase in commercial KI services.

Information and Communications Technology Infrastructure

Many economists regard ICT as a general-purpose platform technology that fundamentally changes how and where economic activity is carried out in today's knowledge-based countries, much as earlier general-purpose technologies (e.g., the steam engine, automatic machinery) propelled growth during the Industrial Revolution.[6] Thus, ICT facilitates broad development of new markets (e.g., for mobile computing, data exchange, and communications) and of new methods, products, organization, and processes. It also raises worker productivity in non-ICT industries.

Because of the shift to knowledge-based production, ICT infrastructure can be as important as or more important than physical infrastructure to raising living standards and remaining economically competitive. A World Bank study of developed and developing countries estimated that a 10 percentage point increase in broadband penetration raises economic growth by 1.2–1.4 percentage points (World Bank 2009:45).

This section examines two broad ICT indicators: an index of ICT infrastructure available to business, consumers, and the public sector; and data on ICT spending by consumers and businesses as a share of GDP. The indexes of ICT infrastructure are composite indicators developed by the *Connectivity Scorecard* that are composed of the following elements:

- The ICT consumer infrastructure measures include data on fixed broadband coverage and penetration, 3G coverage and penetration, wireless telephone penetration, and Internet download speeds.

- The ICT business infrastructure measures include Internet servers and personal computers per capita, ICT investment per capita, and business usage of broadband and mobile data.
- The ICT public sector infrastructure measures include government, health care, and education spending on ICT and a United Nations indicator of online e-government services.[7]

For developing countries, indexes have fewer components due to lack of data availability.

Developed countries. The U.S. ICT infrastructure compares favorably to other large developed countries as measured by these ICT indicators (figure 6-5):

- U.S. businesses invest heavily in and intensively utilize ICT business infrastructure.
- The United States also scores high in public sector infrastructure because of high investment by government, education, and health care sectors in ICT and an extensive number of e-government services.
- The United States scores moderately high in consumer infrastructure. The United States is ahead of Western European countries (except Sweden) in deployment of high-speed broadband but trails Japan and South Korea on this measure.

Other countries that have similar scores to the United States are the United Kingdom, Sweden, and Canada (figure 6-5). These countries were early adopters of ICT, and their business sectors are ICT intensive, particularly in the United States and the United Kingdom, which have large sophisticated service industries.

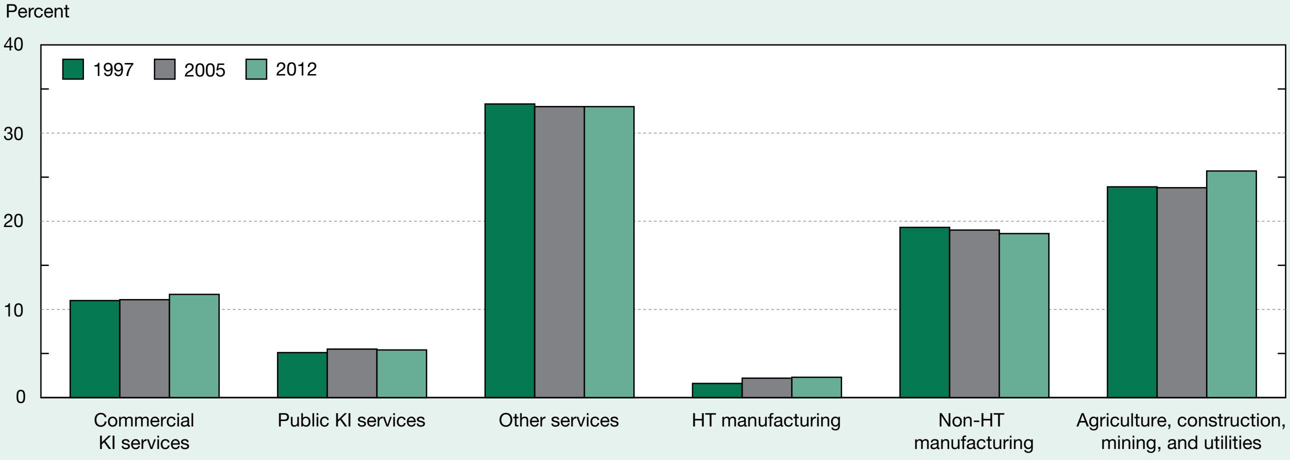
European countries—including France, Germany, and Italy, which were later adopters of ICT—have substantially lower scores in ICT business and public sector infrastructure compared to the United States (figure 6-5). Their business and public sectors are less-intensive users of ICT and invest less in ICT, and their public sectors provide fewer e-government services. Italy and Greece have the weakest index scores among developed countries and, in this respect, are more comparable to developing countries.

South Korea and Japan have the highest scores in consumer infrastructure, which reflects extensive government programs to provide near-universal broadband coverage and 3G networks (figure 6-5). However, these two countries score far weaker in business and public sector ICT infrastructure.

Developing countries. Separate ICT infrastructure indexes for major developing countries show wide variations among them, reflecting in part their level of per capita income (table 6-1; figure 6-6). The three Asian countries—China, India, and Indonesia—have the lowest index scores among the larger developing countries. Indonesia and India have very low scores in the consumer, business, and public sectors because their domestic ICT usage and access for consumers and businesses are limited and uneven, even though India has a high level of ICT service exports and a large pool of skilled ICT workers. China scores somewhat higher on consumer infrastructure, with comparatively higher broadband and fixed-line usage by its populace. China's

Figure 6-4

Selected industry category share of developing economies' GDP: 1997, 2005, and 2012



GDP = gross domestic product; HT = high technology; KI = knowledge intensive; KTI = knowledge and technology intensive.

NOTES: Output of KTI industries on value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. KTI industries include KI services and HT manufacturing industries classified by the Organisation for Economic Co-operation and Development. KI services include business, financial, communications, education, and health. Commercial KI services include business, financial, and communications services. Public KI services include education and health. HT manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and measuring, testing, and control instruments. Developing economies are classified by the World Bank as higher- and lower-middle income and low income.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix tables 6-3–6-7.

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relatively weak score in ICT business infrastructure reflects very low penetration of secure Internet servers and limited international Internet bandwidth.

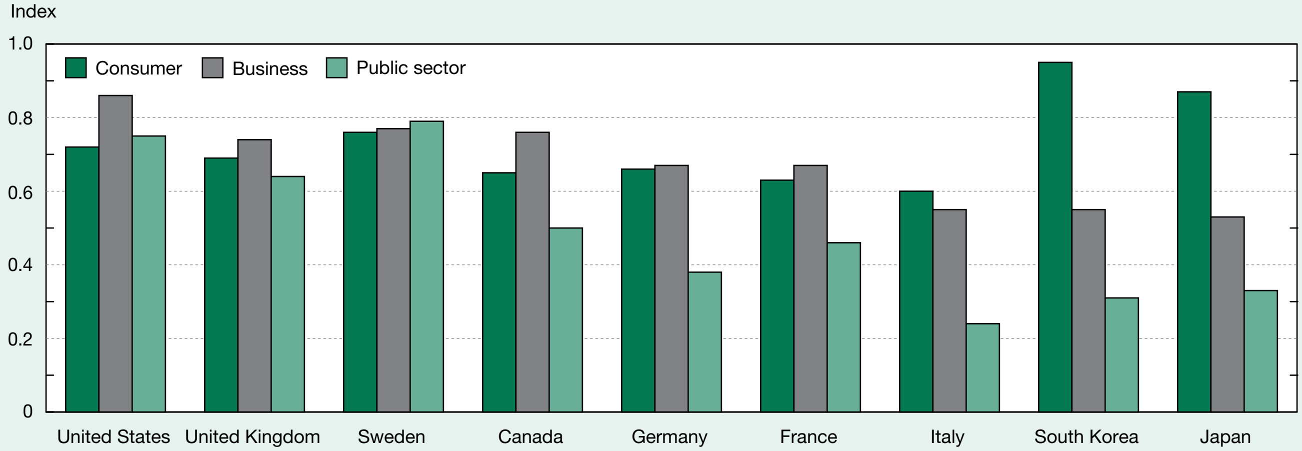
Developing countries outside of Asia have generally higher index scores, with wide variations (figure 6-6). South Africa has the highest score in public sector infrastructure among developing countries but far weaker scores in business and consumer indexes, which are close to those in the Asian countries. Brazil's and Mexico's scores are comparatively higher in the consumer and public sectors, with somewhat lower scores in business infrastructure, particularly for Mexico. Turkey is strong on consumer infrastructure, moderate on business, and poor in the public sector.

Information and Communications Technology Share of Business and Consumer Spending

Among developed countries, the United States and Canada have the highest ICT spending of businesses and consumers as a share of their GDP (figure 6-7). The next

Figure 6-5

ICT infrastructure indexes of selected developed economies: 2011



ICT = information and communications technology.

NOTES: Scores are based on a variety of data and metrics. For more information on methodology and data sources, see http://www.connectivityscorecard.org/methodology/.

SOURCE: ICT Connectivity Scorecard 2011, http://www.connectivityscorecard.org/, accessed 15 January 2013.

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Table 6-1

ICT infrastructure and per capita income of selected developing economies: 2011 and 2012

Economy	ICT infrastructure index score (2011)			Per capita income (2012)[a]
	Consumer	Business	Public sector	
Russia	0.88	0.47	0.73	18,323
Brazil	0.56	0.46	0.58	14,943
Turkey	0.67	0.55	0.38	13,380
China	0.51	0.22	0.31	10,568
Mexico	0.60	0.36	0.52	10,292
South Africa	0.30	0.44	0.83	9,655
Indonesia	0.41	0.08	0.14	5,408
India	0.22	0.04	0.18	4,431

ICT = information and communications technology.

[a] Per capita income is gross domestic product in 2012 dollars purchasing power parity, divided by population.

NOTES: ICT infrastructure scores are based on a variety of data and metrics. For more information on methodology and data sources, see http://www.connectivityscorecard.org/methodology/.

SOURCES: ICT Connectivity Scorecard 2011, http://www.connectivityscorecard.org/, accessed 15 February 2013; The Conference Board, Total Economy Database on Output and Labor Productivity (January 2013), http://www.conference-board.org/data/productivity.cfm, accessed 15 January 2013. See appendix table 6-10.

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highest are South Korea and the United Kingdom, with 5%, followed by Australia, the EU, and Japan, with 4%.

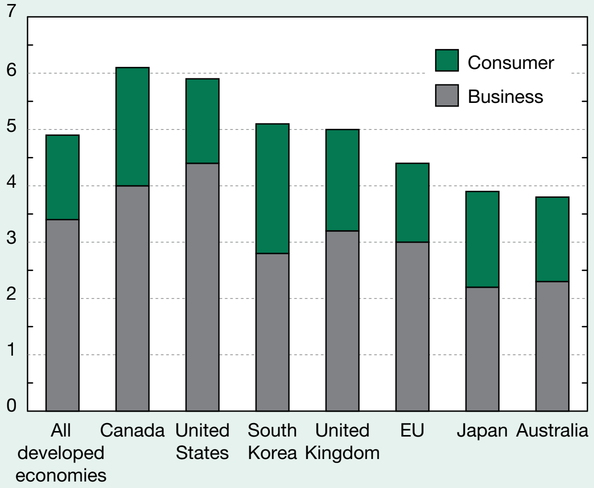
The ICT business spending share is arguably a more important indicator than ICT consumer spending because of the large impact that businesses have on overall economic growth, employment, and productivity. The United States has the highest share of ICT business spending (4.4%), closely followed by Canada (4.0%). The high ICT business spending shares of these two countries coincide with their high scores on ICT business infrastructure (discussed in the previous section). Although scoring as high as the United States and Canada on ICT business infrastructure, the United Kingdom has a lower ICT business spending share of GDP that is nearly the same as the EU average. Japan and Australia have some of the lowest shares in ICT business spending.

Many developing countries have ICT spending shares that are comparable to developed countries (figure 6-8). South Africa, which has the highest share among larger developed countries, matches the levels of Canada and the United States, although South Africa's ICT business spending share is less than that of Canada and the United States. Three countries—Brazil, China, and Turkey—have ICT shares roughly the same as the EU, with similar levels of ICT business spending. India and Indonesia have the lowest ICT spending shares, with their ICT business spending GDP share at 2% or less, coinciding with their low index scores in ICT business infrastructure.

Productivity

Productivity, which is the ratio of production outputs to resource inputs, is considered a key source of economic growth and an indicator of development. The rise in the KTI concentration of economic activity and in business investment in ICT and other knowledge-based assets in many countries has been associated with elevated or rapid productivity growth. This association is evidence that knowledge has become a crucial factor in productivity growth. Business investment in knowledge-based assets—computerized

Figure 6-7
ICT business and consumer spending as a share of GDP for selected developed economies: 2010



EU = European Union; GDP = gross domestic product; ICT = information and communications technology.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) from IHS Global Insight ICT Global Navigator.

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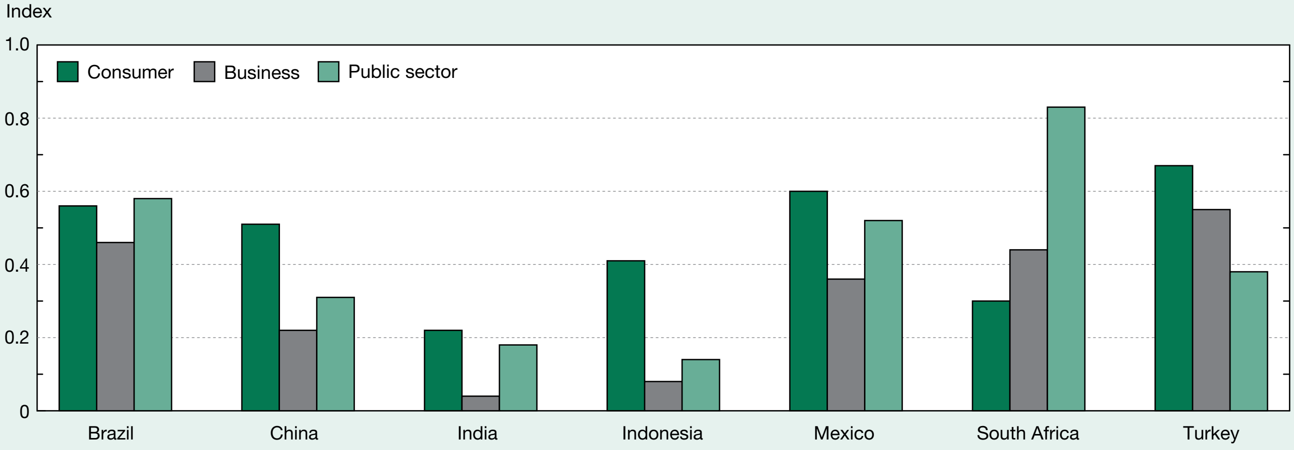
Figure 6-6
ICT infrastructure indexes of selected developing economies: 2011



ICT = information and communications technology.

NOTES: Scores are based on a variety of data and metrics. For more information on methodology and data sources, see http://www.connectivityscorecard.org/methodology/.

SOURCE: ICT Connectivity Scorecard 2011, http://www.connectivityscorecard.org/, accessed 15 January 2013.

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information and software, intellectual property, and economic competencies, including brand equity and training—are estimated to account for 20%–25% of productivity growth in Europe and 27% in the United States between 1995 and 2007 (OECD 2012:2). Because the most accurate measure of productivity, output per hour, is unavailable for many developing countries, GDP per employed person is the proxy measure used here.[8]

After growing at the same pace as developed countries in the late 1990s, labor productivity of developing countries accelerated to reach 6% per annum in the mid-2000s (figure 6-9; appendix table 6-9). The rapid advancement in productivity of developing countries has been attributed to economic liberalization; investment in education, R&D, and physical infrastructure; foreign direct investment and technology transfer by subsidiaries of MNCs; and the migration of workers from agriculture to manufacturing and services. The pace of productivity growth declined in the late 2000s due to cyclical effects of the 2008–09 global recession. Some observers also believe that productivity growth will continue to moderate because China and other fast-growing countries have begun transitioning to a more consumer- and services sector–driven economy, which typically results in lower productivity growth (Conference Board 2013:10).

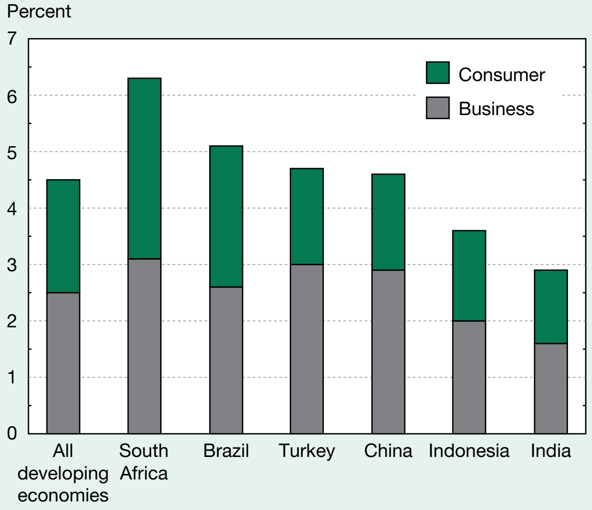
Productivity growth trends among the large developing countries varied widely (figure 6-10; appendix table 6-9):

- China registered the fastest growth of any large developing economy, growing at an average annual rate of nearly 10% between 2003 and 2012, up from 8% between 1997 and 2003.
- India grew the second fastest, increasing at an average annual rate of nearly 6% between 2003 and 2012, up from 4% between 1997 and 2003.
- Three countries—Brazil, Indonesia, and South Africa—had negative growth between 1997 and 2003, followed by modest positive growth between 2003 and 2012. Indonesia had the strongest performance among these countries, with an annual growth rate of 4% between 2003 and 2012. South Africa grew by 3%, with Brazil growing the slowest (1%).

In the developed countries, productivity growth declined from 2% in the early 2000s to negative growth during the 2008–09 recession before rising to about 1% in 2011–12 (figure 6-9; appendix table 6-9). Although the 2008–09 recession was a major factor in the slowdown, productivity growth of developing countries had been slowing prior to the recession. The recovery in productivity growth following the recession has been weak.

Productivity in the United States grew faster than almost all developed countries between 1997 and 2012, with annual average growth of 2.2% between 1997 and 2003 slowing to 1.2% between 2003 and 2012 (figure 6-11; appendix table 6-9). Only South Korea, whose transformation to become a fully developed country is relatively recent, grew faster. Observers and researchers have attributed the United States'

Figure 6-8
ICT business and consumer spending as share of GDP for selected developing economies: 2010



GDP = gross domestic product; ICT = information and communications technology.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2013) from IHS Global Insight ICT Global Navigator.

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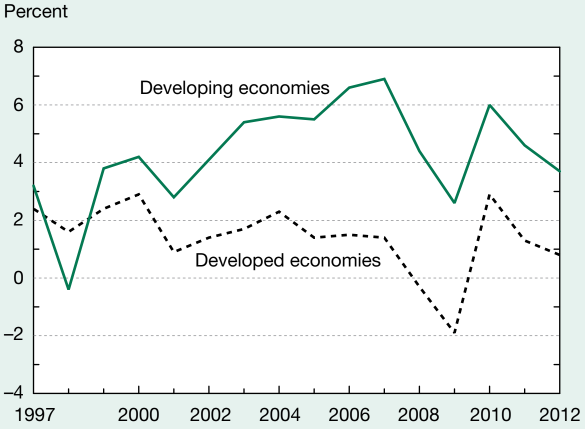
Figure 6-9
Labor productivity growth of developed and developing economies: 1997–2012



GDP = gross domestic product; PPP = purchasing power parity.

NOTES: Labor productivity growth is based on gross domestic product (GDP) per employed person. GDP is in 2012 purchasing power parity (PPP) dollars. Developed countries are those classified by the World Bank as high-income. Developing countries are classified by the World Bank as higher- and lower-middle-income economies and low-income economies.

SOURCE: The Conference Board, Total Economy Database on Output and Labor Productivity (January 2013), http://www.conference-board.org/data/productivity.cfm, accessed 15 January 2013. See appendix table 6-9.

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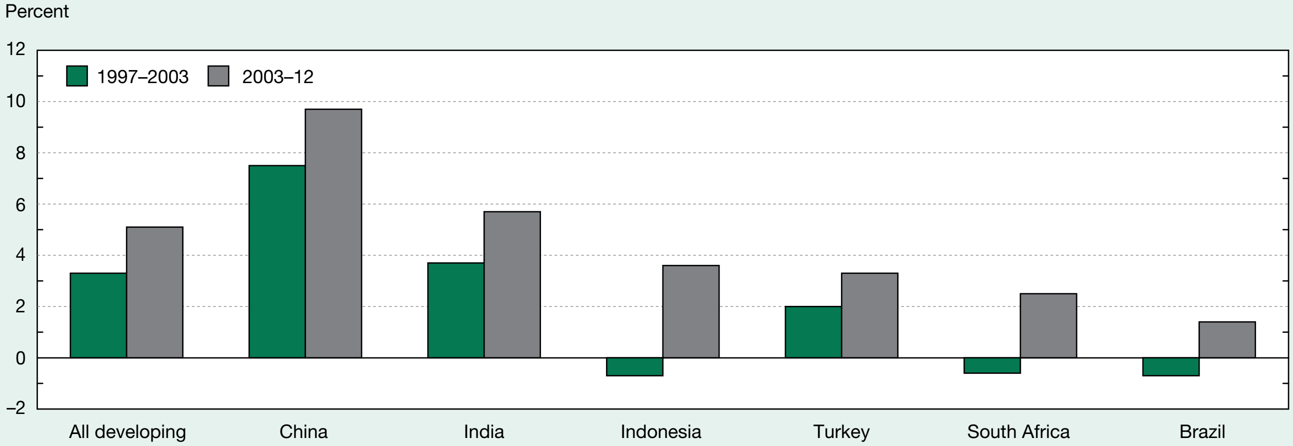
Figure 6-10
Labor productivity growth of selected developing economies: 1997–2012



NOTES: Labor productivity growth is based on gross domestic product (GDP) per employed person. GDP is in 2012 purchasing power parity (PPP) dollars. China includes Hong Kong. Developing countries are classified by the World Bank as higher- and lower-middle-income economies and low-income economies.

SOURCE: The Conference Board, Total Economy Database on Output and Labor Productivity (January 2013), http://www.conference-board.org/data/productivity.cfm, accessed 15 January 2013. See appendix table 6-9.

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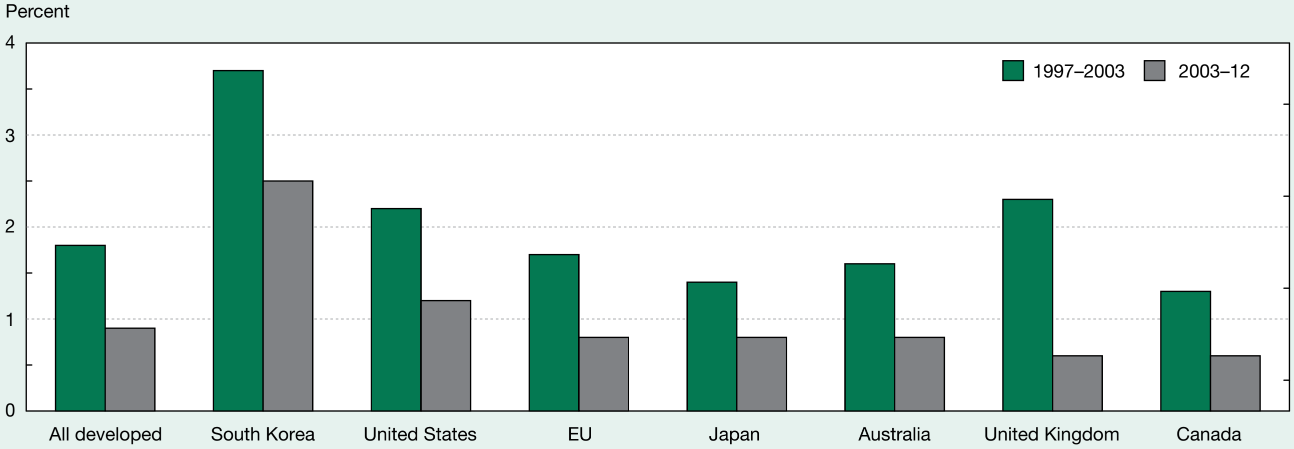
Figure 6-11
Labor productivity growth of selected developed economies: 1997–2012



EU = European Union.

NOTES: Labor productivity growth is based on gross domestic product (GDP) per employed person. GDP is in 2012 purchasing power parity (PPP) dollars. Developing economies are classified by the World Bank as high-income economies.

SOURCE: The Conference Board, Total Economy Database on Output and Labor Productivity (January 2013), http://www.conference-board.org/data/productivity.cfm, accessed 15 January 2013. See appendix table 6-9.

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better performance relative to the EU and Japan to several factors, including faster adoption of ICT technology, more-flexible labor markets, high-quality research universities, and an influx of highly skilled immigrants.

Rapidly rising living standards, expressed as per capita GDP, accompanied the acceleration of productivity growth in developing countries and narrowed their gap with developed countries (figure 6-12; appendix table 6-10). Despite sustained rapid productivity growth by China and several other developing countries, however, their gap with the United States and other developed countries is substantial and is likely to remain for some time, even if China sustains current growth rates. This is because the gap between the levels of per capita GDP in the United States and the developing world is very large. For example, U.S. per capita GDP in 2012 was $49,000 on a purchasing power parity (PPP) basis compared to $10,500 in China, about one-fifth the level of the United States.

Worldwide Distribution of Knowledge- and Technology-Intensive Industries

The second section of the chapter examines the changing shares of global activity in KTI industries attributed to the United States and other major economies (appendix table 6-1). (For an explanation of KTI industries, please see "Chapter Overview.") As national and regional economies change, the worldwide centers of KTI industries shift in importance. Shifts take place for this entire group of industries and for individual service and manufacturing industries within the group. This section examines the positions of the United States and other major economies in KTI industries.

Health and Education Services

Although health and education services are not as fully competitive or globally integrated as other KTI industries, these sectors are major sources of knowledge and innovation that benefit the entire economy. Education trains students for future work in science, technology, and other knowledge fields, and research universities are an important source of knowledge and innovation for other economic sectors.

International comparison of the health and education sectors is complicated by variations in the size and distribution of each country's population, market structure, and the degree of government involvement and regulation. As a result, differences in market-generated value added may not accurately reflect differences in the relative value of these services.

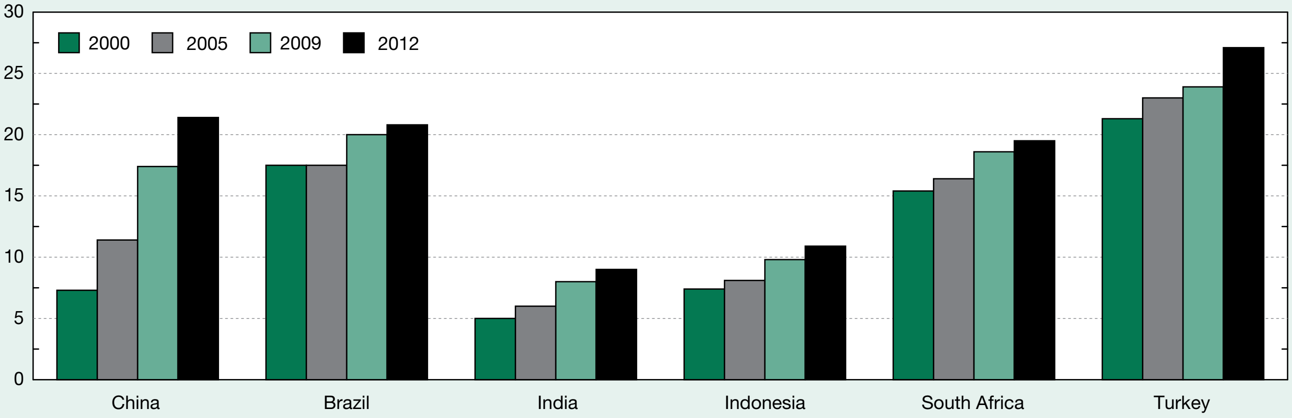
The United States and the EU are the world's largest providers of education services, with world shares of 27%–30% (appendix tables 6-3 and 6-5). China is the third-largest provider, followed by Japan. Country and regional shares are similar in health care, except that Japan places ahead of China (appendix table 6-6).

The U.S. and EU global shares of education and health care fell modestly between 2003 and 2012 (appendix tables 6-3, 6-5, and 6-6). Japan's share fell more sharply. China's global share of education and health care services at least doubled during this period, in line with its rapid economic growth. Brazil, India, and Indonesia showed a similar expansion in their global shares. The growth of education in China

Figure 6-12

GDP per capita for selected developing economies: Selected years, 2000–12

United States = 100



GDP = gross domestic product.

NOTES: GDP per capita income is expressed as an index where 100 equals the per capita income of the United States. GDP per capita income is in 2012 purchasing power parity (PPP) dollars. China includes Hong Kong.

SOURCE: The Conference Board, Total Economy Database on Output and Labor Productivity (January 2013), http://www.conference-board.org/data/productivity.cfm, accessed 15 January 2013. See appendix table 6-10.

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and India coincided with increases in both of these countries in earned doctorates in the natural S&E fields (see chapter 2).

Commercial Knowledge-Intensive Service Industries

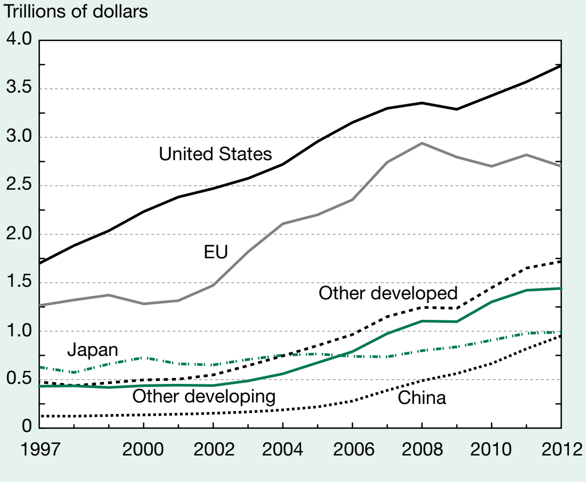
The global value added of commercial KI services—business, financial, and telecommunications—was $11.5 trillion in 2012 (figure 6-13; appendix table 6-4). Business services, which includes the technologically advanced industries of computer programming and R&D services, is the largest service industry ($5.6 trillion), closely followed by financial services ($4.3 trillion), with telecommunications far smaller ($1.6 trillion) (appendix tables 6-8, 6-11, and 6-12).

Patterns and Trends in Developing Countries

Developing countries comprise about one-fifth of global value added of commercial KI services industries (figure 6-13; appendix table 6-4). China (8% global share) is the largest provider among developing countries and essentially ties with Japan as the third-largest global provider. Other large developing countries have global shares of 2% or less.

From 1997 to 2003, the value added of commercial KI services grew at roughly the same rate in developed and developing countries (figure 6-13; appendix table 6-4). Starting in 2003, growth accelerated in developing countries, resulting in their share of global output doubling from 10% to 21% in 2012.

Figure 6-13
Output of commercial KI services for selected regions/countries/economies: 1997–2012



EU = European Union; KI = knowledge intensive.

NOTES: Output of knowledge- and technology-intensive industries is on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. The EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong. Developed economies are classified by the World Bank as high income. Developing economies are classified by the World Bank as upper- and lower-middle income and low income.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix table 6-4.

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China grew the fastest among developing countries and accounted for 45% of the expansion of all developing countries between 2003 and 2012 (appendix table 6-4). China's world share more than doubled to reach 8% to tie with Japan as the third-largest provider (figure 6-13). Among the commercial KI services, China had the largest gain in financial services, which may reflect the substantial role of public-owned or public-supported financial institutions and development banks in that country.

Brazil and India also had sizeable gains in commercial KI services, with each reaching global shares of 2% (appendix table 6-4). Brazil's expansion was led by financial services and telecommunications (appendix tables 6-8 and 6-12). India gained the most in business services, particularly in computer programming, reflecting, in part, the success of firms providing information technology (IT), accounting, legal, and other services to developed countries (appendix tables 6-11 and 6-13). Indonesia, which has a smaller global share than these two countries, grew the second fastest among the larger developing countries (see sidebar, "Indonesia's Rapid Growth in Commercial Knowledge-Intensive Services").

Patterns and Trends in Developed Countries

Commercial KI services industries in developed economies comprise four-fifths of global value added (figure 6-13; appendix table 6-4). The United States has the largest commercial KI services industries, with a 32% share of global value added. U.S. commercial KI services industries employ 18 million workers, 14% of the U.S. labor force, and pay higher-than-average wages (table 6-2; figure 6-14). In addition, these industries have a much higher concentration of skilled workers as measured by the proportion of those in S&E occupations. These industries fund roughly one-fourth of U.S. industry R&D.

The EU is the second-largest global provider of commercial KI services, with a 23% global share, followed by Japan (9%), which is essentially tied with China (figure 6-13).

After growing rapidly between 2003 and 2008, the valued added of commercial KI services of developed economies contracted in 2009 before rebounding in 2010–12 (figure 6-13; appendix table 6-4). However, growth in developed economies lagged developing economies, primarily due to China's rapid expansion. As a result, the global share of developed countries fell from 90% in 2003 to 79% in 2012.

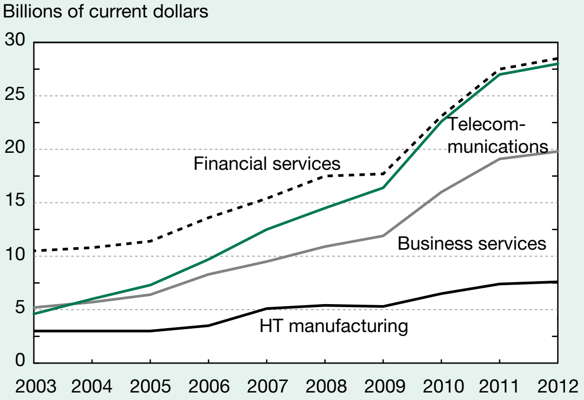
After expanding rapidly prior to the global recession, value added of U.S. commercial KI services dipped in 2009 before rebounding to reach $3.7 trillion in 2012, 12% higher than its level prior to the global recession (figure 6-13; appendix table 6-4). Between 2003 and 2012, the U.S. global share slid from 40% to plateau at 32% beginning in 2011. Employment in U.S. commercial KI services has had a weaker recovery (figure 6-14). Commercial KI services lost 1.0 million jobs during the recession. Although jobs grew modestly in 2011–12, employment in 2012 remains 300,000 jobs below its pre-recession level.

The United States is the leading global provider of business services, which led the growth of U.S. commercial KI industries

Indonesia's Rapid Growth in Commercial Knowledge-Intensive Services

Indonesia's commercial knowledge-intensive services more than doubled between 2007 and 2012, expanding 40% faster than the average for all developing countries (figure 6-A). Among the three individual industries, telecommunications grew the fastest, closely followed by business services. Indonesia's high-technology manufacturing industries also grew rapidly, with their value-added output more than doubling between 2003 and 2012. Indonesia's economy has benefitted from a sharp reduction in its budget deficit and from government programs to improve education, health care, and technological development. Unlike many of its more export-dependent neighbors, Indonesia has managed to skirt the recession, helped by strong domestic demand (which makes up about two-thirds of the economy) and a government fiscal stimulus package of about 1.4% of GDP. In addition, the government has implemented various programs to expand and improve education and health care and to increase technological development.

Figure 6-A
Indonesia's commercial KI services and HT manufacturing industries: 2003–12



HT = high technology; KI = knowledge intensive.

NOTES: Output is on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. Commercial KI services consist of business, financial, and communication services. Business services include computer programming, R&D, and other business services. Financial service includes leasing. HT manufacturing industries are classified by the Organisation for Economic Co-operation and Development and consist of aircraft and spacecraft, communications, computers, pharmaceuticals, semiconductors, and testing, measuring, and control instruments.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix tables 6-8 and 6-11–6-13.

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Table 6-2
Employment and R&D for selected U.S. industries: 2012 or most recent year

Industry	Employment (millions of persons)	S&E share	Average salary (actual $)	Business R&D (2009) ($ billions)
All industries	133.7	4.4	45,000	282.4
Commercial KI services	18.4	15.8	68,000	78.8
HT manufacturing	1.8	26.4	70,000	135.9

HT = high technology; KI = knowledge intensive.

NOTES: Business R&D consists of domestic funding by companies' own internal funds and funds from other sources. Employment consists of the nonagricultural workforce. HT manufacturing industries and KI services are classified by the Organisation for Economic Co-operation and Development. HT manufacturing includes computers, communications, semiconductors, electronic and measuring instruments, aircraft and space vehicles, and pharmaceuticals. KI services include health, education, business, information, and financial services. Commercial KI services include business, information, and financial services. Business R&D of commercial KI services consists of professional and technical services and information. Coverage of some industries may vary among data sources due to differences in classification of industries. Salaries are rounded to the nearest thousand.

SOURCES: Bureau of Economic Analysis, Annual Industry Accounts, http://www.bea.gov/industry/index.htm#annual; Bureau of Labor Statistics, Current Employment Survey, http://www.bls.gov/ces/; Bureau of Labor Statistics, Occupational Employment Survey, special tabulations; National Science Foundation, National Center for Science and Engineering Statistics, Business Research and Development and Innovation Survey, http://www.nsf.gov/statistics/srvyindustry/.

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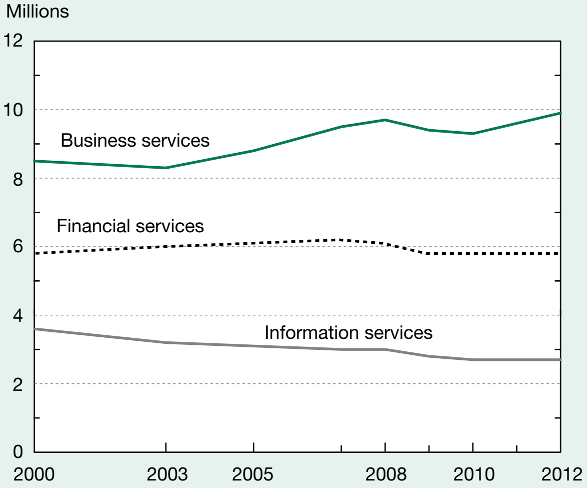
Figure 6-14
U.S. employment in commercial KI services: Selected years, 2000–12



KI = knowledge intensive.

NOTES: KI services are classified by the Organisation for Economic Co-operation and Development. Commercial KI services include business, information, and financial services.

SOURCE: Bureau of Labor Statistics, Current Employment Statistics (August 2013), http://www.bls.gov/ces/, accessed 8 August 2013.

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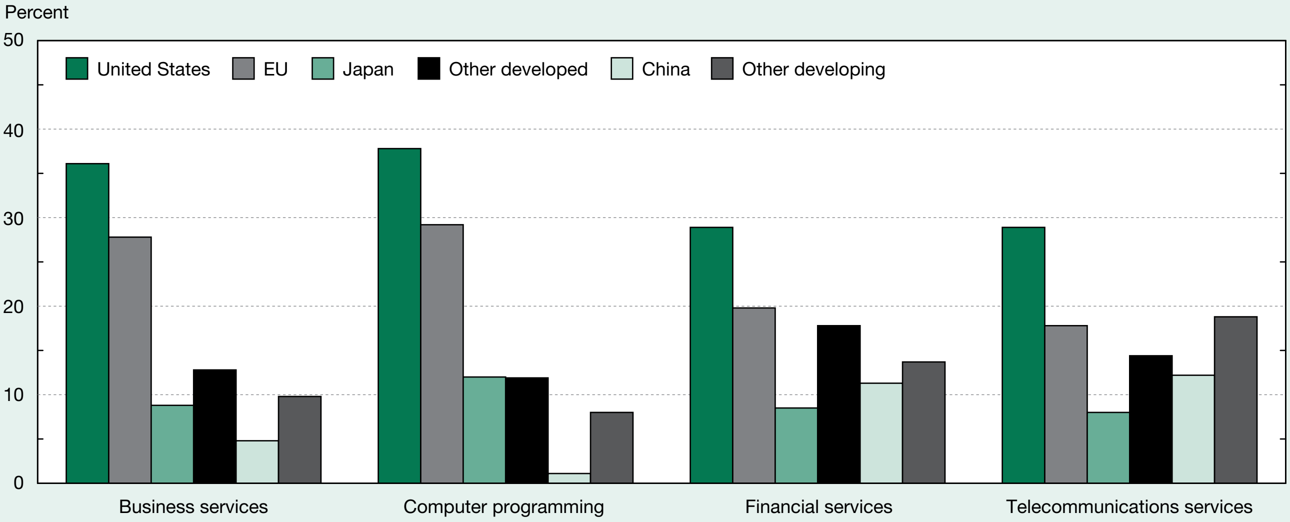
between 2003 and 2012 (figure 6-15; appendix table 6-11). Value added of business services grew slightly faster than all commercial KI industries (55% versus 45%), with value added of computer programming expanding 66% (appendix table 6-13). One source of growth of U.S. business services has been the infrastructure boom in developing countries that have employed U.S. firms in areas including architecture, engineering, and consulting.[9] U.S. employment in business services grew from 8.3 million in 2003 to reach 9.9 million in 2012, 400,000 jobs greater than the pre-recession level (figure 6-14).

The EU, which is the second-largest global provider, has fared worse than the United States since the recession. In the midst of the EU's financial and economic difficulties, the value added of its commercial KI services has remained stagnant in 2009–12 and below its pre-recession peak (figure 6-13; appendix table 6-4). As a result, the EU's global share dropped from 30% in 2008 to 23% 2012.

In the aftermath of the recession, Japan has performed better than the United States or the EU in this industry group. Value-added output continued to expand during and following the recession to reach a level nearly 25% higher than the pre-recession peak (figure 6-13; appendix table 6-4). Japan's share fell slightly, from 11% in 2003 to 9% in 2006, where it has remained steady. However, the substantial appreciation of the Japanese yen relative to the dollar during this period may have overstated the strength of Japan's commercial KI services industries (see sidebar, "Currency Exchange Rates of Major Economies").

Figure 6-15
Global value-added shares of selected regions/countries/economies for selected service industries: 2012



EU = European Union.

NOTES: Output on a value-added basis is shown above bars in trillions of dollars. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. Business services include computer programming, R&D, and other business services. Data on computer programming, a componenet of business services, is provided separately. Financial services include leasing. China includes Hong Kong. The EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Developed countries are classifed as high-income countries by the World Bank. Developing countries are classified by the World Bank as upper- and lower-middle-income countries and low-income countries.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix tables 6-11–6-13.

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Currency Exchange Rates of Major Economies

International comparisons of industry, trade, investment, and other global economic activities often use current dollars at market exchange rates. Most global economic activities are dollar denominated, which facilitates comparison. In addition, many economists believe that market exchange rates reflect, at least to some degree, differences in economic performance among various countries (Balke, Ma, and Wohar 2013:2).

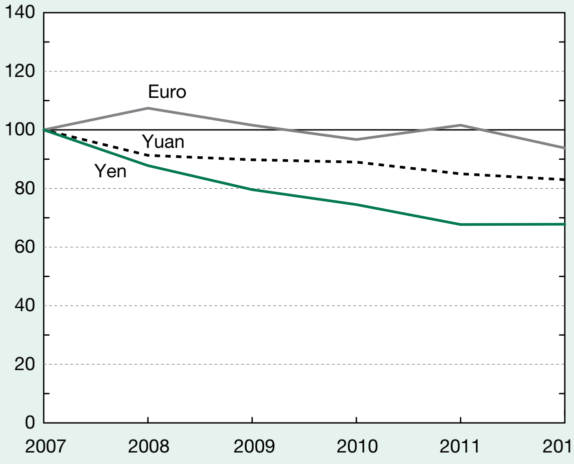
However, fluctuations in exchange rates may reflect factors other than economic performance. Governments can and do take action to influence the level of their exchange rates, ranging from intervening in currency exchange markets so as to exercise almost complete control of rates to using macroeconomic policies and other mechanisms so as to exercise more limited and indirect influence on markets. In addition, factors such as political instability or the short-term effects of global financial events on a country's economy can cause currency fluctuations that are unrelated to enduring differences in national economic performance. Factors such as these mean that comparing economic data from different countries in current dollar terms can sometimes provide an inaccurate and misleading measure of a country's relative economic performance.

Between 2007 and 2012, during the global financial crisis, the worldwide recession, and the subsequent economic recovery, the exchange rates of the four largest economies—China, the EU member countries that use the euro (the Eurozone), Japan, and the United States—exhibited considerable fluctuations (figure 6-B). The Japanese yen showed the largest change among these currencies, with an appreciation of 30% against the U.S. dollar to a nearly post–World War II high. Some experts attributed the strong appreciation of the yen to its attractiveness as a safe haven in response to Europe's debt problems and doubts about U.S. economic growth (Tabuchi 2011). The yuan's exchange rate, which is controlled by China's government, also appreciated against the dollar, although at a more modest pace.

The substantial appreciation of the yen and yuan against the dollar from 2007 to 2012 made Japan's and China's positions in economic activities denominated in current U.S. dollars appear progressively stronger during this period. Denominated in local currency terms, however, their economic performance looked weaker. The disparity was particularly large for Japan. For example, the value added of Japan's high-technology manufacturing industries in current dollars exhibited a slight decline (4%) from 2007 to 2012 (figure 6-C). The value added in yen shows a much deeper decline (35%).

Figure 6-B
U.S. dollar exchange rate with selected currencies: 2007–12

2007 = 100



SOURCE: Federal Reserve, Economic and Research and Data, Foreign Exchange Rates, http://www.federalreserve.gov/releases/h10/current/, accessed 15 May 2013.

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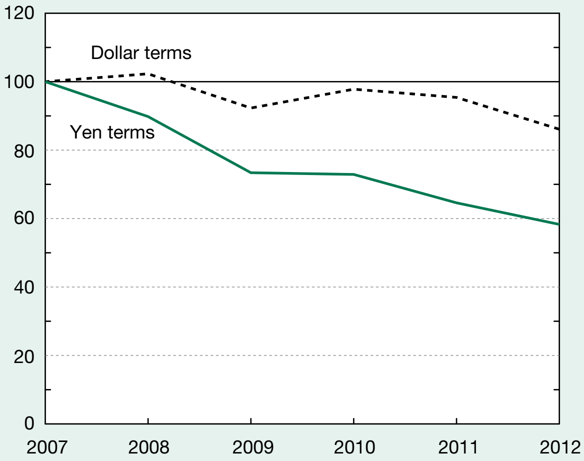
Figure 6-C
Output of Japan's HT manufacturing industries: 2007–12

2007 = 100



HT = high technology.

NOTES: Output of HT manufacturing industries is on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. HT manufacturing industries are classified by the Organisation for Economic Co-operation and Development and include aircraft and spacecraft, communications, computers, pharmaceuticals, semiconductors, and testing, measuring, and control instruments. See appendix table 6-7.

SOURCES: Federal Reserve, Economic Research and Data, Foreign Exchange Rates http://www.federalreserve.gov/releases/h10/current/, accessed 15 May 2013; IHS Global Insight, World Industry Service database (2013).

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Australia had the fastest growth in commercial KI services among large developing economies during this period (appendix table 6-4). Its global share doubled from 1.7% in 2003 to 3.7% in 2012. Australia's rapid expansion is due in part to its growing economic integration with China (see sidebar, "Australia's Commercial Knowledge-Intensive Services Grow Strongly").

High-Technology Manufacturing Industries

Global value added of HT manufacturing was $1.5 trillion in 2012, making up 14% of the manufacturing sector (figure 6-16; appendix tables 6-7 and 6-14). The three ICT manufacturing industries—communications, computers, and semiconductors—make up a collective $0.6 trillion in global value added (appendix tables 6-15–6-17). The three remaining industries are scientific instruments and pharmaceuticals, each with about $350 billion in value added, and aircraft and spacecraft, with $180 billion (appendix tables 6-18–6-20).

Patterns and Trends in Developing Countries

China is the second-largest global producer of HT products (24% global share) (figure 6-16; appendix table 6-7). These HT products are largely exported to the rest of the world. Most of China's production is performed in plants controlled by MNCs using imported inputs and components. Other large developing countries have global shares of 2% or less.

Growth of HT manufacturing in developing countries sharply accelerated starting in 2003 almost entirely due to China's rapid expansion (figure 6-16; appendix table 6-7). Between 2003 and 2012, China's value added rose more than fivefold, resulting in its global share climbing from 8% in 2003 to 24% in 2012. China's output fell slightly in 2009 during the 2008–09 recession, at a time when output declined more substantially in most other developing and developed countries. Among the HT industries, China made the most rapid gain in ICT manufacturing industries, with its global share reaching 36% in 2012 (figure 6-17; appendix tables 6-15–6-17). China also made huge gains in pharmaceuticals, reaching a global share of 25% in 2012 to tie with the EU as the world's largest producer (appendix table 6-18). Production of generic drugs by Chinese-based firms and the establishment of production facilities controlled by U.S. and EU multinationals were major factors in this industry's rapid expansion.

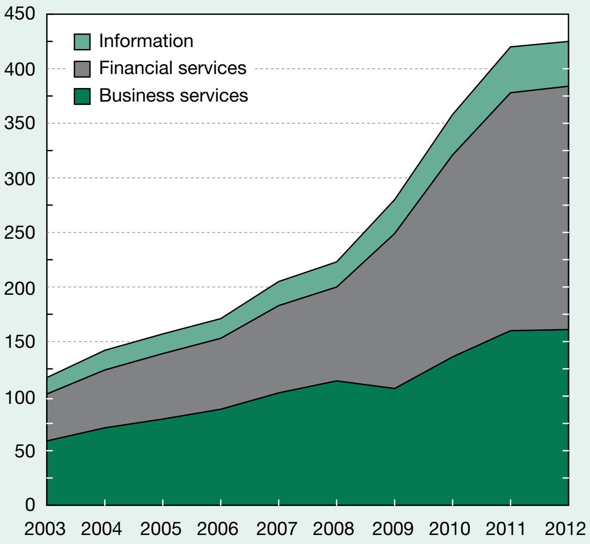
Despite some progress in producing globally competitive HT goods, notably in telecommunications equipment, Chinese HT manufacturing companies largely continue to be limited to lower-value activities, such as final assembly.[10] For example, within the semiconductor industry, Chinese firms have a limited share (20%) of China's rapidly growing market for integrated circuits, which foreign firms continue to dominate (PwC 2012). In addition, Chinese HT companies have not met many of the ambitious targets and goals of the Chinese government's indigenous innovation program.

Australia's Commercial Knowledge-Intensive Services Grow Strongly

Australia's commercial KI services grew four times faster than the average of all developed countries between 2003 and 2012 (figure 6-D; appendix table 6-4). The financial sector grew the fastest among the commercial KI services, with telecommunications and business services growing considerably slower. Australia's high-technology manufacturing industries also grew significantly faster than the developed country average, largely because of rapid growth in its pharmaceuticals industry. Australia's economy has had two decades of uninterrupted growth and was one of the few developed economies to escape the global recession. A primary factor in its growth has been booming demand by China and other Asian countries for its iron ore and other mining commodities. Its dependence on commodity exports has prompted the government to develop policies to make its economic growth more broad based.

Figure 6-D
Australia's commercial KI services industries: 2003–12

Billions of current dollars



KI = knowledge intensive.

NOTES: Output is on a value-added basis. Value added is the amount contributed by a country, firm, or entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. Commercial KI services consist of business, financial, and communications services.See appendix tables 6-8, 6-11, and 6-12.

SOURCE: IHS Global Insight, World Industry Service database (2013).

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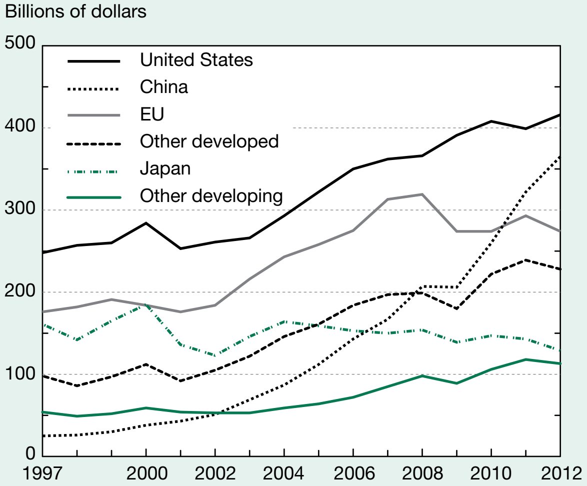
Figure 6-16
Output of HT manufacturing industries for selected regions/countries/economies: 1997–2012



EU = European Union; HT = high technology.

NOTES: Output of HT manufacturing industries is on a value-added basis. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. HT manufacturing industries are classified by the Organisation for Economic Co-operation and Development and include aircraft and spacecraft, communications, computers, pharmaceuticals, semiconductors, and testing, measuring, and control instruments. The EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong. Developed countries classified as high-income countries by the World Bank. Developing countries classified as upper- and lower-middle-income countries and low-income countries by the World Bank.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix table 6-7.

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Anecdotal reports suggest that some multinationals are relocating their facilities from China to other developing countries with lower labor costs or reshoring production in developed countries in response to increases in transportation costs and in China's manufacturing wages.[11] China's growth in ICT manufacturing industries appears to have slowed during the 2000s even prior to the global recession, although the slowdown may reflect the limitations of further expanding China's huge capacity (figure 6-18; appendix tables 6-15–6-17). However, China remains an attractive location for foreign MNCs because of its well-developed and globally capable manufacturing infrastructure. In addition, China's growing and potentially huge domestic market is prompting some foreign HT firms to expand their production facilities and establish R&D laboratories to develop products for China's rapidly growing consumer market.

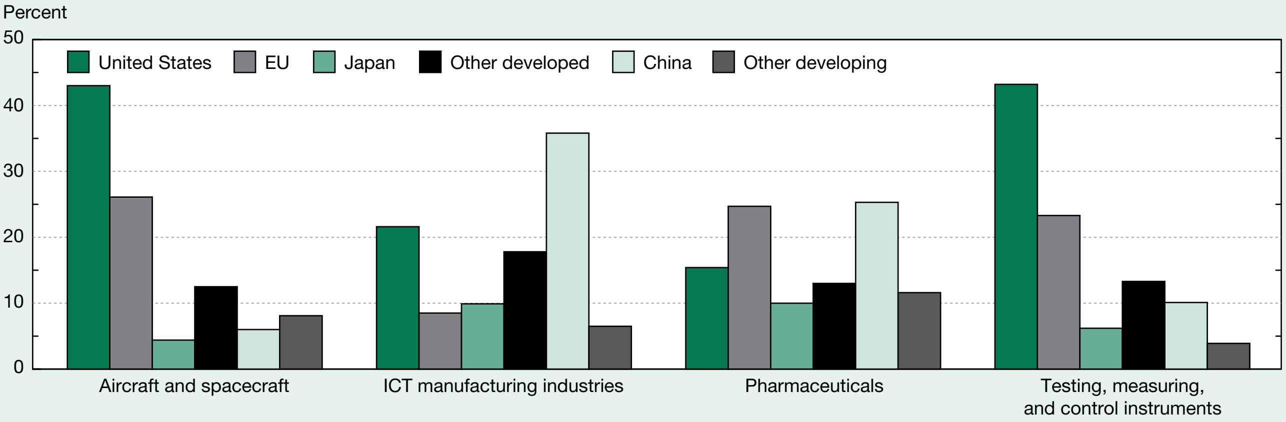
Other large developing countries that grew rapidly included Brazil and India (see sidebar, "Brazil's and India's High-Technology Manufacturing Industries").

Patterns and Trends in Developed Countries

Developed countries make up 66% of global value added of HT manufacturing industries (appendix table 6-7). The United States, which has a 27% global share, is the largest global producer (figure 6-16). U.S. HT manufacturing industries employ 1.8 million workers, 16% of the manufacturing labor force, and pay higher-than-average wages due, in part, to their high concentration of highly skilled S&E workers (table 6-2). Although a small part of the U.S economy, U.S. HT manufacturing industries fund about one-half of U.S. business R&D.

The EU and Japan are the third- and fourth-largest global producers with shares of 18% and 8%, respectively (figure 6-16; appendix table 6-7). Several Asian economies are both

Figure 6-17
HT manufacturing industries of selected regions/countries/economies: 2012



EU = European Union; HT = high technology; ICT = information and communications technology.

NOTES: HT manufacturing industries are classified by the Organisation for Economic Co-operation and Development and include aircraft and spacecraft, communications, computers, pharmaceuticals, semiconductors, and testing, measuring, and control instruments. ICT manufacturing industries consist of computers, communications, and semiconductors. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. China includes Hong Kong. The EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Developed countries classified as high-income countries by the World Bank. Developing countries classified as upper- and lower-middle-income countries and low-income countries by the World Bank.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix tables 6-21 and 6-25–6-31.

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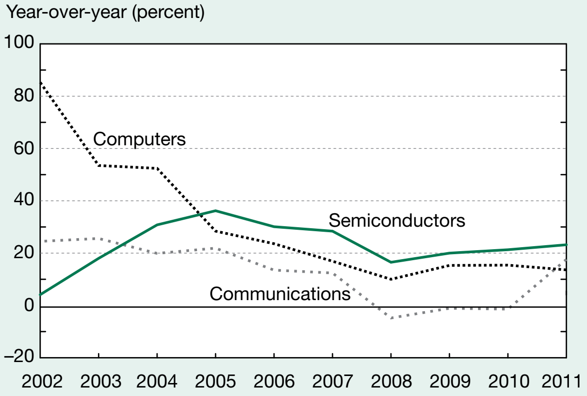
Figure 6-18
Output of China's ICT manufacturing industries: 2002–11



ICT = information and communications technology.

NOTES: Growth is on a 3-year moving-average basis of the value added of ICT manufacturing industries. Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. ICT manufacturing industries consist of communications, computers, and semiconductors. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2013). See appendix tables 6-15–6-17.

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major domestic producers and suppliers of inputs and components to China. The largest—Singapore, South Korea, and Taiwan—have a collective share of 8%.

After expanding briskly prior to the recession, the value added by HT manufacturing industries of developed countries contracted by 5% in 2008, a far larger decline than in developed countries' commercial KI services (figure 6-16; appendix table 6-7). The recovery of HT manufacturing industries following the global recession was modest. Between 2003 and 2012, the global share of developed countries fell steadily from 86% in 2003 to 69% in 2012, due entirely to a collective 18 percentage point decline in the global shares of the United States, the EU, and Japan.

In the United States, value added dipped slightly in 2008 during the recession before rebounding strongly to reach 14% higher than its pre-recession level (figure 6-16; appendix table 6-7). After falling from 33% in the early 2000s to 27% in 2008, the U.S. global share has remained roughly steady in 2009–12.

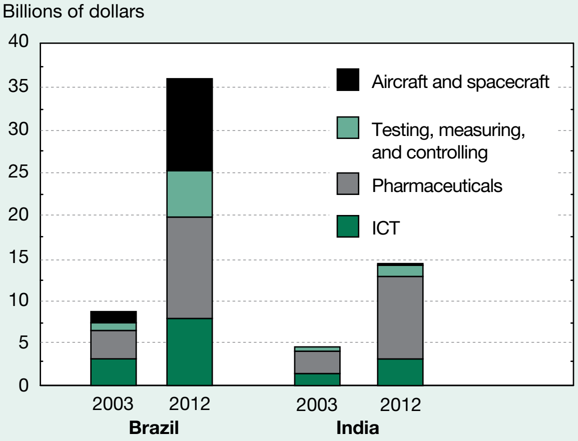
U.S. employment has fared worse prior to and following the recession. HT manufacturing jobs fell from 2.5 million in 2000 to 2.0 million in 2008 before shedding 200,000 more jobs during the global recession (figure 6-19). Furthermore, HT manufacturing employment has remained stagnant following the recession. The steady loss of employment reflects the relocation of production to China and other countries and

Brazil's and India's High-Technology Manufacturing Industries

Brazil's high-technology (HT) manufacturing industries grew more than twice as fast as the average for all developing countries, excluding China, between 2003 and 2012. Pharmaceuticals and aircraft and spacecraft led the growth of Brazil's HT industries (figure 6-E). The expansion of Brazil's pharmaceuticals industry has been boosted by the establishment of manufacturing plants by foreign multinationals to capitalize on Brazil's growing consumer market. Brazil is a major global producer of aircraft and has invested heavily in R&D for spacecraft and satellites. Growth was also rapid in scientific instruments.

India's pharmaceuticals industry, a globally competitive industry, has led the growth of its HT manufacturing industries, which quadrupled in value added between 2003 and 2012 (figure 6-E). India's pharmaceuticals industry is a major global manufacturer of generic drugs and, more recently, has been conducting clinical trials and manufacturing drugs for Western pharmaceutical companies. India, which has been weak in manufacture of electronics, has also had significant growth in its three information and communications technology (ICT) manufacturing industries. Most production of ICT manufacturing has been low value-added assembly in plants controlled by foreign multinational companies; however, the government has recently released its strategy for strengthening its electronic manufacturing industry.

Figure 6-E
Selected manufacturing industries of Brazil and India: 2003 and 2012



ICT = information and communications technologies.

NOTES: Output is on a value-added basis. Value added is the amount contributed by a country, firm, or entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. ICT manufacturing industries consist of communications, computers, and semiconductors. See appendix tables 6-15–6-20.

SOURCE: IHS Global Insight, World Industry Service database (2013).

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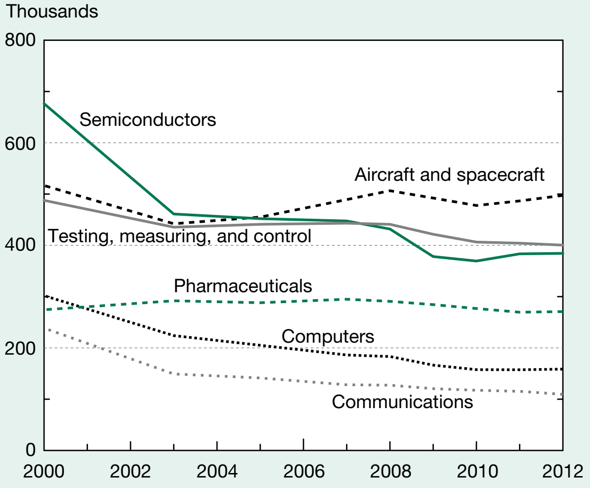
also the rapid productivity growth of U.S. HT manufacturing industries, which have eliminated some jobs, particularly those in routine tasks (see sidebar, “U.S. Manufacturing and Employment”). Researchers and policymakers have concluded that the location of HT manufacturing and R&D activities may lead to the migration of higher-value activities abroad (Fuchs and Kirchain 2010:2344).

Trends among individual U.S. industries were variable:

- Testing, measuring, and control instruments led growth of U.S. HT manufacturing industries due to increased demand for these products for a variety of purposes, including meeting environmental standards (appendix table 6-19). However, employment declined from 490,000 jobs in 2000 to 400,000 jobs in 2012 (figure 6-19).
- The United States is also the largest producer in aircraft and spacecraft, reflecting its historical dominance and the U.S. government’s procurement of military aircraft and spacecraft (figure 6-17; appendix table 6-20). Employment remained flat in this industry at about 500,000 jobs (figure 6-19).
- Value-added output in ICT industries contracted, reflecting the relocation of production abroad and labor saving from rapid productivity growth (appendix tables 6-15–6-17). Employment dropped from 1.2 million in 2000 to 650,000 in 2012 (figure 6-19).

Figure 6-19
U.S. employment in HT manufacturing industries: 2000–12



HT = high technology.

NOTES: HT manufacturing industries are classified by the Organisation for Economic Co-operation and Development. HT manufacturing industries include aircraft and spacecraft, communications, computers, pharmaceuticals, semiconductors, and testing, measuring, and control instruments.

SOURCE: Bureau of Labor Statistics, Current Employment Statistics (August 2013), http://www.bls.gov/ces/, accessed 8 August 2013.

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U.S. Manufacturing and Employment

Several signs point to an increase in U.S. manufacturing activity after years of decline. After falling continuously in the previous decade, employment in the U.S. manufacturing sector increased somewhat in 2011–12, coinciding with a rebound in this sector’s output following the 2008–09 global recession.[*] According to press reports, several firms, including Apple, GE, and Lenovo, are building new manufacturing facilities in the United States (Booth 2013:1). Furthermore, some analysts and researchers predict a resurgence in U.S. manufacturing production, pointing to low transportation and energy costs, modest U.S. labor costs, and favorable currency exchange rates as factors conducive to manufacturing growth (PwC 2012:3).

However, other observers doubt that large-scale increases in employment will accompany increased U.S. manufacturing production. Many U.S. manufacturing industries are highly productive, which allows them to increase output substantially without increasing employment much. Although manufacturers in the United States and other high-income economies will continue to hire more high-skilled workers, manufacturing employment is likely to continue to decline over the next several decades due to further advances in productivity and global competitive pressures (McKinsey Global Institute 2012:4).

In interpreting recent trends in manufacturing production and employment, it is helpful to take into account several broader trends and patterns:

- The share of manufacturing production and employment has steadily declined in the United States and other advanced countries over the past several decades (Shipp et al. 2012:61).
- In wealthy countries, manufacturing continues to play a key role in innovation, productivity, and exports, even as its share of output and employment declines.
- As a share of a country’s economy, manufacturing production and employment peak when a country’s per capita income reaches a middle level (McKinsey Global Institute 2012:3). At higher per capita income levels, output and employment grow more rapidly in the service sector than in manufacturing.

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[*] Employment in the U.S. manufacturing sector increased by about 200,000 jobs in both 2011 and 2012, according to the U.S. Bureau of Labor Statistics’ Current Employment Survey, http://www.bls.gov/ces/data.htm, accessed 10 June 2013.

- Pharmaceuticals showed little growth during this period (appendix table 6-18). The expiration of patents on highly profitable blockbuster drugs, the lack of new breakthrough drugs, increasing competition from generic drugs, and the relocation of production to other countries were among the factors accounting for tepid growth.

Other major Asian producers—Singapore, South Korea, and Taiwan—showed little change in their global shares during this period. After rapid expansion in HT manufacturing in the prior two decades, companies based in these economies have relocated some of their production facilities to China and other low-cost locations. For example, many Taiwanese ICT firms have shifted their production to mainland China.

Trade and Other Globalization Indicators

The third section of this chapter examines several trade and globalization measures associated with KTI industries in the United States and other economies. (For an explanation of KTI industries, please see "Chapter Overview.") In the modern world economy, production is more often *globalized* (i.e., value is added to a product or service in more than one nation) and less often *vertically integrated* (i.e., conducted under the auspices of a single company and its subsidiaries) than in the past. These trends have affected all industries, but their impact has been pronounced in many commercial KTI industries. The broader context is the rapid expansion of these industrial and service capabilities in many developing countries, both for export and internal consumption, accompanied by an increasing supply of skilled, internationally mobile workers. (See chapter 3 for a discussion on the migration of highly skilled labor.)

This section focuses on cross-border trade of international KI services and HT trade and on U.S. trade of ATP. (See "U.S. Trade in Advanced Technology Products" later in this chapter for a discussion of how the U.S. Census Bureau's classification of ATP differs from the classification of HT products based on the OECD industry classification.) It will also examine trade and other globalization measures of U.S. multinationals in KTI industries. Trade data are a useful although imperfect indicator of globalization (for a discussion, see sidebar, "Measurement and Limitations of Trade Data").

This discussion of trade trends in KI services and HT manufactured products focuses on (1) the trading zones of the North American Free Trade Agreement (NAFTA), with a particular focus on the United States, and the EU; (2) China, which is rapidly taking on an increasingly important role in KTI trade; (3) Japan and other Asian countries; and (4) large developing countries, including Brazil, India, and Indonesia.

The EU, East Asia, and NAFTA have substantial volumes of intraregional trade. This section treats trade within these three regions in different ways. Intra-EU and NAFTA exports are not counted because they are integrated trading zones with common external trade tariffs and few restrictions on intraregional trade. This kind of trade is treated as essentially equivalent to trade between China and Hong Kong, which is excluded because it is essentially intraeconomy trade. (Data on trade in commercial KI services between China and Hong Kong are not available.) Intra-Asian trade is counted for other Asian countries because they have a far smaller degree of trade integration.

Measurement and Limitations of Trade Data

Trade data are based on a classification of goods or services themselves. In the case of product trade, trade is assigned one product code according to the Harmonized Commodity Description and Coding System, or Harmonized System (HS).* The product classification of trade is fundamentally different from the industry classification used in the last section, which is based on the primary activity of the industry that produced a product and not on the characteristics of the product itself. Thus, the two classifications cannot be mapped onto each other. For example, an export classified as a computer service in the product-based system may be classified in the industrial classification as computer manufacturing because it originated from a firm in that industry.

Data on exports and imports represent the market value of products and services in international trade. Exports of products are assigned by the importing country's port of entry to a single country of origin. For goods manufactured in multiple countries, the country of origin is determined by where the product was "substantially transformed" into its final form.

The value of product trade entering or exiting a country's ports may include the value of components, inputs, or services classified in different product categories or originating from countries other than the country of origin. For example, China is credited with the full value (i.e., factory price plus shipping cost) of a smart phone when it is assembled in China, although made with components imported from other countries. In these data, countries whose firms provide high-value services such as design, marketing, and software development are typically not credited for these contributions.

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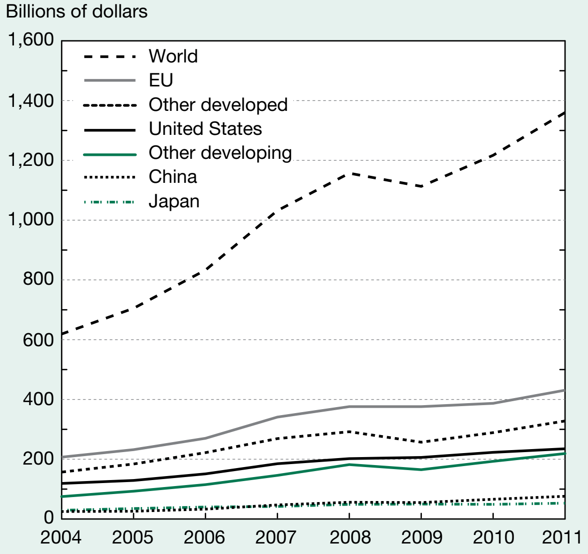
* HS is a system for classifying goods traded internationally that was developed under the auspices of the Customs Cooperation Council. Beginning on 1 January 1989, HS numbers replaced schedules previously adhered to in more than 50 countries, including the United States. For more information, see http://www.census.gov/foreign-trade/guide/sec2.html#htsusa.

Global Trade in Commercial Knowledge- and Technology-Intensive Goods and Services

Exporting goods and services to other countries is one measure of a country's economic success in the global market—the goods and services it produces compete in a world market. In addition, exports have an important advantage over domestic purchases in that they bring in income from external sources and do not consume the income of a nation's own residents.

Global trade in commercial KTI goods and services consists of four services—business, communications, computer and information, and finance—and six HT products—aerospace, communications, computers, pharmaceuticals, semiconductors, and scientific instruments.[12] Global cross-border exports of commercial KTI goods and services were an estimated $3.7 trillion, consisting of $2.3 trillion of exports of HT products and $1.4 trillion of commercial KI services (figure 6-20; appendix table 6-21).

Figure 6-20
Commercial KI service exports, by selected region/country/economy: 2004–11



EU = European Union; KI = knowledge intensive.

NOTES: Commercial KI service exports consist of communications, business services, financial services, and computer and information services. Financial services includes finance and insurance services. EU exports do not include intra-EU exports. Developed countries are classified as high-income economies by the World Bank. Developing countries are classified as higher- and lower-middle-income economies and low-income economies by the World Bank. The sum of the regions/countries/economies does not add to the world total due to rounding and discrepancies.

SOURCE: World Trade Organization, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 8 August 2013.

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Commercial Knowledge-Intensive Services

Global exports of commercial KI made up one-third of all commercial services. Among the commercial KI services, business services was the largest ($800 billion), followed by finance (which includes insurance) ($300 billion), computer and information services ($170 billion), and communications ($80 million).[13]

The United States, the EU, Japan, and other developed countries export $1.0 trillion in commercial KI services, comprising 77% of global exports (figure 6-20). China and other developing countries export far less than developed countries ($0.3 trillion).

Patterns and Trends in Developing Countries

Exports of developing countries make up a small share (22%) of global exports of commercial KI services. China and India have the largest global export shares of any developing economy (6%–7% each), and they are tied as the third largest in the world, behind the United States and the EU (table 6-3; figure 6-20).[14]

India is notable for being the largest exporter of computer and information services, attesting to the strong market position of Indian firms providing IT and related services to the rest of the world (table 6-3). China and India both have substantial surpluses in trade of commercial KI services. Other developed countries have global export shares of less than 2%.

Between 2004 and 2011, cross-border commercial KI exports of developing countries nearly tripled to reach $296 billion, expanding much faster than in developed countries but from a much lower base (figure 6-20). The global share of developing countries rose from 16% to 22% during this period.

China's exports tripled during this period, resulting in its global export share climbing from 4% to 7% (table 6-3; figure 6-20). China's trade balance in commercial KI services widened from a surplus of $3 billion to $11 billion in 2010.[15]

India's exports also expanded rapidly, with its global share rising from 4% to 7%. India's surplus expanded from $11 billion to $50 billion during this period.[16]

Patterns and Trends in Developed Countries

The EU is the largest exporter of commercial KI services, with a global share of 32% (figure 6-20). The United States is the second-largest exporter, with a global share of 17%. The EU and United States both have surpluses in trade of commercial KI services in contrast to their deficits in HT product trade (table 6-4). Japan, which has a small deficit in commercial KI services trade, is the fifth-largest exporter, behind India and China.[17]

Between 2004 and 2011, growth of commercial KI exports of developed economies trailed developing economies, resulting in their global share falling from 83% to 77% (figure 6-20).

U.S. exports of commercial KI services more than doubled to reach $235 billion; the U.S trade surplus climbed from $33 billion to $52 billion (table 6-4; figure 6-20). Exports of business services, the largest component, slighted lagged overall export growth. The trade surplus in other business services increased from $29 billion to $39 billion. U.S. exports of R&D services, a component of business services, rose from $13 billion in 2006 to $22 billion in 2010. The trade surplus edged down from $4 billion to $2 billion (see sidebar, "U.S. Trade in R&D Services").

In the EU, commercial KI services grew at a similar pace, reaching more than $400 billion in 2011, with the EU's surplus more than doubling to reach $127 billion (table 6-4; figure 6-20). Among the commercial KI services, computer information services grew the fastest, nearly tripling to reach $57 billion. Exports of business services, the largest component, slightly lagged overall growth. The EU's trade surpluses of these two commercial KI exports both grew substantially. EU's exports of financial services (which include insurance) also grew rapidly with the surplus widening from $25 billion to $51 billion.

High-Technology Goods

Global HT product exports—aircraft and spacecraft; computers; communications; semiconductors; pharmaceuticals; and testing, measuring, and control instruments—were $2.3 trillion in 2012, making up 16% of the $14.7 trillion in exports of all manufactured goods (figure 6-21; appendix tables 6-21 and 6-24). Among the HT products, ICT products—communications, computers, and semiconductors—are the largest, with a collective value of $1.4 trillion (appendix tables 6-25–6-28). The remaining three industries—testing, measuring, and control instruments; pharmaceuticals; and aircraft and spacecraft—range from $200 billion to $400 billion each (appendix tables 6-29–31).

Table 6-3

India's and China's trade in commercial KI services: 2011

(Billions of dollars)

	India			China		
Category	Exports	Imports	Balance	Exports	Imports	Balance
All commercial KI services	94	43	50.7	76	65	10.9
Computer information services	44	2	41.8	12	4	8.3
Financial services	9	14	-5.5	4	20	-16.6
Other business services	39.5	25.5	14.1	58.3	39.6	18.7
Communications services	1.7	1.4	0.3	1.7	1.2	0.5

KI = knowledge intensive.

NOTES: Commercial KI services trade consists of communications, business services, financial services, computer and information services, and other business services. Financial services includes finance and insurance.

SOURCE: World Trade Organization, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 8 August 2013.

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Table 6-4

U.S. and EU commercial KI services trade, by category: 2004, 2008, and 2011

(Billions of dollars)

	2004			2008			2011		
Category	Exports	Imports	Balance	Exports	Imports	Balance	Exports	Imports	Balance
United States									
All commercial KI services	118.9	86.4	32.5	201.7	165.7	36.0	235.1	183.6	51.5
Computer and information services	8.7	8.6	0.1	13.1	16.9	-3.8	15.5	24.5	-9.0
Financial services	43.7	40.2	3.5	72.2	76.1	-3.9	81.0	72.8	8.2
Other business services	61.6	32.3	29.3	101.8	64.3	37.5	117.2	78.2	39.0
Communications services	4.9	5.2	-0.3	10.3	8.4	1.9	12.9	8.1	4.8
EU									
All commercial KI services	207.5	141.1	52.7	376.2	252.5	123.9	431.6	274.7	126.6
Computer and information services	20.2	10.0	7.3	44.7	18.8	20.3	57.1	20.3	30.4
Financial services	49.8	24.9	41.6	93.1	40.0	54.7	96.3	45.5	41.6
Other business services	129.3	97.2	4.8	220.2	175.4	50.0	254.2	187.6	53.0
Communications services	8.2	9.0	-1.0	18.2	18.3	-1.1	24.0	21.2	1.7

EU = European Union; KI = knowledge intensive.

NOTES: Commercial KI services trade consists of communications, other business services, financial services, and computer and information services. Financial services includes finance and insurance. EU trade does not include intra-EU trade.

SOURCE: World Trade Organization, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 8 August 2013.

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The bulk of global exports ($1.4 trillion) originate from developed countries—primarily from the EU, the United States, Japan, and several Asian economies, including Singapore, South Korea, and Taiwan (figure 6-21; appendix tables 6-21 and 6-32). A large share of HT exports of developed countries is made up of components and inputs that are imported by China, Mexico, and other developing countries for final assembly. Exports of developing countries, which make up $0.9 trillion, are largely finished goods imported by developed countries (figure 6-21).

Between 2003 and 2012, global HT exports doubled to reach $2.3 trillion (appendix table 6-21). The HT share of manufactured exports declined from 22% to 16% during this period (appendix table 6-24).

Patterns and Trends in Developing Countries

China is the largest exporter of HT products among developing countries and is also the world's largest exporter, with a 28% share of global HT exports (table 6-5; figure 6-21; appendix table 6-21). Other developing countries have global shares of 3% or less.

Between 2003 and 2012, HT exports of developing countries grew twice as fast as those of developed countries. As a result, the developing countries increased their share of global HT exports from 29% to 40% (figure 6-21; appendix table 6-21). China grew the fastest among the developing countries, with its exports reaching $632 billion, becoming the world's largest exporter. China's trade surplus climbed from $30 billion to $280 billion during this period.

U.S. Trade in R&D Services

Trade in research and development services is part of U.S. trade in business services, a component of commercial KI services. In 2011, companies located in the U.S. exported $24 billion in these services and imported $22 billion, based on Bureau of Economic Analysis (BEA) statistics.* Most of this trade occurs between affiliated parties, that is, within multinational companies (MNCs) (appendix table 6-22).

Details by regions and countries (available for total trade, not by affiliation) show that Europe is the top destination for U.S. R&D services exports, with a 64.9% share in 2011. For R&D services imports, Europe is also the largest trading partner but with a lower share, at 46.6% in 2011. The Asia-Pacific region was the second-largest destination for R&D services exports, receiving 15.9% of U.S. exports in these services. The region's share as a source of imports was higher, at 29.4% in 2011.

Data for earlier years were collected under the category "research, development, and testing (RDT) services" (appendix table 6-23). These data show that U.S. exports of RDT services rose from $13 billion to $24 billion between 2006 and 2010. The trade surplus fell from $4 billion to $2 billion during this period. The European imports share of RDT services declined steadily from 62.3% in 2006 to 49.4% in 2010. At the same time, the share of RDT services imports from the Asia-Pacific region increased from 17.4% in 2006 to 22.7% in 2007 to just below 30% annually from 2008 to 2010.

R&D and testing services imports from the Asia-Pacific region increased most notably from India (from $427 million in 2006 to $1.6 billion in 2010), China (from $92 million to $955 million) and Japan (from $550 million to $1.3 billion). This trend is consistent with increased R&D activities in these countries both overall (gross expenditures in R&D) and by affiliates of U.S. MNCs (see the "International Comparisons of R&D Performance" and "R&D by Multinational Companies" sections in chapter 4).

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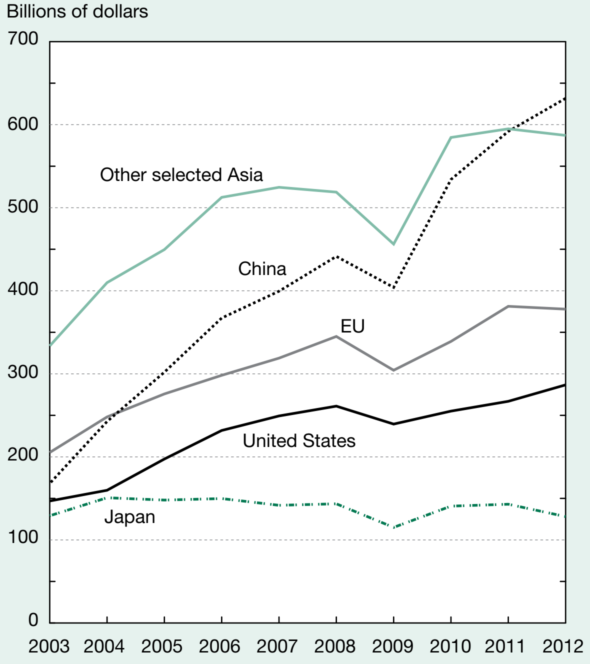
* Statistics for 2011 are from the Benchmark Survey of Transactions in Selected Services and Intellectual Property with Foreign Persons. See appendix table 6-22 for details.

Figure 6-21
Exports of HT products, by selected region/country/economy: 2003–12



EU = European Union; HT = high technology.

NOTES: HT products include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. China includes Hong Kong. The EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Exports of the United States exclude exports to Canada and Mexico. Exports of the EU exclude intra-EU exports. Exports of China exclude exports between China and Hong Kong. Other selected Asia consists of Malaysia, Phillippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: IHS Global Insight, World Trade Service database (2013). See appendix table 6-21.

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However, because many of China's exports consist of inputs and components imported from other countries, China's trade surplus is likely much less in value-added terms (see sidebar, "International Initiative to Measure Trade in Value-Added Terms").

China's ICT exports, which dominate China's HT product exports, more than tripled to reach almost $560 billion during this period (table 6-5; appendix tables 6-25–6-28). China's ICT trade surplus expanded from almost $40 billion to over $280 billion. Its exports of testing, measuring, and control instruments grew at the same pace to reach almost $60 billion (appendix table 6-31).

Trends varied widely among other developing countries (appendix table 6-21):

- Vietnam grew the fastest of any developing country, with its HT exports growing from less than $1 billion to $17 billion. Vietnam has become a low-cost location for assembly of cell phones and other ICT products, with some firms shifting production out of China and other developing countries, where labor costs are higher.
- India's exports rose sevenfold to reach $26 billion due to expansion in pharmaceuticals and ICT products.

Patterns and Trends in Developed Countries

The bulk of global exports of HT goods ($1.4 trillion) originate from developed countries—primarily the EU, the United States, Japan, and several Asian economies (figure 6-21; appendix tables 6-21 and 6-32). The EU and the United States are the largest and second-largest global exporters among developed economies. Japan, South Korea, and Taiwan are the next-largest exporters, each with a global share of between 6% and 8%.

Between 2003 and 2012, exports of developed economies nearly doubled to reach $1.4 trillion in 2012 (figure 6-21; appendix table 6-21). Because exports of developing economies grew much faster than developed economies, the global share of developed economies fell from 71% to 60%.

In the United States, HT product exports grew slightly faster than the average for all developed economies' exports (appendix table 6-21). The U.S. global share slipped from 14% to 13%. The U.S. HT product trade position, which had been in balance in the late 1990s, experienced a widening deficit during this period, going from $88 billion to $130 billion.[18]

U.S. growth of HT product exports was led by pharmaceuticals and by aircraft and spacecraft (appendix tables 6-29 and 6-30). Pharmaceutical exports more than doubled in value to reach $39 billion, with the trade deficit widening from $13 billion to $24 billion. Exports of aircraft and spacecraft climbed to $96 billion, with the U.S. trade surplus at nearly $80 billion in 2012, up from $21 billion in 2003.

Exports of ICT products, the largest component, grew slower than the average for all HT products to reach $94 billion (appendix tables 6-25–6-28). The U.S. trade deficit in ICT products widened from $95 billion to $192 billion.

The EU exhibited a similar trend, with growth in its HT product exports led by aircraft and spacecraft, pharmaceuticals, and testing, measuring, and control instruments (appendix tables 6-29–6-31). The trade surpluses in these three products widened substantially. The EU's trade deficit in ICT products deepened from $65 billion to $112 billion (appendix tables 6-25–6-28).

Other major Asian exporters—Japan, South Korea, and Taiwan—showed divergent trends (appendix table 6-21). Japan's exports trailed the average for all developed countries, with its global share falling from 12% to 6%. Japan's decline from an export powerhouse in electronics reflects its lengthy economic stagnation, the financial difficulties of Japanese electronics firms, and Japanese companies offshoring their production to Taiwan, China, and other lower-cost locations.

Table 6-5
HT product exports, by selected region/country/economy: 2012
(Billions of dollars)

Region/country/economy	All HT products	ICT	Aircraft and spacecraft	Pharmaceuticals	Testing, measuring, and control instruments
China	631.7	557.1	3.4	13.5	57.7
EU	377.9	105.3	51.4	141.9	79.3
United States	286.7	94.3	96.3	38.7	57.4
Japan	128.1	74.2	4.5	4.8	44.6
Other selected Asia	560.8	457.0	6.1	15.9	81.8

EU = European Union; HT = high technology; ICT = information and communications technologies.

NOTES: HT products include aircraft and space vehicles, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. ICT products include communications, semiconductors and computers, and office machinery. China includes Hong Kong. Exports of China exclude exports between China and Hong Kong. Exports of the United States exclude exports to Canada and Mexico. The EU excludes Cyprus, Luxembourg, Malta, and Slovenia. Exports of the EU exclude exports to EU member countries. Other selected Asia includes Malaysia, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: IHS Global Insight, World Trade Service database (2013). See appendix tables 6-21 and 6-25–6-30.

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Taiwan's HT exports doubled during this period, and it surpassed Japan in 2010 to become the largest developed Asian exporter of HT products. South Korea's HT exports also doubled, and it reached Japan's level in 2012. Both of these economies' rapid gains in HT exports were due to growth of ICT product exports, which make up most of their HT exports (appendix tables 6-25–6-28).

U.S. Trade in Advanced Technology Products

The Census Bureau has developed a classification system for internationally traded products based on the degree to which they embody new or leading-edge technologies. This classification system has significant advantages for determining whether products are HT and may be a more precise and comprehensive measure than the product classification based on the OECD classification for HT industry production. It categorizes ATP trade into 10 major technology

International Initiative to Measure Trade in Value-Added Terms

The Organisation for Economic Co-operation and Development (OECD)/World Trade Organization (WTO) Trade in Value Added (TiVA) initiative is developing estimates of trade measured in value-added terms to complement conventional measures of trade. In a world where goods and services are often produced through global supply chains, value-added measures of international trade have two substantial advantages over conventional trade measures. First, they record the amount of global trade more accurately; they record value only once, in the country in which it is added. In contrast, conventional trade measures overstate the value of internationally traded goods and services, recording the entire (gross) value of an item every time it crosses a national border. Second, value-added measures produce better estimates of national contributions to the value of goods and services in international trade. In contrast, conventional trade measures attribute the entire (gross) value of the goods and services a country trades to that country, even if a portion of the value was produced by other countries in the supply chain. The OECD's estimate of the U.S. trade balance in iPhones shows that the United States has a much smaller estimated trade deficit with China, the location of final assembly and export of iPhones, and larger trade deficits with countries that supply inputs to the iPhone (table 6-C).

OECD/WTO estimates of trade in value-added terms are derived from OECD country-level input-output tables. Input-output tables track the interrelationships among domestic industries and also between domestic industries and consumers—households, government, industry, and export customers. OECD/WTO built international input-output tables that link exports in one country to the purchasing industries or final-demand consumers in the importing country. The international input-output tables estimate trade among countries on an industry basis using coefficients derived from bilateral product and services trade data, which are not collected on an industry basis.

OECD/WTO estimates of trade in value-added terms assume that the share of imports in any product consumed directly as intermediate consumption or final demand (except imports) is the same for all users. This assumption is reasonable for developed countries, where there is little product differentiation between what is produced for export and what is produced for the domestic market. This assumption is probably less realistic for developing countries because the import content of exports is usually higher than the import content of products destined for domestic consumption.

The most recent version of the OECD/WTO database, released in May 2013, covers 58 economies (including all OECD countries, Brazil, China, India, Indonesia, Russia, and South Africa) and the years 1995, 2000, 2005, 2008, and 2009. Trade in value-added indicators and additional information are available at http://www.oecd.org/industry/ind/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm.

Table 6-C
U.S. trade balance in iPhones, by selected country/economy
(Millions of dollars)

Type of trade	China	Germany	South Korea	Taiwan	ROW
Balance (gross)	-1,646	0	0	0	0
Balance (value added)	-65	-161	-800	-207	-413

ROW = rest of world.

SOURCE: Organisation for Economic Co-operation and Development, Trade in Value-Added: Concepts, Methodologies and Challenges, http://www.oecd.org/sti/ind/49894138.pdf, accessed 15 March 2013.

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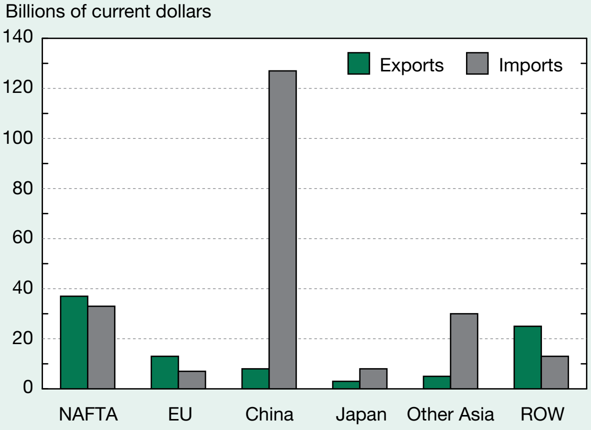
areas, including aerospace, biotechnology, electronics, ICT, life sciences, and optoelectronics.[19]

U.S. trade in ATP products is an important component of overall U.S. trade, accounting for about one-fifth of combined nonpetroleum exports and imports. Five technology areas—ICT, aerospace, electronics, life sciences, and optoelectronics—account for more than 90% of the total value of U.S. ATP exports and imports (table 6-6; appendix tables 6-33–6-38). ICT is the largest, with a share of 44%, followed by aerospace, with a 21% share. Life sciences and electronics each have a share of 11%. Optoelectronics has a share of 5%. The largest U.S. ATP trading partners are China; other Asian countries, including Japan, South Korea, and Malaysia; the EU; and NAFTA partners Canada and Mexico.

In 2012, the United States exported $305 billion in ATP goods and imported $396 billion, resulting in a deficit of $92 billion (figures 6-22 and 6-23; appendix table 6-33). Trends varied widely by technology area (table 6-6):

- Trade in ICT products produced a deficit of $128 billion, the largest of any technology area. The largest trading partner is China, which dominates this area.
- In the life sciences area, the United States ran a small deficit of $12 billion, largely with the EU.
- The United States has a surplus of $66 billion in aerospace, the largest of any technology area. The largest trading partner in this area is the EU.

Figure 6-22
U.S. advanced technology product trade in ICT, by selected region/country/economy: 2012



EU = European Union; ICT = information and communications technology; NAFTA = North America Free Trade Agreement; ROW = rest of world.

NOTES: China includes Hong Kong. Other Asia includes Malaysia, Singapore, South Korea, and Taiwan. NAFTA includes Canada and Mexico. Advanced technology product trade is classified by the Census Bureau and consists of advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, ICT, life sciences, optoelectronics, nuclear, and weapons.

SOURCE: U.S. Census Bureau, Foreign Trade Statistics, Advanced Technology Trade database, http://www.census.gov/foreign-trade/statistics/country/index.html, accessed 15 January 2013. See appendix table 6-34.

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Table 6-6
U.S. ATP trade in selected technology areas, by selected region/country/economy: 2012
(Billions of dollars)

Technology area	NAFTA	EU	China	Japan	Other Asia	ROW
Aerospace						
Exports	8.2	29.6	11.0	8.1	9.6	38.5
Imports	9.0	20.2	0.7	4.7	1.2	3.2
Balance	-0.9	9.3	10.3	3.4	8.4	35.2
Electronics						
Exports	8.5	2.4	6.6	1.3	13.2	9.2
Imports	2.6	2.5	3.1	2.6	12.3	10.8
Balance	5.9	-0.1	3.4	-1.3	0.9	-1.5
ICT						
Exports	36.6	13.5	8.0	3.5	5.1	24.7
Imports	33.3	7.0	127.4	8.4	30.5	12.9
Balance	3.3	6.5	-119.4	-4.9	-25.4	11.8
Life sciences						
Exports	3.7	11.8	3.3	3.7	2.0	7.1
Imports	4.4	27.2	2.1	1.8	2.0	7.0
Balance	-0.7	-15.4	1.2	2.0	0.0	0.1

ATP = advanced technology products; EU = European Union; ICT = information and communications technology; NAFTA = North American Free Trade Agreement; ROW = rest of world.

NOTES: China includes Hong Kong. EU includes current member countries. Other Asia includes Malaysia, South Korea, Singapore, and Taiwan. ATP trade is classified by the Census Bureau and consists of advanced materials, aircraft and space vehicles, biotechnology, electronics, flexible manufacturing, information and communications technology, life sciences, optoelectronics, nuclear, and weapons.

SOURCE: U.S. Census Bureau, Foreign Trade Statistics, Advanced Technology Trade database, http://www.census.gov/foreign-trade/statistics/country/index.html, accessed 15 January 2013. See appendix tables 6-34–6-37.

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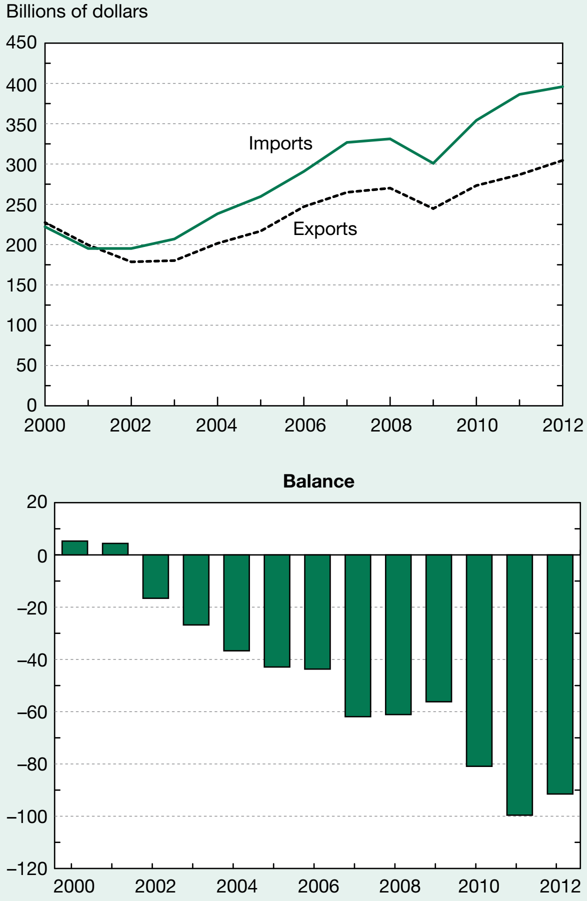
- The United States had a small surplus ($7 billion) in electronics. Leading trading partners are Malaysia and South Korea.

Trends in U.S. Advanced Technology Products Trade

Between 2003 and 2012, U.S. ATP imports grew faster than exports, resulting in the trade deficit widening from $27 billion to $92 billion (figure 6-23; appendix table 6-33). Among the four largest technology areas, exports of life sciences grew the fastest (143%), with imports increasing at the same rate, resulting in the trade deficit remaining roughly stable (appendix table 6-37).

Figure 6-23
U.S. trade in advanced technology products: 2000–12



NOTE: Advanced technology product trade is classified by the Census Bureau and consists of advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications technologies, life sciences, optoelectronics, nuclear, and weapons.

SOURCE: U.S. Census Bureau, Foreign Trade Statistics, Advanced Technology Trade database, http://www.census.gov/foreign-trade/statistics/country/index.html, accessed 15 January 2013. See appendix table 6-33.

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Aerospace exports grew the next fastest, and outpaced growth of imports, resulting in the trade surplus widening from $27 billion to $66 billion (appendix table 6-35). Trends in exports and imports in these two technology areas have largely been driven by trade with the EU, the largest partner in these two areas.

Exports of ICT products grew the slowest among these four technology areas, with much faster growth of imports (appendix table 6-34). The trade deficit in ICT products more than doubled to reach nearly $130 billion, with the trade deficit with China reaching nearly $100 billion. As in U.S. HT international trade, the rising deficit in U.S. ATP trade has largely occurred in ICT products and with China.

In electronics, the United States had a surplus of between $16 billion and $25 billion for much of the 2000s. Between 2011 and 2012, the trade surplus fell to $7 billion because of a decline in exports combined with an increase in imports (appendix table 6-36).

U.S. Multinational Companies in Knowledge- and Technology-Intensive Industries

The Bureau of Economic Analysis (BEA) conducts an annual survey of U.S. multinationals that includes firms in KTI industries. The BEA data are not directly comparable with the world industry data used in the previous sections. However, the BEA data provide additional information on the globalization of activity and employment in U.S. multinationals in these industries.

Commercial Knowledge-Intensive Service Industries

U.S. multinationals in commercial KI services industries generated $1.1 trillion in value added in 2010 (preliminary), of which $873 billion (76%) occurred in the United States (appendix table 6-39). Financial services ranks first by value added ($471 billion), followed by information services ($384 billion) and business services ($297 billion). Production in business services was the most globalized, as measured by the distribution between U.S. and foreign value added, with 31% of value added originating from foreign economies in 2010 (figure 6-24). Financial services were the next highest (28%), followed by information services (15%).

U.S. multinationals in commercial KI services industries employed 7.4 million workers worldwide, of whom 5.4 million (72%) were employed in the United States (appendix table 6-39). Employment was highest in financial services, at 2.5 million, followed by 1.6 million employed in information services and 1.2 million employed in business services. Employment was most globalized in business services (foreign share of 44%), followed by financial services (24%) and information services (19%) (figure 6-24).

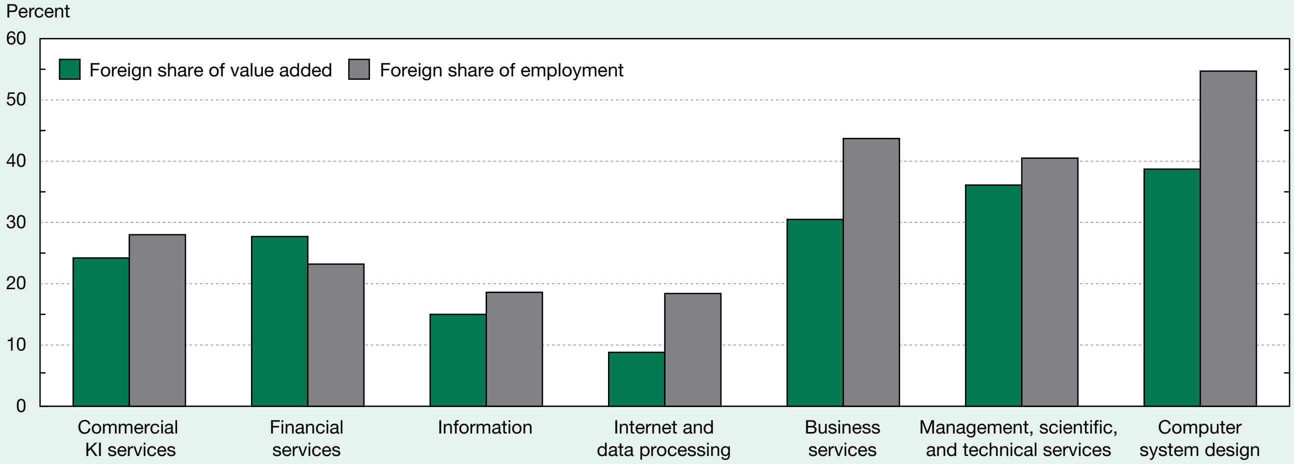
High-Technology Manufacturing Industries

U.S. multinationals in the HT manufacturing industries (excluding aircraft and spacecraft) generated more than $400 billion worldwide in value added in 2010 (preliminary), of which about two-thirds originated in the United States (figure 6-25; appendix table 6-39). Production in the computer industry was the most globalized, as measured by the distribution between U.S. and foreign value added, with 45% of value added originating from foreign locations in 2010 (figure 6-25). Pharmaceuticals was the second highest (40%), followed by semiconductors (35%) and then by testing, measuring, and control instruments (28%). Communications is the least-globalized industry, with 17% of value added produced outside of the United States.

U.S. multinationals in HT manufacturing employed 2.4 million workers worldwide, with 1.2 million workers (about

Figure 6-24

Globalization indicators of U.S. multinationals in commercial KI services: 2010



KI = knowledge intensive.

NOTES: Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs. Commercial KI services are classified by the Organisation for Economic Co-operation and Development and include business, financial, and communications. Internet and data processing are part of communications. Management, scientific, and technicals and computer system design are part of business services.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies (2009–10), http://www.bea.gov/international/di1usdop.htm, accessed 15 February 2013. See appendix table 6-39.

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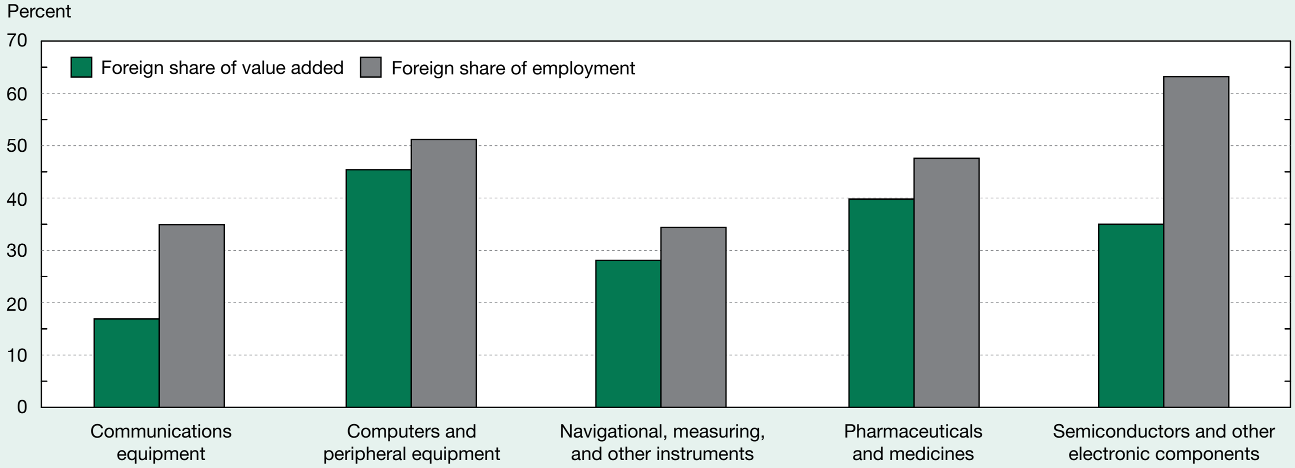
Figure 6-25

Globalization indicators of U.S. multinationals in selected manufacturing industries: 2010



NOTE: Value added is the amount contributed by a country, firm, or other entity to the value of a good or service and excludes purchases of domestic and imported materials and inputs.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies, 2009–10, http://www.bea.gov/international/di1usdop.htm, accessed 15 February 2013. See appendix table 6-39.

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50%) employed in the United States in 2010 (preliminary) (appendix table 6-39). More than 60% of the semiconductor workforce of 600,000 workers is employed abroad, the highest share among these industries (figure 6-25). Multinational companies in two industries—computers and pharmaceuticals—employ around 50% of their workforce abroad. The communications and testing, measuring, and control instruments industries have less than 40% of their workforces employed abroad.

U.S. and Foreign Direct Investment in Knowledge- and Technology-Intensive Industries

Foreign direct investment (FDI) has the potential to generate employment, raise productivity, transfer skills and technology, enhance exports, and contribute to long-term economic development (Kumar 2007). Receipt of FDI may indicate a developing country's emerging capability and integration with countries that have more established industries. FDI in specific industries may suggest the potential for these industries' evolution and the creation of new technologies.

This section uses data from BEA on U.S. direct investment abroad and foreign investment in the United States in KTI industries. The rising volume of trade by U.S.-based KTI firms has been accompanied by increases in U.S. direct investment abroad and FDI in the United States. Estimates of U.S. direct investment abroad and FDI in the United States are lower-bound estimates because a substantial share of outward and inward investment is allocated to holding companies that own companies in other industries.

U.S. Direct Investment Abroad

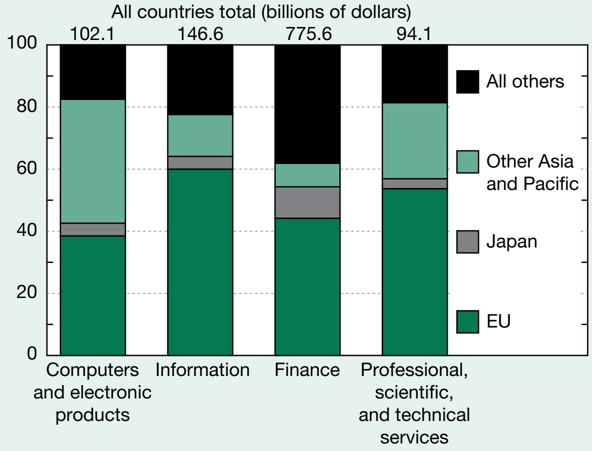
The stock of U.S. direct investment abroad in computer and electronic products, which includes the HT industries of communications, semiconductors, and testing, measuring, and control instruments, was $102 billion in 2012 (figure 6-26). The Asia and Pacific region receives 43% of U.S. direct investment abroad.[20] The EU is the next-largest recipient, with a share of 39%.

The stock of U.S. direct investment abroad in commercial KI services industries was $1.0 trillion in 2012 (figure 6-26). Financial services accounted for most U.S. direct investment abroad, with far smaller shares for information and professional, scientific, and technical services. The EU is the largest recipient in these three industries, with shares ranging from 44% to 54%. The Asia and Pacific region, including Japan, is the next largest, with shares of 18%–28% in these industries.

Foreign Direct Investment in the United States

The stock of inward FDI in U.S. computer electronics manufacturing industries was $61 billion in 2012, less than the amount the United States invested abroad in these industries (figure 6-27). Limited data on the geographical region show that the Asia and Pacific region is the largest investor,

Figure 6-26
U.S. outward foreign direct investment in selected industries: 2012
Share (percent)



EU = European Union.

NOTES: Finance excludes depository institutions. Other Asia and Pacific includes Australia, China, Hong Kong, India, Indonesia, Malaysia, New Zealand, Philippines, Singapore, South Korea, Taiwan, Thailand, and others.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies 2012, http://www.bea.gov/international/di1usdop.htm, accessed 10 August 2013.

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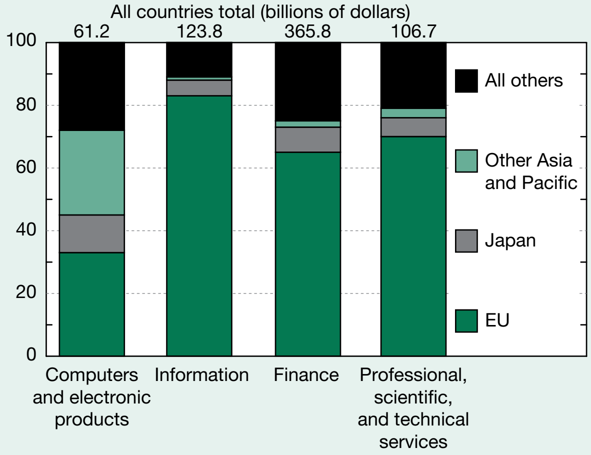
Figure 6-27
Foreign direct investment in selected U.S. industries, by selected region/country/economy: 2012
Share (percent)



EU = European Union.

NOTES: Investment in billions of dollars is shown above each industry. Finance excludes depository institutions. Other Asia and Pacific includes Australia, China, Hong Kong, India, Indonesia, Malaysia, New Zealand, Philippines, Singapore, South Korea, Taiwan, Thailand, and others.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, Foreign Direct Investment in the U.S.: Balance of Payments and Direct Investment Position Data, http://www.bea.gov/international/di1fdibal.htm, accessed 15 January 2013.

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with a share of 39%. The EU is the second largest, with a share of 33%.

Similarly, the stock of inward FDI in U.S. commercial KI services, at $596 billion in 2011, was less than the amount the United States invested abroad in these industries (figure 6-27). The EU is the largest investor in these industries, with shares of 65%–83% in these industries.

Innovation-Related Indicators of the United States and Other Major Economies

The fourth section of this chapter examines several innovation-related measures in industries, with a focus on KTI industries. OECD defines innovation as the "implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method" (OECD/Eurostat 2005:46–47). Innovation is widely recognized as instrumental to the realization of commercial value in the marketplace and as a driver of economic growth. New ICT technologies, for example, have stimulated the creation of new products, services, and industries that have transformed the world economy over the past several decades.

This section presents data on how innovation activity varies among U.S. industries, using information from NSF's BRDIS. The section also includes three indicators of activities that can facilitate innovation but do not themselves constitute innovation. Two of these, patents and trade in royalties and fees, are indicators of invention—they protect intellectual property in inventions that can have value for commercial innovations. The third indicator concerns early stage financing for U.S. HT small businesses, which can be an important milestone in the process of bringing new products and services to market.

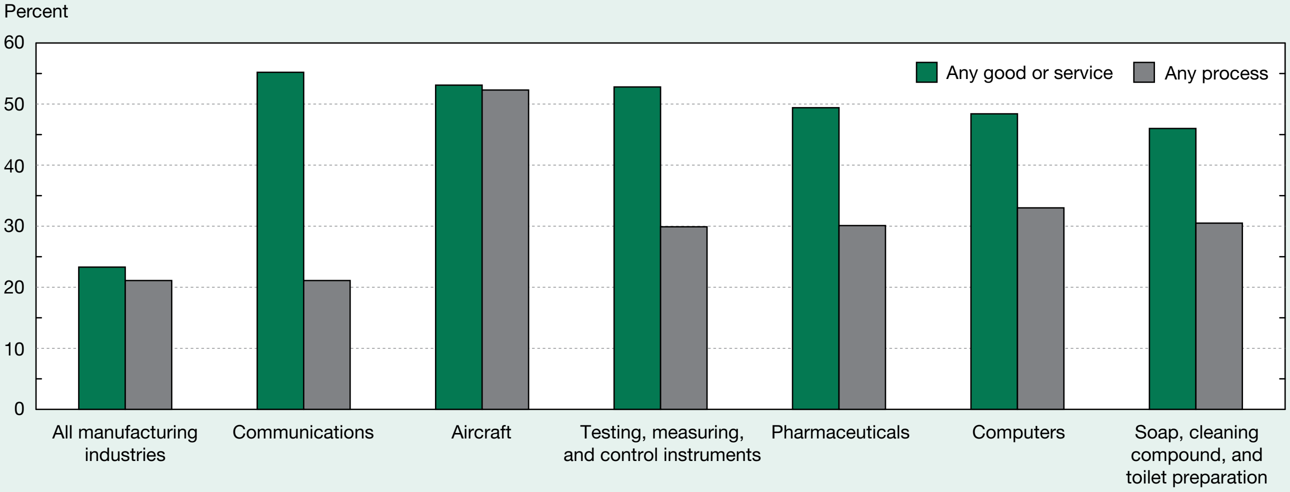
Innovation Activities by U.S. Businesses

BRDIS provides innovation indicators that are representative of all U.S.-located businesses with five or more employees. Survey results indicate which kinds of companies introduced new goods, services, or processes between 2008 and 2010.[21] Data from the 2010 survey suggest that U.S. KTI industries have a much higher incidence of innovation than other industries.

In the U.S. manufacturing sector, five of the six HT manufacturing industries—aircraft; communications; computers; pharmaceuticals; and testing, measuring, and control instruments—reported rates of product and process innovation that were at least double the manufacturing sector average (figure 6-28). Most of these industries reported significantly higher rates of innovation in both goods and services, suggesting that high rates of innovation by manufacturing companies go hand-in-hand with innovations in services.

Several of these industries—notably, aerospace; computers; pharmaceuticals; and testing, measuring, and control instruments—reported higher-than-average rates of process innovations, particularly in production methods, logistics, and delivery methods. Innovation is also higher in several commercial KI services industries in comparison to other nonmanufacturing industries (figure 6-29).[22] Software firms lead in incidence of innovation, with 69% of companies reporting the introduction of a new product or service, compared to the 9% average for all nonmanufacturing industries.

Figure 6-28
Share of U.S. manufacturing companies reporting innovation activities, by selected industry: 2008–10



NOTES: The survey asked companies to identify innovations introduced from 2008 to 2010. Figures are preliminary and may later be revised. Data may not be internationally comparable. The sum of yes plus no percentages may not add to 100% due to item response to some innovation question items.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (2010).

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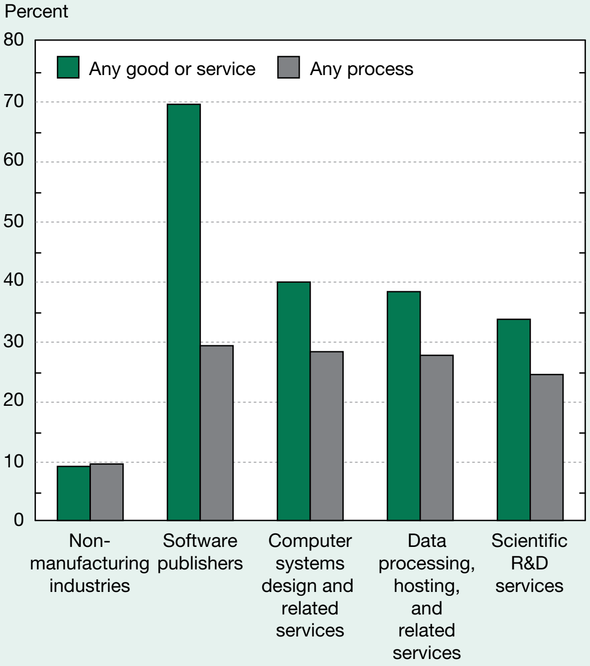
Innovation is also three to four times higher than the nonmanufacturing average in three other industries—computer systems design, data processing and hosting, and scientific R&D services.

Global Trends in Patenting

To foster innovation, nations assign property rights to inventors in the form of patents. These rights allow the inventor to exclude others from making, using, or selling the invention for a limited period in exchange for publicly disclosing details and licensing the use of the invention.[23] Inventors obtain patents from government-authorized agencies for inventions judged to be "new . . . useful . . . and . . . nonobvious."[24]

Patenting is an intermediate step toward innovation, and patent data provide indirect and partial indicators of innovation. Not all inventions are patented, and the propensity to patent differs by industry and technology area. Not all patents are of equal value, and not all foster innovation—patents may be obtained to block rivals, negotiate with competitors, or help in infringement lawsuits (Cohen, Nelson, and Walsh 2000). In HT industries, where innovation is cumulative, firms may build "thickets" of patents that impede or raise the cost of R&D and innovation (Noel and Schankerman 2009:2).

Figure 6-29
Share of U.S. nonmanufacturing companies reporting innovation activities, by selected industry: 2008–10



NOTES: The survey asked companies to identify innovations introduced in 2008–10. The sum of yes plus no percentages may not add to 100% due to item nonresponse to some innovation question items. Figures are preliminary and may later be revised. Data may not be internationally comparable.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (2010).

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Indeed, the vast majority of patents are never commercialized. However, the smaller number of patents that are commercialized result in new or improved products or processes or even entirely new industries. In addition, their licensing may provide an important source of revenue, and patents may provide important information for subsequent inventions and technological advances.

This discussion focuses largely on patent activity at the U.S. Patent and Trademark Office (USPTO). It is one of the largest patent offices in the world and has a significant share of applications and grants from foreign inventors because of the size and openness of the U.S. market.[25] Although U.S. patents are naturally skewed toward U.S. inventions, these market attributes make U.S. patent data useful for identifying trends in global inventiveness.

This section also deals with patents filed in all three of the world's largest patenting centers: the United States, the EU, and Japan. Because of the high costs associated with patent filing and maintenance in these three patent offices, inventions covered by these patents are likely to be valuable.

U.S. Patent and Trademark Office Grants

The USPTO granted inventors more than 250,000 patents in 2012 (appendix tables 6-40 and 6-41). U.S. inventors were granted 120,000 patents, making them the largest recipient, with a share of nearly one-half of patents granted worldwide. Japan, the next largest, was granted 51,000 patents. The EU, ranked third, received 36,000 patents. Other developed economies, largely South Korea and Taiwan, were together granted the same number as the EU. Developing countries received 9,000 patents (less than 4% of total patents). China and India received by far the largest number of patents granted to developing countries.

The number of USPTO patents remained essentially flat at 170,000 patents between 2003 and 2009 before rising rapidly to reach 250,000 in 2012 (appendix table 6-40). The rapid growth in 2010–12 may reflect recovery from the recession, along with USPTO efforts to decrease its backlog of patent applications. The United States enacted a new patent law in 2011 that was aimed in part at reducing the backlog of USPTO patent applications.

Between 2003 and 2012, the number of USPTO patents granted to U.S.-based inventors grew from 87,000 to 120,000 patents, trailing the pace of growth of all patents (appendix table 6-40). As a result of U.S. growth lagging behind overall growth, the U.S. share fell 5 percentage points to reach 48% (figure 6-30). The decline in the U.S. share likely indicates increased technological capabilities abroad, globalization that makes patent protection in foreign countries more important, and patenting by U.S.-based inventors located abroad, such as patents granted to inventors located in subsidiaries of U.S. MNCs.

Patents granted to Japan and the EU grew slightly slower than the growth of overall patents, resulting in their shares slightly declining to 20% and 14%, respectively (figure 6-30; appendix table 6-40). Slow growth of USPTO patenting by Japan and the EU may indicate sluggish economic activity or an increased preference to patent in their home patent offices.

Patents granted to other developed economies rose three times faster than growth of all patents to reach 37,000 patents (appendix table 6-40). South Korea and Taiwan led growth of these developed economies, with their patent grants rising to 13,000 and 11,000, respectively.

Patents granted to developing countries rose exponentially (but from a very low base) to reach 9,000 patents (table 6-7; figure 6-30; appendix table 6-40). China and India led growth of developing countries, with their patents reaching 5,000 and 2,000 patents, respectively.

U.S. Patent and Trademark Office Patenting Activity by U.S. Companies

Patenting by U.S. industry provides an indication of inventive activity, mediated by the relative importance in different industries of patenting as a business strategy.

According to the NSF BRDIS survey, U.S. KTI industries account for a large share of USPTO patent grants (figure 6-31; appendix table 6-42). The BRDIS data on USPTO patents are not comparable with the USPTO patent data presented in the previous and following section.[26] U.S. HT industries were granted 29,000 of the 58,000 patents granted to all U.S. manufacturing industries in 2011. The HT industry share of patents granted to all manufacturing industries (50%) is far higher than its share of value added of all manufacturing industries (19%). The U.S. semiconductor industry was issued the largest number of patents (10,000) among these HT industries, followed by 2,000 to 5,000 each for aerospace, computers, communications equipment, pharmaceuticals, and testing, measuring, and control instruments.

U.S. commercial KI services received 46% of the 43,000 patents issued to nonmanufacturing industries in 2011 (figure 6-31; appendix table 6-42). These industries' share of patents is much higher than their value-added share of all

Table 6-7
USPTO patents granted for selected countries: 2003, 2008, and 2012

Country	2003	2008	2012
Brazil	132	101	201
China	613	1,607	5,351
India	354	651	1,756
Malaysia	48	159	213
South Africa	111	90	140

USPTO = U.S. Patent and Trademark Office.

NOTE: Patent grants are fractionally allocated between the United States and all other countries on the basis of the proportion of the residences of all named inventors.

SOURCE: The Patent Board,™ special tabulations (2013) of the Proprietary Patent database. See appendix table 6-40.

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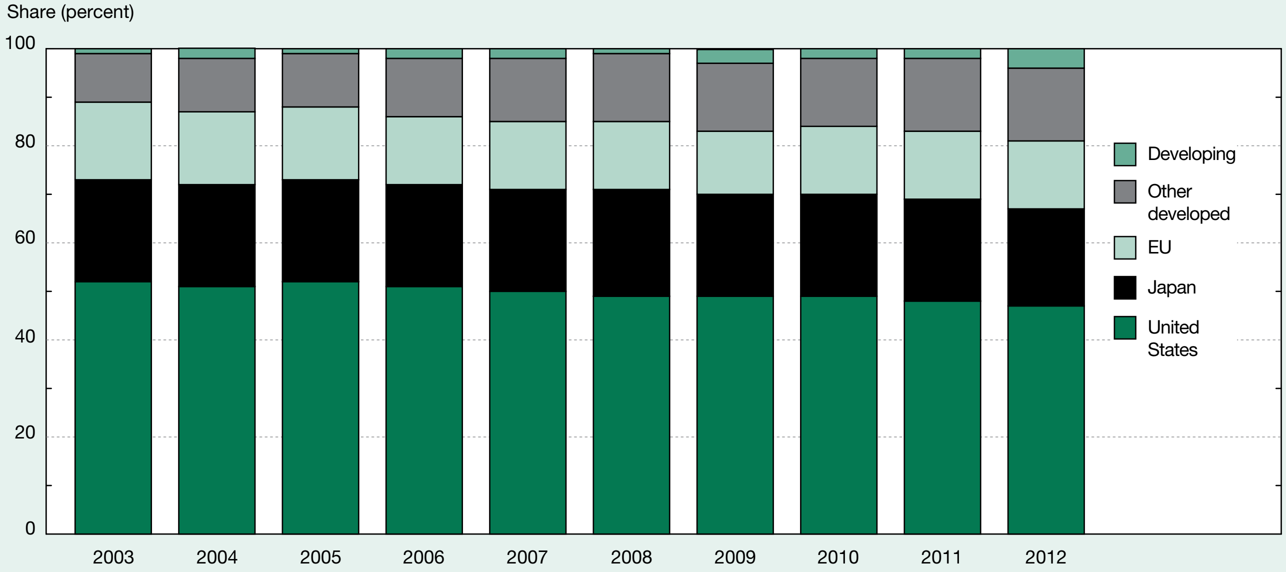
Figure 6-30
USPTO patents granted, by location of inventor: 2003–12



EU = European Union; USPTO = U.S. Patent and Trademark Office.

NOTES: Technologies are classified by The Patent Board.™ Patent grants are fractionally allocated among countries on the basis of the proportion of the residences of all named inventors.

SOURCE: The Patent Board,™ special tabulations (2013) from Proprietary Patent database. See appendix table 6-40.

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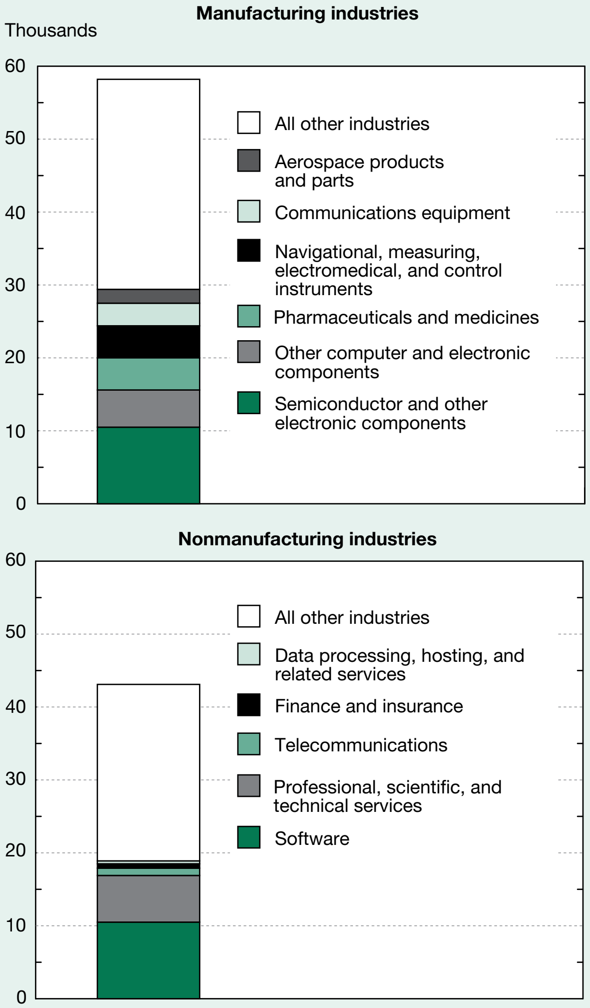
nonmanufacturing industries (32%), similar to the position of HT manufacturing industries. The software industry accounted for 10,000 patents, more than half of the patents issued to commercial KI services; professional and technical services were ranked second, with 6,000 patents. Two industries in professional and technical services—scientific R&D services and computer systems design—reported significant patenting activity.

Figure 6-31
USPTO patents granted, by selected U.S. industry: 2011



USPTO = U.S. Patent and Trademark Office.

NOTES: Detail may not add to total because of rounding. Industry classification is based on dominant business code for domestic R&D performance where available. For companies that did not report business codes, classification used for sampling was assigned. Statistics are based on companies in the United States that reported to the survey, regardless of whether they did or did not perform or fund R&D. These statistics do not include an adjustment to the weight to account for unit nonresponse. For a small number of companies that were issued more than 100 patents by USPTO, counts from USPTO.gov were used to supplement survey data.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey, 2011. See appendix table 6-42.

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U.S. Patent and Trademark Office Patents Granted, by Technology Area

This section discusses trends in four broad, NSF-classified technology areas that are closely linked to science or KTI industries—ICT; biotechnology and pharmaceuticals; medical electronics and medical equipment; and automation, control, and measuring technologies. This NSF classification assigns patents to technology areas on the basis of information contained in the patents; it is not comparable to patent data from BRDIS presented in the previous section, which classify patents based on the industry of the company to which the patent was issued.

Patents granted in the four broad, NSF-classified technology areas make up more than half of all U.S. patents:

- The largest area is ICT, which consists of networking, information processing, telecommunications, semiconductors, and computer systems (table 6-8; appendix tables 6-43–6-47). It accounts for nearly 40% of all USPTO patents.
- Health-related technologies consist of two broad areas, biotechnology and pharmaceuticals and medical electronics and medical equipment. These two technology areas each have shares of 6% (appendix tables 6-48–6-51).
- A fourth broad area includes automation and control and measuring and instrumentation technologies, with a share of 6% (appendix tables 6-52 and 6-53).
- Between 2003 and 2012, USPTO patents granted in ICT technologies more than doubled, compared to a 50% increase in patents in all technologies (appendix tables 6-43–6-47). Trends varied widely among the five ICT technology areas:
  - Patents granted in information processing and networking at least tripled to reach 14,000 and 24,000, respectively.
  - Patents in telecommunication nearly doubled to reach 17,000.
  - Patents in computer systems lagged overall growth (55%) to reach 15,000.
  - Patents in semiconductors grew the slowest (18%) to reach 16,000.
- Biotechnology and pharmaceuticals trailed growth of patents in all technologies (36% versus 50%) (appendix tables 6-48 and 6-49). Growth was particularly weak in pharmaceuticals, which grew 16%. This weak growth coincides with consolidation of the pharmaceutical industry in the last several years, stronger price and safety regulation of drugs in many developed countries, increased competition from generics, and little growth in U.S. Food and Drug Administration approval of new drugs.

Positions of Major Patenting Regions and Countries in Selected Technology Areas

This section presents shares of the United States, the EU, and several Asian countries in these four broad technology areas averaged over 2010–12. A technology area share greater (less) than the share of all patents signifies that patents by a region, country, or economy are concentrated (weaker) in a particular technology.

ICT. U.S. patenting activity is concentrated in the broad ICT technology area, with a share 4 percentage points higher than its share of all patents (figure 6-32). However, the U.S. position varies widely among the individual technology areas:

- The United States is highly concentrated in two areas—information processing and networking—with shares more than 10 percentage points higher (appendix tables 6-43 and 6-44).
- The United States has average activity in two areas—computer systems and telecommunications (appendix tables 6-45 and 6-47). The United States is weak in semiconductors, with its share more than 10 percentage points below its share of all patents (appendix table 6-46).

EU patenting activity in ICT is comparatively low (figure 6-32). Several studies suggest that the EU has lagged behind the United States in ICT technology, but the pattern may also reflect a preference of EU inventors to patent in the European Patent Office.

In Asia, Japan and Taiwan have similar ICT patterns, with an overall weakness in ICT (figures 6-32 and 6-33). They have weaker activity in three technologies—networking, information processing, and telecommunications (appendix

Table 6-8

USPTO patents granted in selected technology areas: 2003, 2008, and 2012

Technology area	2003	2008	2012
Automation, control, and measurement	11,062	12,583	15,773
Biotechnology and pharmaceuticals	10,969	9,499	14,969
ICT	40,441	51,842	90,140
Computer systems	9,789	11,148	15,260
Information processing	7,533	13,268	27,880
Networking	2,626	5,806	10,986
Semiconductors	13,108	11,080	15,272
Telecommunications	7,385	10,540	20,743
Medical electronics and equipment	9,987	6,262	14,555

ICT = information and communications technology; USPTO = U.S. Patent and Trademark Office.

NOTE: Technologies are classified by The Patent Board.™

SOURCE: The Patent Board,™ special tabulations (2013) of the Proprietary Patent database. See appendix tables 6-43–6-53.

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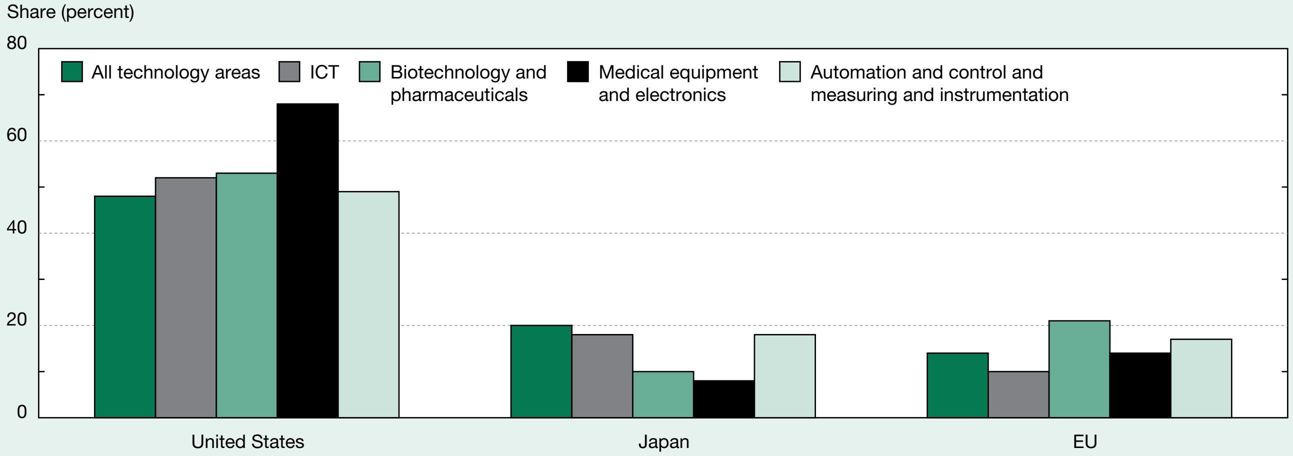
Figure 6-32

USPTO patents granted, by selected technology areas for selected country/economy of inventor: 2010–12



EU = European Union; ICT = information and communications technologies; USPTO = U.S. Patent and Trademark Office.

NOTES: Technologies are classified by The Patent Board.™ Patents are fractionally allocated among countries on the basis of the proportion of the residences of all named inventors.

SOURCE: The Patent Board,™ special tabulations (2013) from Proprietary Patent database. See appendix tables 6-40 and 6-43–6-53.

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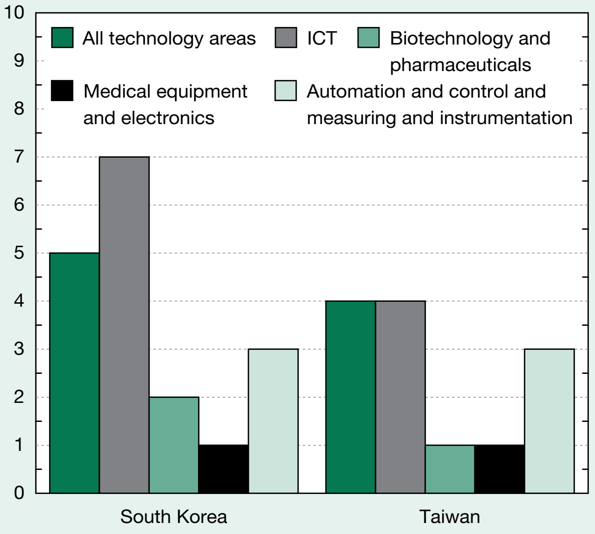
tables 6-43–45). They have concentrated patenting activity in computer systems and semiconductors (appendix tables 6-46 and 6-47).

Biotechnology and Pharmaceuticals. The United States is concentrated in this area, with a high concentration in biotechnology and a somewhat high concentration in pharmaceuticals (figure 6-32; appendix tables 6-48 and 6-49). The EU is highly concentrated in this area, with very strong activity in pharmaceuticals and above-average activity in biotechnology. South Korea and Taiwan are weak in this area (figure 6-33).

Medical Electronics and Equipment. The United States has a very high concentration in medical electronics and equipment with a share that is 20 percentage points higher than its share of all patents (figure 6-32; appendix tables 6-50 and 6-51). The United States is equally strong in the two individual technology areas. The EU's patenting activity is average in this area, and South Korea and Taiwan have much weaker activity (figure 6-33).

Automation and Control; Measuring and Instrumentation. The United States has a somewhat higher concentration in automation and control and average activity in measuring and instrumentation (figure 6-32; appendix tables 6-52 and 6-53). The EU has higher-than-average concentration in these two technology areas. South Korea and Taiwan have weaker activity in these two technology areas (figure 6-33).

Figure 6-33
USPTO patents granted, by selected technology areas for inventors located in South Korea and Taiwan: 2010–12



ICT = information and communications technologies; USPTO = U.S. Patent and Trademark Office.

NOTES: Technologies are classified by The Patent Board.™ Patents are fractionally allocated among countries/economies on the basis of the proportion of the residences of all named inventors.

SOURCE: The Patent Board,™ special tabulations (2013) from Proprietary Patent database. See appendix tables 6-40 and 6-43–53.

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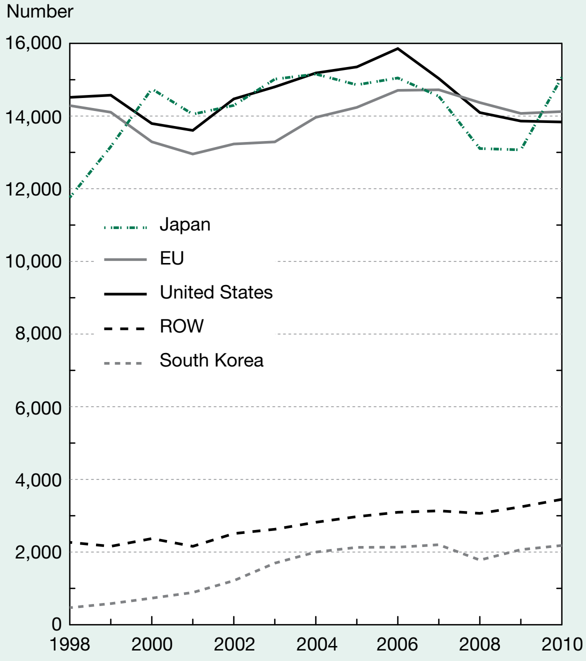
Patenting Valuable Inventions: Triadic Patents

Using patent counts as an indicator of national inventive activity does not differentiate between inventions of minor and substantial economic potential. Inventions for which patent protection is sought in three of the world's largest markets—the United States, the EU, and Japan—are likely to be viewed by their owners as justifying the high costs of filing and maintaining these patents in three markets. These *triadic patents* serve here as an indicator of higher-value inventions, although growing patent activity in China, India, South Korea, and other locations may limit the utility of this measure. The number of triadic patents is strongly correlated with expenditures on industry R&D, suggesting that countries with higher patenting activity make greater investments to foster innovation (OECD 2009:36).

Between 2000 and 2010, the number of triadic patents grew slightly from 45,000 to 49,000 (figure 6-34; appendix

Figure 6-34
Global triadic patent families, by selected region/country/economy: 1998–2010



EU = European Union; ROW = rest of world.

NOTES: Triadic patent families include patents applied in the U.S. Patent and Trademark Office, European Patent Office, and Japan Patent Office. Patent families are fractionally allocated among regions/countries/economies based on the proportion of the residences of all named inventors.

SOURCE: Organisation for Economic Co-operation and Development, Patents Statistics, http://stats.oecd.org/WBOS/index.aspx, Patents by Region database, accessed 15 January 2011. See appendix table 6-54.

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table 6-54). During this period, the United States, the EU, and Japan had roughly equal numbers of triadic patents.[27] South Korea's filings rose much faster than overall growth, resulting in its share of triadic patents doubling from 2% to 4%. Filings by all other countries remained at less than 1% of all triadic patents during this period.

Trade in Royalties and Fees

Firms trade intellectual property when they license or franchise proprietary technologies, trademarks, and entertainment products to entities in other countries. Trade in intellectual property can involve patented and unpatented techniques, processes, formulas, and other intangible assets and proprietary rights; broadcast rights and other intangible rights; and the rights to distribute, use, and reproduce general-use computer software. These transactions generate revenues in the form of royalties and licensing fees. Trade in royalties and fees is a rough indicator of technology transfer across the global economy and the international value of an economy's intellectual property. However, differences in tax policies and protection of intellectual property also likely influence the volume and geographic patterns of global trade in royalties and fees (Gravelle 2010:8; Mutti and Grubert 2007:112).

Global exports of royalties and fees were estimated at $241 billion in 2011 (figure 6-35). The United States, the EU, and Japan are collectively the largest global exporters, with a global share of 85%.

The United States is by far the world's largest exporter of royalties and fees, with exports of $121 billion and a large and growing surplus (figure 6-35). The volume and geographic patterns of U.S. trade in royalties and fees have been influenced by U.S.-based multinationals transferring their intellectual property to low-tax jurisdictions or their foreign subsidiaries to reduce their U.S. and foreign taxes (Gravelle 2010:8; Mutti and Grubert 2007:112). The EU is the second largest, with exports of $54 billion. The EU has a small deficit in trade of royalties and fees. Japan is the third largest, with exports of $29 billion, and has a substantial trade surplus.

Exports of major developing countries are much lower than those of developed countries (figure 6-36). Developing countries are typically net importers of royalties and fees as they seek to acquire technology from abroad to foster development of their economies. China is the largest developing country exporter of royalties and fees, with $743 million (figure 6-36). Brazil is the second largest, with $590 million, followed by India ($300 million). These three countries have had growing deficits in their trade of royalties and fees.

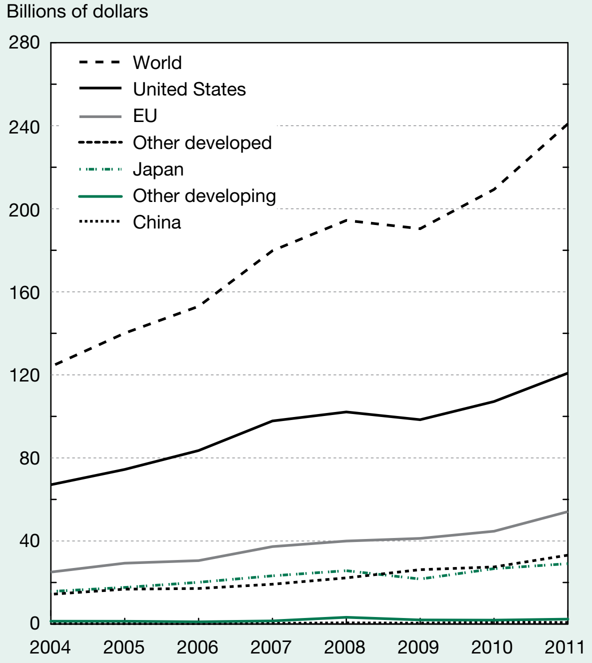
U.S. High-Technology Small Businesses

Many of the new technologies and industries seen as critical to U.S. innovation and economic growth are identified with small businesses. Many large HT businesses invest in and acquire small businesses as part of their efforts to develop and commercialize new technologies. Biotechnology, the Internet, and computer software are examples of industries built around new technologies in whose initial commercialization microbusinesses—those with fewer than five employees—played an important role. Trends in the number of microbusinesses in emerging or established HT sectors may point to innovative industries with future areas of growth. This section covers patterns and trends that characterize microbusinesses operating in HT industries as classified by the Bureau of Labor Statistics (BLS), which is different than OECD's HT classification. Two sources of financing for HT small businesses—venture capital and the U.S. government's SBIR—are also examined using data from Dow Jones and other sources.

Characteristics of Microbusinesses in U.S. High-Technology Industries

The number of microbusinesses in industries classified as HT by BLS is about 320,000, two-thirds of all firms operating in these industries (table 6-9; figure 6-37; appendix table 6-55).[28] Services account for 95% (300,000) of U.S. HT

Figure 6-35
Global exports of royalties and fees, by selected region/country/economy: 2004–11



EU = European Union.

NOTES: EU exports do not include intra-EU exports. Developed countries are classified as high-income economies by the World Bank. Developing countries are classified as upper- and lower-middle income and low income by the World Bank. Sum of regions/countries/economies does not add up to total due to rounding and discrepancies.

SOURCE: World Trade Organization, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 8 August 2013.

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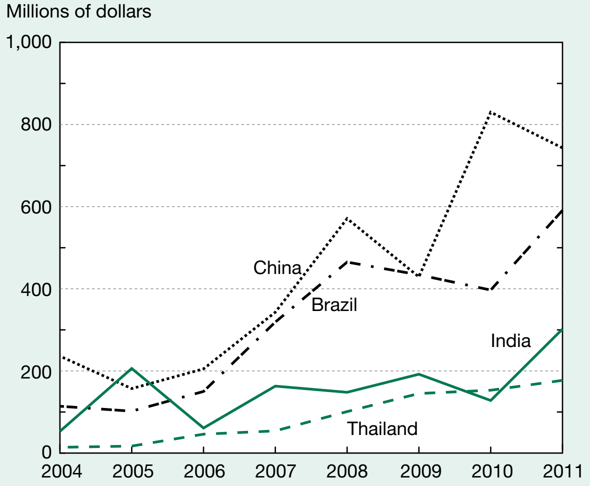
microbusinesses; manufacturing accounts for 4% (12,000), with the remainder in other industries (e.g., agriculture, mining, and construction). Similarly, services dominate employment in HT microbusinesses, with a very small share employed in manufacturing.

Figure 6-36
Exports of royalties and fees of selected developing countries: 2004–11



NOTE: Developing countries are classified as upper- and lower-middle income and low income by the World Bank.

SOURCE: World Trade Organization, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 8 August 2013.

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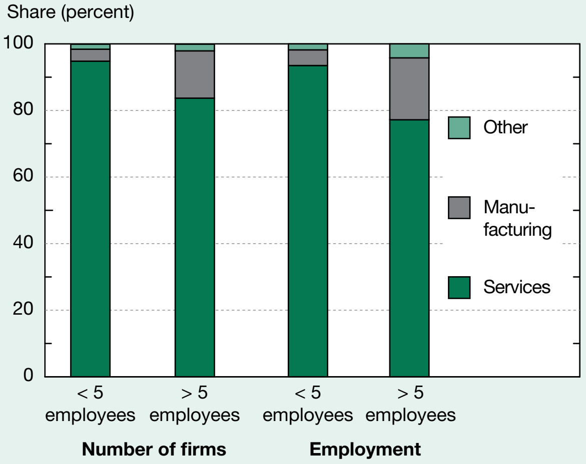
Figure 6-37
U.S. HT industries, by share of industry sector: 2010



HT = high technology.

NOTES: Firms with fewer than five employees include those reporting no employees on their payroll. A firm is an entity that is either a single location with no subsidiary or branches or the topmost parent of a group of subsidiaries or branches. HT industries are defined by the Bureau of Labor Statistics (BLS) by the basis of employment intensity of the technology-oriented occupations, based on the BLS Occupational Employment Survey of 2011. HT small business employment is a lower-bound estimate because employment data are not available for a few industries due to data suppression.

SOURCES: U.S. Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/econ/susb/, accessed 15 May 2013; Hecker DE. 2006. High-technology employment: A NAICS-based update, *Monthly Labor Review* 128(7):57–72, http://www.bls.gov/opub/mlr/2005/07/art6full.pdf, accessed 15 May 2013. See appendix table 6-55.

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Table 6-9
Number of firms and employment of U.S. HT microbusinesses, by selected industries: 2010

Industry	Number of firms	Employment
All industries	316,636	437,604
All manufacturing industries	11,512	20,683
Navigational, measuring, electromedical, and control instruments	1,645	3,025
Other general-purpose machinery	1,589	3,036
Industrial machinery	1,128	2,129
Semiconductors and other electronic components	1,121	1,954
All others	6,029	10,539
All services industries	300,259	408,968
Management, scientific, and technical consulting	117,678	140,953
Computer systems design and related	80,767	107,719
Architectural, engineering, and related	61,046	95,055
All others	40,768	65,241
All other industries	4,865	7,953

HT = high technology.

NOTES: Firms with less than 5 employees include those reporting no employees on their payroll. A firm is an entity that is either a single location with no subsidiary or branches or the topmost parent of a group of subsidiaries or branches. HT industries are defined by the Bureau of Labor Statistics (BLS) by the basis of employment intensity of the technology-oriented occupations based on BLS's 2011 Occupation Employment Survey. HT small business employment is a lower-bound estimate because employment data are not available for a few industries due to data suppression.

SOURCES: U.S. Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/econ/susb/, accessed 15 May 2013; Hecker DE. 2006. High-technology employment: A NAICS-based update, *Monthly Labor Review* 128(7):57–72, http://www.bls.gov/opub/mlr/2005/07/art6full.pdf, accessed 15 March 2013. See appendix table 6-55.

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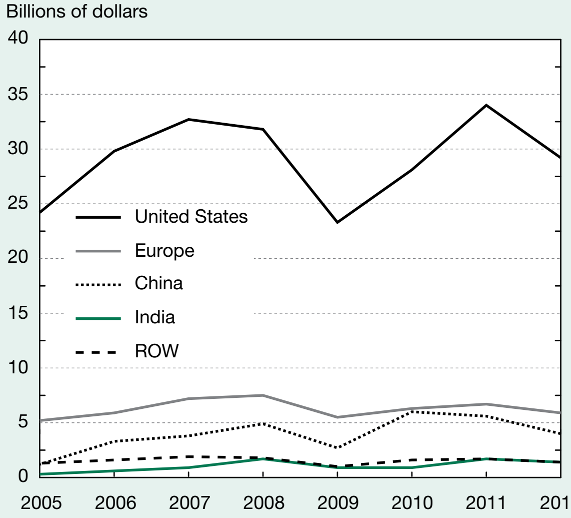
Three HT services—management, scientific, and technical consulting; computer systems design; and architectural and engineering—dominate HT services with a collective share of more than 80% of all firms and employment (table 6-9). In HT manufacturing, four industries—navigational, measuring, electromedical, and control instruments; other general purpose machinery; industrial machinery; and semiconductors—are large employers with a collective share of nearly 50%.

Entrepreneurial Investment in HT Small Businesses

Entrepreneurs seeking to start or expand a small firm with new or unproven technology may not have access to public or credit-oriented institutional funding. (In this section, business denotes anything from an entrepreneur with an idea to a legally established operating company.) Often, entrepreneurs rely on friends and family for financing. However, when they need or can get access to larger amounts of financing, venture capital investment and SBIR financing are often critical to financing nascent and entrepreneurial HT businesses. This section examines patterns and trends of these two types of financing in the United States and internationally (venture capital only).

Venture capital investment. The United States accounted for $29 billion in venture capital, nearly 70% of global venture capital in 2012 (figure 6-38; appendix table 6-56). Europe and China are the next largest, accounting for $6 billion and $4 billion, respectively. Venture capital financing in India was $1 billion. Much of the financing occurring outside of the United States probably originates from U.S.-based venture capital firms.

Figure 6-38
Venture capital investment, by selected region/country/economy: 2005–12



ROW = rest of world.

NOTE: ROW consists of Canada and Israel.

SOURCE: Dow Jones, special tabulations (2013) from VentureSource database, http://www.dowjones.com/info/venture-capital-data.asp.

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Between 2005 and 2012, global venture capital financing rose by 30% to reach $42 billion (figure 6-38). After falling sharply during the recession, venture capital bounced back to its pre-recession level in 2011 before falling $8 billion in 2012. Venture capital invested in the United States grew more slowly than outside the United States, with the result that the U.S. share of global venture capital fell from 75% to 70% (figure 6-38). The expansion of venture capital outside of the United States coincides with the globalization of finance, greater commercial opportunities in rapidly growing developing countries, and the decline of yields on existing venture capital investments in U.S. companies. In China, venture capital grew from $1 billion in 2005 to $4 billion in 2012, resulting in its global share more than doubling to reach 10% (figure 6-38). Venture capital investment in India grew from $300 million to $1.4 billion, with India's global share rising from 1% to 3%.

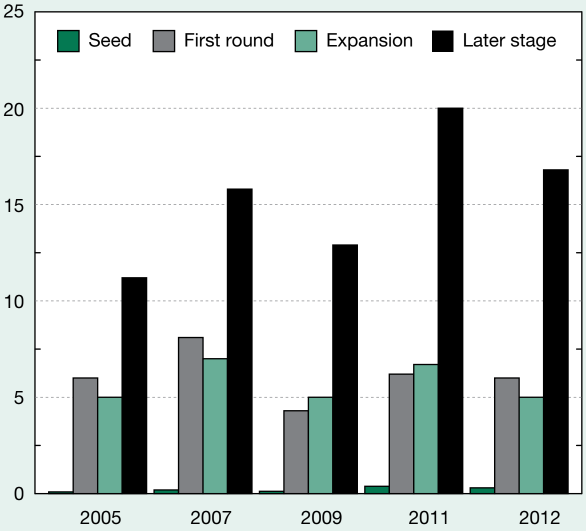
Venture capital investment is generally categorized into four broad stages of financing:

- **Seed** supports proof-of-concept development and initial product development and marketing.
- **First round** supports product development and marketing and the initiation of commercial manufacturing and sales.
- **Expansion** provides working capital for company expansion; funds for major growth (including plant expansion, marketing, or development of an improved product); and financing to prepare for an initial public offering (IPO).
- **Later stage** includes acquisition financing and management and leveraged buyouts. Acquisition financing provides resources for the purchase of another company, and management and leveraged buyouts provide funds to enable operating management to acquire a product line or business from either a public or a private company.

In 2012, later stage venture capital investment comprised 60% ($17 billion) of total U.S. venture capital investment, up from 50% in 2005 (figure 6-39; appendix table 6-56). Knowledgeable observers have attributed the shift to later-stage investment because of a desire for lower investment risk, a decline in yields on existing investments of venture capitalists, and a sharp decline in IPOs and acquisitions of venture capital–backed firms, which has required venture capital investors to provide additional rounds of financing.[29]

In contrast to the predominance of later-stage investment, investment in the seed stage, the earliest stage, amounted to 1% ($300 million) of total U.S. venture capital investment (figure 6-39; appendix table 6-56). Despite the amount tripling in value between 2005 and 2012, seed's share of venture capital investment remained at 1% or less. Investment in the first-round stage, which follows seed, represented 21% ($6.0 billion) of venture capital investment in 2012. Investment in this stage remained constant, resulting in its share falling 6 percentage points to 21% in 2012. Financing

Figure 6-39
U.S. venture capital investment, by financing stage: Selected years, 2005–12
Billions of dollars



NOTES: Seed consists of proof-of-concept development and initial product development and marketing. First round consists of product development and marketing and the initiation of commercial manufacturing and sales. Expansion consists of second-round financing that provides working capital for company expansion and financing to prepare for an initial public offering. Later stage includes acquisition financing and management and leverage buyouts.

SOURCE: Dow Jones, special tabulations (2013) from VentureSource database, http://www.dowjones.com/info/venture-capital-data.asp. See appendix table 6-56.

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of the expansion stage, which follows first round, represented 18% ($5.0 billion) of venture capital investment in 2012. Investment in this stage stayed constant between 2002 and 2012, resulting in its share falling from 22% to 18%.

Five technologies—biopharmaceuticals, business support services, consumer information services, medical devices and equipment, and software—dominate U.S. venture capital financing (table 6-10). During 2009–12, these five technologies accounted for more than 60% of total and seed stage investment.

Software led these technologies in venture capital investment, receiving $19.2 billion in 2009–12 (table 6-10; appendix table 6-56). Total and early stage investment in software rose between 2005 and 2012, resulting in software's share of total investment remaining steady (23%) and its share of early stage investment increasing from 16% to 34%. Biopharmaceuticals was second, receiving $14.7 billion. Total investment in biopharmaceuticals fell from $4.0 billion in 2005 to $3.4 billion in 2012, resulting in its share falling from 17% to 12%. Seed stage financing dropped from $7 million to $6 million during this period. Consumer information services received $13.5 billion in 2009–12. Total venture capital investment in this technology area rose from less than $700 million in 2005 to $2.8 billion in 2012. Growth in early stage financing was also rapid, rising from less than $10 million to $79 million, resulting in its share more than doubling from 11% to 26%.

Small Business Innovation Research Financing. The U.S. federal government's SBIR program provides early stage public financing to help U.S. small or start-up

Table 6-10
U.S. venture capital investment, by selected financing stage and technology/industry: 2009–12
(Millions of U.S. dollars)

Technology/industry	2009	2010	2011	2012	2009–12 total
All financing stages					
All technologies/industries	23,291	28,131	34,006	29,208	114,636
Software	3,350	4,183	4,973	6,663	19,169
Biopharmaceuticals	3,820	3,466	4,043	3,380	14,709
Consumer information services	2,264	4,107	4,328	2,823	13,522
Business support services	2,248	2,748	4,261	3,698	12,955
Medical devices and equipment	3,060	2,551	3,403	2,765	11,779
Seed stage					
All technologies/industries	120	230	376	302	1,028
Software	22	44	128	102	296
Consumer information services	36	60	95	79	270
Business support services	18	39	46	23	126
Media and content	6	3	10	21	40
Medical software and information services	3	6	4	13	26

NOTES: Technologies are classified by Dow Jones. Seed stage consists of proof of concept and initial product development.

SOURCE: Dow Jones, special tabulations (2013) of VentureSource database, http://www.dowjones.com/info/venture-capital-data.asp. See appendix table 6-56.

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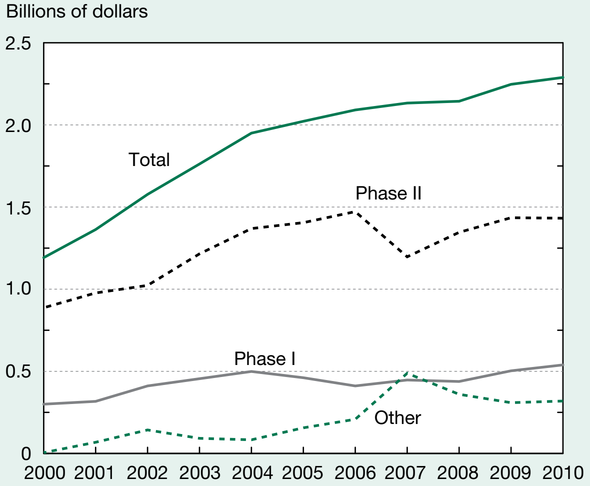
companies to commercialize technology derived from federal R&D. (For more information on SBIR, see chapter 4, "Small Business Innovation-Related Programs.") The SBIR program provides financing in two phases:

- Phase I funds the evaluation of the scientific and technical merit and feasibility of a company's new ideas.
- Phase II funds further scientific and technical review and requires a commercialization plan.

SBIR provided $2.3 million in financing for nearly 6,000 awards in 2010 (figure 6-40).[30] The majority of SBIR financing occurs in Phase II, which provided $1.4 million to fund more than 4,000 awards in 2010. The next largest financing stage, Phase I, provided $0.5 million for nearly 2,000 awards in 2010. The remainder ($0.3 million) provided funding for technical assistance, commercial outreach, and other activities. After nearly doubling from $1.1 million in 2000 to $2.0 million in 2004, SBIR financing grew far more slowly in the latter half of the decade to reach $2.2 million in 2010. Between 2000 and 2010, Phase II financing lagged the overall growth of SBIR financing, resulting in the share of Phase II declining from 77% to 64%. In contrast, Phase I's share of SBIR financing remained roughly steady at 20%–24% during this period.

Figure 6-40
SBIR investment, by financing phase: 2000–10



SBIR = Small Business Innovation Program.

NOTES: SBIR investment is by fiscal year. Investment is the amount budgeted by U.S. federal agencies for SBIR financing. Phase I evaluates the scientific and technical merit and feasibility of ideas. Phase II is subject to further scientific and technical review and requires a commercialization plan. Other includes technical assistance and commercial outreach.

SOURCE: SBIR Report Data, http://www.sbir.gov/awards/annual-reports, accessed 15 June 2013.

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Investment and Innovation in Clean Energy Technologies

The fifth section of this chapter examines clean energy and energy-conservation and related technologies. Clean energy, like KTI industries, has a strong link to S&T. Clean energy and energy-conservation and related technologies—including biofuels, solar, wind, nuclear, energy efficiency, pollution prevention, smart grid, and carbon sequestration—have become a policy focus in developed and developing nations. These technologies are KTI and thus are closely linked to scientific R&D. Production, investment, and innovation in these energies and technologies are rapidly growing in many countries. Prompted by concerns over the high cost of fossil fuels and their impact on the climate, governments have developed various inducements, such as subsidies and tax incentives, and increased funding for clean energy R&D.

This section examines venture capital and total private financing data from Bloomberg New Energy Finance and public research, development, and demonstration (RD&D) data from the International Energy Agency (IEA). The IEA data discussed here cover RD&D. They are not comparable to the energy R&D data described in chapter 4, which focus on R&D.[31]

Commercial Investment

Global commercial investment in clean energy technologies, including early stage angel and venture capital investment and later-stage financing, was $160 billion in 2012 (figure 6-41).[32] Two technologies—wind and solar—dominate clean energy investment, with a combined share of 85% (figure 6-42).

Between 2005 and 2012, global clean energy investment rose from less than $30 billion to $159 billion (figure 6-41). The rapid rise of investment was interrupted by a dip during the global recession before climbing back to its level prior to the recession. This rise has been spurred by government policies to encourage clean energy financing and production and by falling costs in wind, solar, and other energy technologies. Global investment appears to have plateaued since the global recession due to several factors, including the sluggish global economy, cutbacks by many governments on subsidies, tax and other incentives for clean energy, and a substantial decline in natural gas prices due to hydraulic fracturing technologies.

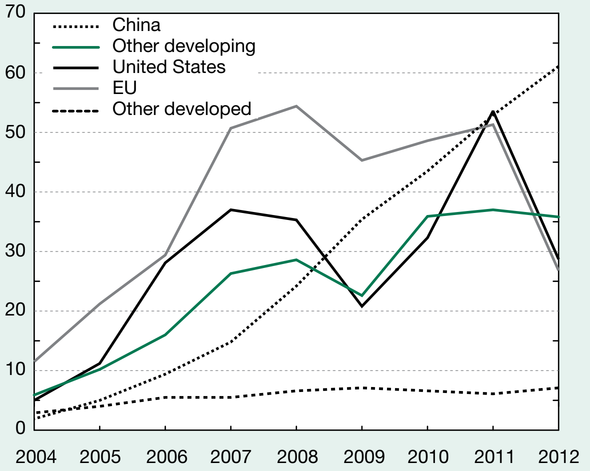
Patterns and Trends in Developing Countries

In 2012, almost $100 billion in commercial investment in clean energy occurred in China and other developing countries, making up over 61% of global investment (figure 6-41). Clean energy financing in China was an estimated $61 billion, more than in any economy in the world (35% share of global investment). The comparable amount for other developing countries was $36 billion.

Between 2005 and 2012, clean energy investment in developing countries rose from $8 billion to nearly $100 billion (figure 6-41). The global share of developing countries

Figure 6-41
Financial new investment in clean energy technologies, by selected region/country/economy: 2004–12

Billions of dollars



EU = European Union.

NOTES: Clean energy technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency technologies. Financial new investment includes private and public R&D, venture capital, private equity, and public markets. Mergers and acquisitions are excluded.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2013).

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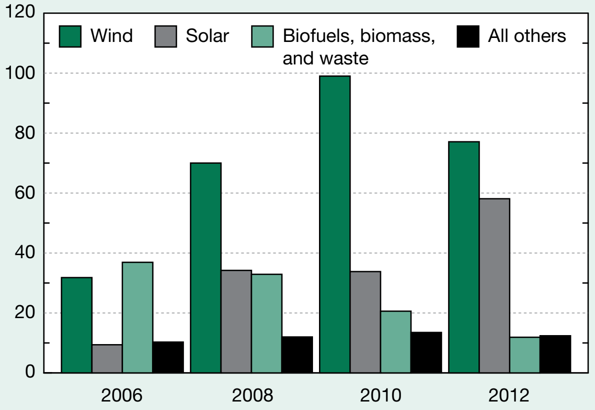
Figure 6-42
Financial new investment in clean energy technologies, by selected energy and technology: 2006–12

Billions of dollars



NOTES: Clean energy technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency technologies. Financial new investment includes private and public R&D, venture capital, private equity, and public markets. Mergers and acquisitions are excluded.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2013).

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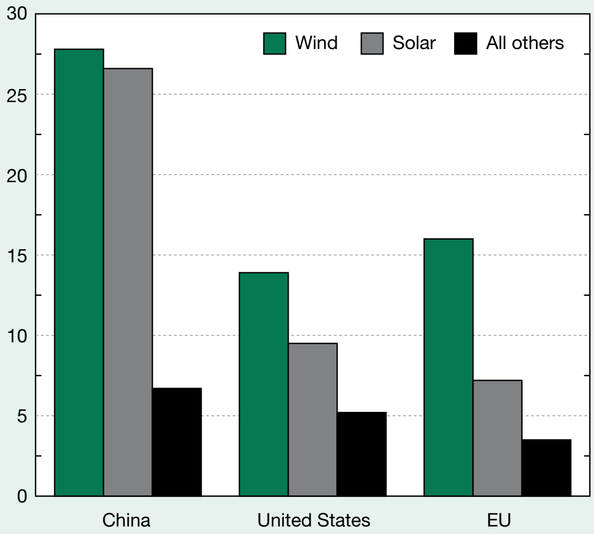
climbed from about one-third of clean energy investment to nearly two-thirds during this period.

China was the primary driver of investment in developing countries; China's commercial investment rose exponentially from less than $2 billion in 2004 to $61 billion in 2012 (figure 6-41). The uninterrupted growth of clean energy investments in China reflects the government's policies targeted at wind and solar energy to make China a major world producer in these technologies and to reduce China's reliance on fossil fuels. Investment in wind energy, which was $28 billion in 2012, made up the largest share of China's investment between 2004 and 2012 (figure 6-43). Investment in solar also rose rapidly. It reached $27 billion in 2012, reflecting China's emergence as a major manufacturer of low-cost photovoltaic modules.

Clean energy investment in other developing countries has also risen rapidly, from $6 billion to $36 billion (figure 6-41). The rapid rise of investment in countries such as Brazil, India, Indonesia, and Mexico reflects the adoption of policies by these countries to encourage clean energy, lower costs relative to developed countries, and rapid economic growth and growing energy demand.

Figure 6-43
Financial new investment in clean energy technologies in China, the United States, and the EU, by technology: 2012

Billions of dollars



EU = European Union.

NOTES: Clean energy technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency technologies. Financial new investment includes private and public R&D, venture capital, private equity, and public markets. Mergers and acquisitions are excluded.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2013).

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Patterns and Trends in Developed Economies

Investment in the United States, the EU, and other developed economies was $63 billion, 39% of global investment (figure 6-41). The United States and the EU, with from $27 billion to $29 billion each, tied as the second-largest locations of clean energy investment, behind China. Investment in other developed economies is much smaller, amounting to a collective $7 billion.

Between 2004 and 2012, clean energy investment in developed economies rose from $19 billion to $63 billion (figure 6-41). Investment has been volatile in the aftermath of the global recession. Investment rebounded in 2010 and reached a new high of $110 billion in 2011 before plunging to $63 billion in 2012, its lowest level since 2006.

After rising steadily prior to the global recession, U.S. investment fell sharply in 2008 before recovering to $32 billion in 2010, near its pre-recession level (figure 6-41). Investment spiked in 2011 to $45 billion before falling to $29 billion in 2012 due to the expiration of temporary financing provisions and subsidies. Wind and solar energy have led the growth of U.S. investment between 2004 and 2012 (figure 6-43). Wind investment reached $14 billion in 2012, closely followed by solar energy, which was $10 billion.

In the EU, the global recession had less impact on commercial investment compared to the United States (figure 6-41). However, investment fell by half in 2012 to $27 billion due to the EU's economic and financial crisis and sharp cutbacks in government support for solar and other clean energies in Germany, Spain, and the United Kingdom. Investment in solar energy in 2012 was $7 billion, less than half its level in 2008 (figure 6-43). Investment in wind energy was also down sharply.

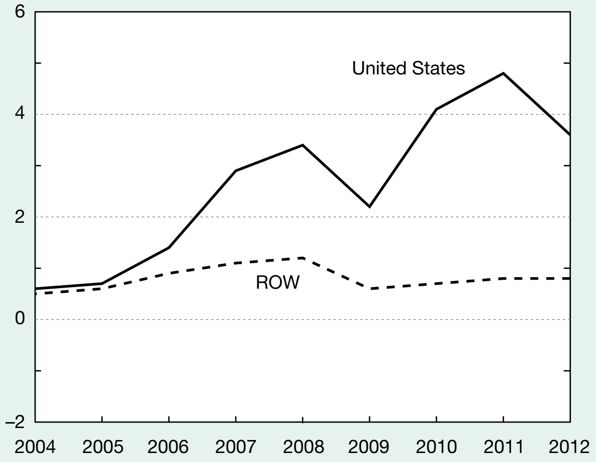
Venture Capital Investment

Venture capital investment is a useful indicator of market assessment of nascent and future trends in clean energy technologies. Global venture capital investment in clean energy was $4.4 billion in 2012, making up 3% of commercial financial investment (figure 6-44). The United States is the main location of venture capital financing for clean energy technologies, with more than 80% of global investment in 2012.

Among the technology areas, energy smart and efficiency technologies make up nearly half of venture capital financing (figure 6-45). The energy smart and efficiency category covers a wide range of technologies, from digital energy applications to efficient lighting, electric vehicles, and the smart grid that maximizes the energy efficiency of existing energy sources and networks. Two other technology areas—solar and biofuels—accounted for about 20% each of all venture capital financing.

After rising rapidly to reach $5 billion prior to the global recession, venture capital investment plunged in 2009. It then rebounded from $4 billion to $5 billion in 2010–12 (figure 6-44). Between 2004 and 2012, three technology areas—energy smart and efficiency, solar, and biofuels—led growth (figure 6-45). Biofuels grew the fastest among these technologies, but from a low base, to reach $0.9 billion. Solar rose from less than $0.2 billion to reach $1.0 billion. Energy smart and efficiency, the largest technology area, grew from $0.8 billion to $2.0 billion.

Figure 6-44
Global venture capital investment in clean energy technologies: 2004–12
Billions of dollars



ROW = rest of world.

NOTE: Clean energy technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency technologies.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2013).

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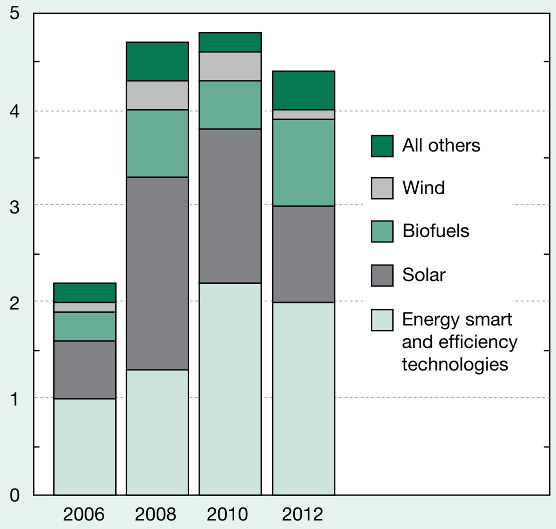
Figure 6-45
Global venture capital investment in clean energy technologies, by selected technology: 2006–12
Billions of dollars



NOTE: Clean energy technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency technologies.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2013).

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U.S. venture capital investment in the energy smart and efficiency and the solar areas is likely a result of several factors, including American Recovery and Reinvestment Act of 2009 (ARRA) funding of R&D in these technologies and U.S. loan guarantees for companies operating in these areas. In addition, energy efficiency technologies are less capital intensive than other clean energy technologies, have a shorter time horizon than most other energy technologies, can be applied to a wider range of energy products and services, and are less reliant on government incentives or subsidies that may be withdrawn.

Public Research, Development, and Demonstration Expenditures in Clean Energy Technologies

Major developed economies invested an estimated $13.0 billion on public RD&D in clean energy and nuclear technologies in 2011 (table 6-11; figure 6-46). Clean energy technologies include renewables (solar, wind, ocean), bioenergy, hydrogen, fuel cells, carbon capture and storage, energy efficiency, and other power and storage.[33]

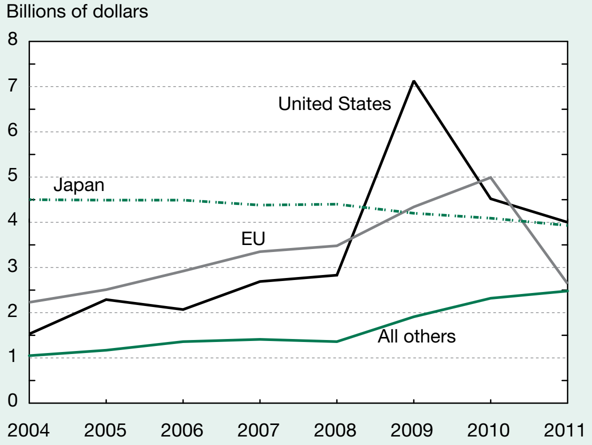
Nuclear energy was the largest area, receiving $5.6 billion in 2011, nearly one-third of total RD&D (table 6-11). The next two largest areas are energy efficiency and renewable energy (solar, wind, ocean, bioenergy), which received $3.6 and $2.4 billion, respectively. The fourth largest, other power and storage, received $1.1 billion.

The United States and Japan are the largest investors in clean energy and nuclear RD&D, with each spending $4.0 billion in 2012 (figure 6-46). The EU is the next largest, with expenditures of $2.6 billion. Three other countries—Canada, South Korea, and Australia—had significant expenditures. Canada's RD&D was $1 billion, and Australia and South Korea each spent between $500 million and $600 million.

Between 2004 and 2008, clean energy and nuclear RD&D rose steadily to reach $12 billion in 2008 before spiking up to $17.6 billion in 2009 due to stimulus spending in the United States and the EU (table 6-11; figure 6-46). Clean energy and nuclear RD&D fell in 2010 and 2011 with the fading of stimulus spending to reach $13.1 billion in 2011. Trends among the individual technology areas varied between 2004 and 2011:

- CO_2 capture and storage had the fastest growth, rising from $100 million to $1.1 billion.

Figure 6-46
Government RD&D expenditures of selected developed countries/economies in clean energy and nuclear technologies: 2004–11



EU = European Union; RD&D = research, development, and demonstration.

NOTES: Clean energy and nuclear technologies include solar, wind, bioenergy, nuclear, fuel cells, hydrogen, CO_2 capture and storage, other power and storage, and energy efficiency. The EU includes Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Spain, Sweden, and the United Kingdom. All others include Australia, Canada, and South Korea.

SOURCE: International Energy Agency, Statistics and Balances, http://www.iea.org/stats/index.asp, accessed 15 January 2013.

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Table 6-11
Government RD&D of selected developed countries in clean energy and nuclear technologies, by technology area: Selected years, 2004–11
(Billions of dollars)

Year	All clean energy and nuclear technologies	Nuclear	Energy efficiency	Renewable energy	Hydrogen and fuel cells	Other power and storage	CO_2 capture and storage
2004	9.3	5.2	1.5	1.3	0.6	0.5	0.1
2008	12.0	5.7	2.4	1.9	1.0	0.6	0.4
2009	17.6	5.7	4.3	4.1	0.9	1.6	1.0
2010	15.9	5.7	3.9	3.5	0.8	0.9	1.0
2011	13.0	4.6	2.4	3.6	0.6	0.8	1.1

RD&D = research, development, and demonstration.

NOTES: Clean energy and nuclear technologies include solar, wind, bioenergy, nuclear, fuel cells, hydrogen, CO_2 capture and storage, other power and storage, and energy efficiency. Detail may not add to total because of rounding. Countries included are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Netherlands, Norway, Poland, Portugal, Slovakia, South Korea, Spain, Sweden, Switzerland, United Kingdom, and United States.

SOURCE: International Energy Agency, Statistics and Balances, http://www.iea.org/stats/index.asp, accessed 15 March 2013.

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- ♦ Spending on renewable energy nearly tripled to reach $3.6 billion.
- ♦ Energy efficiency expenditures rose by 50% to reach $2.4 billion.
- ♦ Nuclear energy declined from $5.2 billion to $4.6 billion.

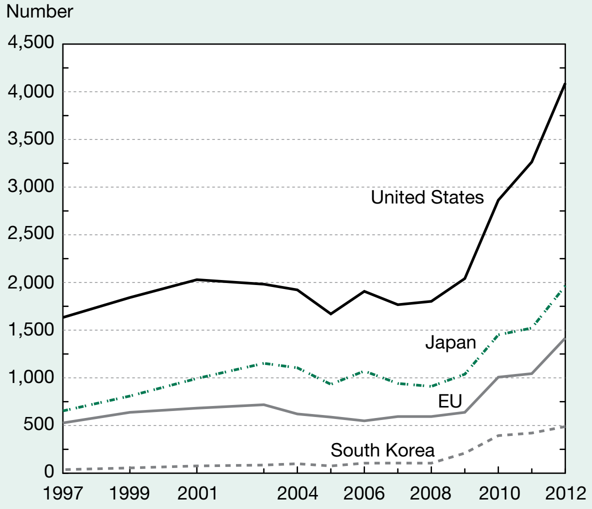
The United States outpaced the EU and Japan in growth of clean energy and nuclear RD&D during this period (table 6-12; figure 6-46). U.S. RD&D rose from $1.5 billion in 2004 to $2.8 billion in 2008 before surging to $7.1 billion in 2009 due to ARRA spending. Renewable and energy efficiency received the bulk of ARRA spending, which temporarily increased spending in each technology area by about $1.5 billion. U.S. RD&D dropped in 2010 and 2011 to reach $4.0 billion, $2.5 billion higher than its RD&D in 2004. The EU's RD&D increased from $2.2 billion in 2004 to reach a stimulus-induced high of $5.0 billion in 2010 before dropping to $2.6 billion in 2011, still 18% higher than its level in 2004. Japan's RD&D declined from $4.5 billion to $3.9 billion.

Patenting of Clean Energy and Pollution Control Technologies

USPTO patents granted in clean energy and pollution control technologies can be classified using a taxonomy developed for this purpose. The taxonomy classifies patents involving bioenergy, nuclear, wind, solar, energy storage, smart grid, and pollution mitigation. The number of patents in these technologies jumped to a record high in 2012, which could reflect USPTO efforts to speed up processing of applications (figure 6-47; appendix table 6-57).[34] (For a more detailed description of how this taxonomy identifies clean energy and pollution control patents, see the sidebar in chapter 5, "Identifying Clean Energy and Pollution Control Patents.") U.S. resident inventors were granted slightly less than half of the 8,800 clean energy and pollution control technology patents in 2012, continuing the advantage of non-U.S. inventors in these fields since 2003.

Among non-U.S. inventors, Japan, the EU, and South Korea, in that order, are the main recipients of U.S. patents for clean energy and pollution control technologies, with a collective share of 44% of total patents granted (figure 6-47;

Figure 6-47
USPTO patents in alternative energy and pollution control technologies, by selected region/country/economy of inventor: Selected years, 1997–2012



EU = European Union; USPTO = U.S. Patent and Trademark Office.

NOTES: Clean energy and pollution control technologies include alternative energy, energy storage, smart grid, and pollution mitigation. Alternative energy includes solar, wind, nuclear, hydropower, wave/tidal/ocean, geothermal, and electric/hybrid. Energy storage includes batteries, compressed air, flywheels, superconductivity, magnet energy systems, ultracapacitors, hydrogen production and storage, and thermal energy. Pollution mitigation includes recycling; control of air, water, and solid waste pollution; environmental remediation; cleaner coal; and capture and storage of carbon and other greenhouse gases. Technologies are classified by The Patent Board.™ Patent grants are fractionally allocated among regions/countries on the basis of the proportion of the residences of all named inventors.

SOURCE: The Patent Board,™ Proprietary Patent database, special tabulations (2013). See appendix table 6-57.

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Table 6-12
U.S. government RD&D expenditures on clean energy and nuclear technologies: 2007–11
(Millions of dollars)

Year	All clean energy and nuclear technologies	Energy efficiency	Renewable energy	Nuclear energy	Hydrogen and fuel cells	Other power and storage technologies
2007	2,690	585	594	898	343	140
2008	2,831	692	468	1,008	335	127
2009	7,131	2,196	2,280	871	368	951
2010	4,519	1,422	1,338	907	340	281
2011	3,996	882	1,161	1,225	260	178

RD&D = research, development, and demonstration.

NOTE: Clean energy and nuclear technologies include solar, wind, bioenergy, nuclear, fuel cells, hydrogen, CO_2 capture and storage, other power and storage, and energy efficiency.

SOURCE: International Energy Agency, Statistics and Balances, http://www.iea.org/stats/index.asp, accessed 15 March 2013.

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appendix table 6-57). Japan received 22%, and EU inventors received 16%. South Korean inventors received 6% of total patents, up from 2% in 2003. Patents granted to inventors in China and Taiwan have been increasing rapidly, although from a low base. In 2012, China's and Taiwan's shares of total patents were 2% each, up from 1% or less in 2003.

Clean energy and pollution control technology patents comprise four broad areas: alternative energy, with 5,000 patents granted; energy storage, with 1,000 patents; smart grid, with 800 patents; and pollution mitigation, with 2,000 patents (table 6-13; appendix tables 6-58–6-61). The proportion of alternative energy patents rose from 27% in 1997 to 59% in 2012, with major share gains by fuel cells and solar patents. Pollution mitigation technologies declined from 56% to 23%, driven by share losses of air and water quality.

Patent technology activity indexes measure the world share of a region, country, or economy in clean energy and clean technologies relative to its world share in patents in all technologies. A ratio greater than 1 signifies that patents by a region, country, or economy are concentrated in a particular technology (table 6-14).

In alternative energy patents, the U.S. has a high concentration in bioenergy and solar technologies and relatively low patent activity in fuel cells, hybrid vehicles, and wind energy (table 6-14; appendix tables 6-62–6-66). The EU has relatively high concentrations in bioenergy, wind, and nuclear and a relatively low concentration in electric hybrid technologies (appendix table 6-67). Japan has a high concentration of patents in electric hybrid technologies and fuel cells but relatively low activity in bioenergy, solar, and wind. South Korea has a high concentration in fuel cells but low concentrations in bioenergy, solar, and wind.

The United States and the EU have relatively low concentrations of patents in energy storage because of their low activity in battery technology, but this is an area of high concentration for Japan and South Korea (table 6-14; appendix tables 6-59 and 6-68). Despite its overall low concentration of patents in energy storage, the United States has a high concentration of patents in hydrogen power and storage (appendix table 6-69).

In smart grid, the United States has a high concentration of patents, the EU has a slightly above-average concentration, and Japan and South Korea have relatively low concentrations (table 6-14; appendix table 6-60).

In pollution mitigation technologies, the United States has a slightly above-average concentration of patents, with high concentrations in carbon capture and storage and in cleaner coal (table 6-14; appendix tables 6-61, 6-70, and 6-71). The EU has a particularly high concentration of patents in air pollution and a high concentration in carbon capture and storage (appendix table 6-72). Japan has average patenting activity in this area, with high concentrations in air pollution and in carbon capture and storage. South Korea has relatively low concentrations in all pollution mitigation technologies (appendix tables 6-73–6-75).

Table 6-13
USPTO patents granted in alternative-energy and pollution-control technologies, by technology area: Selected years, 1997–2012

Technology	1997	2002	2007	2010	2012
All alternative-energy and pollution-control technologies	3,087	4,094	3,701	6,260	8,834
Alternative energy	846	1,522	1,605	3,094	5,214
Bioenergy	52	74	101	226	564
Electric and hybrid vehicles	189	405	396	543	896
Fuel cells	95	374	549	1,093	1,143
Solar	212	397	261	671	1,472
Wind	29	65	173	362	856
All others	269	207	125	199	283
Energy storage	349	576	508	989	1,098
Batteries	220	329	227	523	632
Hydrogen production and storage	77	141	186	307	284
All others	52	106	95	159	182
Pollution mitigation	1,719	1,856	1,382	1,916	2,064
Air	696	877	731	1,084	1,183
Capture and storage of carbon and other greenhouse gases	57	89	64	157	215
Cleaner coal	96	61	41	171	240
Water	271	371	306	321	311
All others	599	458	240	183	115
Smart grid	291	304	366	543	811

USPTO = U.S. Patent and Trademark Office.

NOTES: Alternative-energy and pollution-control technologies include alternative energy, energy storage, smart grid, and pollution mitigation. Alternative energy includes solar, wind, nuclear, bioenergy, hydropower, wave, tidal, ocean, geothermal, and electric and hybrid automobiles. Pollution mitigation includes recycling; control of air, water, and solid waste pollution; environmental remediation; cleaner coal; and capture and storage of carbon and other greenhouse gasses. Energy storage includes batteries, compressed air, flywheels, superconductivity, magnet energy systems, ultracapacitors, hydrogen production and storage, and thermal energy. Technologies are classified by The Patent Board.™ The sum of individual technologies may exceed broad areas, and the sum of the broad categories may exceed the total because some of the patents are assigned to multiple individual technologies or broad areas.

SOURCE: The Patent Board,™ special tabulations (2013) of the Proprietary Patent database. See appendix tables 6-57–6-75.

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Table 6-14

Patenting activity in alternative-energy and pollution-control technologies, by selected country/economy: 2009–12

(Activity index)

Technology	United States	EU	Japan	South Korea
All alternative-energy and pollution-control technologies	0.97	1.12	1.10	1.11
Alternative energy	0.95	1.21	1.10	1.06
Bioenergy	1.45	1.04	0.22	0.21
Fuel cells	0.71	0.77	1.83	2.18
Hybrid electric	0.79	0.83	2.00	0.97
Solar	1.14	0.97	0.69	0.86
Wind	0.86	2.81	0.37	0.08
Energy storage	0.71	0.53	1.68	3.06
Batteries	0.40	0.39	2.11	4.67
Hydrogen power and storage	1.15	0.75	0.95	1.22
Smart grid	1.26	1.08	0.43	0.50
Pollution mitigation	1.07	1.25	0.97	0.44
Air	0.94	1.43	1.36	0.42
Capture and storage of carbon and other greenhouse gases	1.33	1.11	0.37	0.45
Cleaner coal	1.50	0.70	0.31	0.18

EU = European Union.

NOTES: Alternative-energy and pollution-control technologies include alternative energy, energy storage, smart grid, and pollution mitigation. Alternative energy includes solar, wind, nuclear, bioenergy, hydropower, wave, tidal, ocean, geothermal, and electric and hybrid automobiles. Pollution mitigation includes recycling; control of air, water, and solid waste pollution; environmental remediation; cleaner coal; and capture and storage of carbon and other greenhouse gases. Energy storage includes batteries, compressed air, flywheels, superconductivity, magnet energy systems, ultracapacitors, hydrogen production and storage, and thermal energy. Technologies are classified by The Patent Board.™ Patent grants are fractionally allocated among countries/economies on the basis of the proportion of the residences of all named inventors. The EU includes current member countries. The activity index consists of the ratio of the countries'/economies' share of the indicated technology to the countries'/economies' share of the total grants. A ratio of greater than 1.00 signifies more active patenting in the selected technology; a ratio of less than 1.00 signifies less active patenting.

SOURCE: The Patent Board,™ special tabulations (2011) of the Proprietary Patent database. See appendix tables 6-57–6-75.

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Conclusion

The U.S. economy continues to be the leading global economy in technology-based industries, as measured by its overall performance, market position in these industries, and position in patenting and other measures of innovation-related activities.

The strong competitive position of the U.S. economy overall is tied to continued U.S. global leadership in many KTI industries. The United States continues to hold the dominant market position in commercial KI services, which account for nearly one-fifth of global economic activity, and in HT manufacturing industries. The U.S. trading position in commercial KI services and licensing of patents and trade secrets remains strong, as evidenced by the continued U.S. surpluses in these areas. The United States is the leading source of RD&D and venture capital financing of clean energy technologies.

The overall U.S. ranking notwithstanding, its market position in almost all of these industries has not been improving; in many cases, it has slipped. China, the second-largest producer in HT manufacturing industries, has narrowed its gap with the United States. U.S. production and employment have fallen sharply in the HT manufacturing industries of communications, computers, and semiconductors, coinciding with U.S. companies moving assembly and other activities to China and other countries. The U.S. trade position in these products has shifted to deficit because, although exports have increased, imports have increased even more. In addition, productivity growth of the U.S. economy has slowed in the 2000s relative to the 1990s.

For much of the 2000s, the EU's position was similar to that of the United States—relatively strong overall economic performance, with a slowdown in productivity and flatlining or slight declines in its market position in KTI industries. During this period, Japan's economy showed less dynamism compared with the economies of the United States and the EU, and its market position declined steeply in many KTI industries. Japan's loss of market position in HT manufacturing industries was due, in part, to Japanese companies shifting production to China and other Asian economies.

Among large developing countries, China's progress clearly stands out. China has become a leading provider of commercial KI services and the second-largest global producer in HT manufacturing industries. China has become the largest global exporter in HT manufacture products and has developed surpluses in trade of HT manufacturing products and commercial KI services. China has become the world's largest source of commercial financing for clean energy and a leading producer in the solar industry. China has led the acceleration of productivity growth in developing countries over the last decade. However, China's indigenous capability in KTI industries and other indicators is uneven. Much of China's HT manufacturing output is controlled by MNCs that import higher-value components from other countries. Chinese companies have made limited progress in more technologically advanced and higher-end manufacturing activities. In addition, China's share of USPTO and economically valuable patents remains very small.

Other developing economies—including Brazil, India, and Indonesia—are showing rapid progress in their overall economic growth and technological capabilities. Their market positions in many KTI industries have strengthened, coinciding with their rapid economic growth and development. Productivity growth has accelerated in most developing countries.

Led by China, KTI industries in developing countries have grown much faster than developed economies in the aftermath of the recession. The United States has generally fared better than other developed countries in most KTI industries in the aftermath of the 2008–09 global recession. Although productivity growth has been weak, the United States continues to grow faster than most other developed countries. The EU's market position in KTI industries has eroded because of the EU's economic and financial problems. Japan continues to lose market share in many KTI industries.

Notes

1. See the Organisation for Economic Co-operation and Development (OECD) (2001) for a discussion of classifying economic activities according to degree of "knowledge intensity." Like all classification schemes, the OECD classification has shortcomings. For example, knowledge- and technology-intensive (KTI) industries produce some goods or services that are neither knowledge intensive nor technologically advanced. In addition, multiproduct companies that produce a mix of goods and services, only some of which are KTI, are assigned to their largest business segment. Nevertheless, data based on the OECD classification allows researchers and analysts to trace, in broad outline, the worldwide trends toward greater interdependence in science and technology and the development of KTI sectors in many of the world's economies.

2. In designating these high-technology (HT) manufacturing industries, the Organisation for Economic Co-operation and Development (OECD) estimated the degree to which different industries utilized R&D expenditures made directly by firms in these industries and the R&D embedded in purchased inputs (indirect R&D) for 13 countries: the United States, Japan, Germany, France, the United Kingdom, Canada, Italy, Spain, Sweden, Denmark, Finland, Norway, and Ireland. Direct R&D intensities were calculated as the ratio of total R&D expenditure to output (production) in 22 industrial sectors. Each sector was weighted according to its share of the total output among the 13 countries, using purchasing power parities as exchange rates. Indirect intensities were calculated using the technical coefficients of industries on the basis of input-output matrices. OECD then assumed that, for a given type of input and for all groups of products, the proportions of R&D expenditure embodied in value added remained constant. The input-output coefficients were then multiplied by the direct R&D intensities. For further details concerning the methodology used, see OECD (2001). It should be noted that several nonmanufacturing industries have R&D intensities equal to or greater than those of industries designated by OECD as HT manufacturing. For additional perspectives on OECD's methodology, see Godin (2004).

3. See Atkinson and McKay (2007:16–17) for a discussion of and references to the impact of information technology on economic growth and productivity.

4. See Mudambi (2008) and Reynolds (2010) for a discussion on the shift to knowledge-based production and geographical dispersion of economic activity.

5. Data on the health care sector include social services.

6. See Bresnahan and Trajtenberg (1995) and DeLong and Summers (2001) for discussions of information and communications technologies and general-purpose technologies.

7. These information and communications technologies (ICT) infrastructure indexes originate from the Connectivity Scorecard, which has developed a variety of ICT indexes for developed and developing countries. The ICT infrastructure indexes are benchmarked against the best-in-class country among developed and developing countries. The business ICT infrastructure index is composed of metrics on business hardware and software and penetration of business lines. The consumer infrastructure index is composed of indicators on penetration of telephone lines and broadband. The government infrastructure index is composed of metrics related to e-government capacity and the share of schools connected to the Internet. More information on the methodology can be found at http://www.connectivityscorecard.org/methodology/.

8. Gross domestic product (GDP) per person employed is an imprecise measure of labor productivity. For example, labor productivity using this measure is skewed in countries that are major petroleum exporters because their GDP is boosted by their petroleum exports, with little input from labor.

9. See Jensen (2012) for a discussion of U.S business services firms helping to build infrastructure in developing countries.

10. See Williamson and Raman (2011) for a discussion of China's acquisition of foreign companies.

11. See *Economist* (Coming home 2013) for a discussion of multinational firms choosing to have more of their manufacturing take place in developed countries.

12. Commercial knowledge-intensive services and goods trade does not correspond to commercial knowledge- and technology-intensive industries because industry and trade data are collected on different bases. Industry production data are classified by primary industry, and trade data are classified by product or service.

13. Data on services exports are available from the World Trade Organization (2013).

14. India's export share is for 2009; 2010 data are not available.

15. Data for China's trade balance in commercial KI services are available from the World Trade Organization (2013).

16. Data for India's trade balance in commercial KI services are available from the World Trade Organization (2013).

17. Data on commercial KI exports by country are available from the World Trade Organization (2013).

18. The U.S. trade balance is affected by many other factors, including currency fluctuations, differing fiscal and monetary policies, and export subsidies and trade restrictions between the United States and its trading partners.

19. The 10 technology areas are advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications technology, life sciences, optoelectronics, nuclear, and weapons. More information on collection, definition, and measurement of advanced technology products trade data can be found at http://www.census.gov/foreign-trade/guide/sec2.html.

20. The Asia and Pacific region includes Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore, South Korea, Taiwan, and Thailand.

21. The National Science Foundation (NSF) Business R&D and Innovation Survey's (BRDIS's) definition of innovation is very similar to the Organisation for Economic Co-operation and Development definition. For more information, see NSF, BRDIS, http://www.nsf.gov/statistics/srvyindustry/about/brdis/.

22. Business R&D and Innovation Survey data are not available for the entire U.S. service sector.

23. Two legal concepts define who has the right to the grant of a patent—*first to file* and *first to invent*. In a first-to-file system, the patent is granted to the first person to file for protection. In the first-to-invent system, the patent is granted to the person who is determined to be the first inventor. The first-to-file system is used in all countries, including the United States, which switched to a first-to-file system in March 2013 after the enactment of the America Invents Act of 2011.

24. U.S. patent law states that any person who "invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent." The law defines *nonobvious* as "sufficiently different from what has been used or described before that it may be said to be nonobvious to a person having ordinary skill in the area of technology related to the invention." These terms are part of the criteria in U.S. patent law. For more information, see the U.S. Patent and Trademark Office, "What Is a Patent?" (http://www.uspto.gov/patents/index.jsp#).

25. The Japan Patent Office is also a major patent office but has a much smaller share of foreign patents than the U.S. Patent and Trademark Office and the European Patent Office.

26. The Business R&D and Innovation Survey data are collected from a sample of U.S. firms, whereas the U.S. Patent and Trademark Office data are from administrative records of all U.S inventors, including individuals and nonprofits.

27. Triadic patent families with coinventors residing in different countries are assigned to their respective regions, countries, or economies on a fractional-count basis (i.e., each region, country, or economy receives fractional credit on the basis of the proportion of its inventors listed on the patent). Patents are listed by *priority year*, which is the year of the first patent filing. Data for 1998–2003 are estimated by the Organisation for Economic Co-operation and Development.

28. The high-technology (HT) definition used here is from the Bureau of Labor Statistics and differs from that used in earlier sections. See Hecker (2005) for a definition and the methodology for determining HT industries.

29. Another possibility is that the behavior of venture capital investors changed because fewer opportunities for attractive risky investments were available in the 2000s than in the 1990s.

30. Data on number of awards are available at http://www.sbir.gov/awards/annual-reports.

31. The International Energy Agency (IEA) manual states: "The IEA concept of Energy RD&D differs from the Frascati concept of R&D, in that (i) it focuses on energy related programmes only; (ii) it includes 'demonstration projects'; and (iii) it includes state owned companies. . . . The energy RD&D data collected by the IEA should not be confused with the data on government budget appropriations or outlays on R&D (GBAORD) collected by the OECD Directorate for Science, Technology, and Industry for the socio-economic objective 'Production, distribution and rational utilisation of energy'" (IEA 2011:16–17).

32. Bloomberg's data include investment in renewable energy, biofuels, energy efficiency, smart grid and other energy technologies, carbon capture and storage, and infrastructure investments targeted purely at integrating clean energy. Investment in solar hot water, combined heat and power, renewable heat, and nuclear are excluded, as are the proceeds of mergers and acquisitions (which do not contribute to new investment).

33. The International Energy Agency has no official definition of clean energy. This discussion includes public research, development, and demonstration in energy efficiency, renewable energy, nuclear, hydrogen and fuel cells, CO_2 capture and storage, and other power and storage technologies.

34. The U.S. Patent and Trademark Office initiated a green technology pilot program on 7 December 2009 that expedites processing of some applications related to green technologies. For more information, see http://www.uspto.gov/patents/init_events/green_tech.jsp.

Glossary

Affiliate: A company or business enterprise located in one country but owned or controlled (10% or more of voting securities or equivalent) by a parent company in another country; may be either incorporated or unincorporated.

Commercial knowledge-intensive (KI) services: KI that are generally privately owned and compete in the marketplace without public support. These services are business, communications, and financial services.

Company or firm: A business entity that is either in a single location with no subsidiaries or branches or the topmost parent of a group of subsidiaries or branches.

European Union (EU): As of June 2013, the EU comprised 27 member nations: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Croatia joined the EU in July 2013. Unless otherwise noted, Organisation for Economic Co-operation and Development data on the EU include all 28 members; data on the EU from other sources are limited to the 27 nations that were members as of June 2013.

Foreign direct investment: Financial investment by which a person or an entity acquires a lasting interest in and a degree of influence over the management of a business enterprise in a foreign country.

Gross domestic product (GDP): The market value of all final goods and services produced within a country within a given period of time.

High-technology (HT) manufacturing industries: Those that spend a relatively high proportion of their revenue on R&D, consisting of aerospace, pharmaceuticals, computers and office machinery, communications equipment, and scientific (medical, precision, and optical) instruments.

Hydraulic fracturing: The procedure of fracturing rock by a pressurized liquid to extract oil, gas, and other hydrocarbons that formerly had been inaccessible with conventional technologies. The slang term for hydraulic fracturing is "fracking."

Information and communications technologies (ICT) industries: A subset of knowledge- and technology-intensive industries, consisting of two high-technology manufacturing industries, computers and office machinery and communications equipment and semiconductors, and two knowledge-intensive service industries, communications and computer services, which is a subset of business services.

Intellectual property: Intangible property resulting from creativity that is protected in the form of patents, copyrights, trademarks, and trade secrets.

Intra-EU exports: Exports from European Union (EU) countries to other EU countries.

Knowledge- and technology-intensive (KTI) industries: Those that have a particularly strong link to science and technology. These industries are five service industries, financial, business, communications, education, and health, and five manufacturing industries, aerospace, pharmaceuticals, computers and office machinery, communications equipment, and scientific (medical, precision, and optical) instruments.

Knowledge-intensive (KI) industries: Those that incorporate science, engineering, and technology into their services or the delivery of their services, consisting of business, communications, education, financial, and health services.

Normalizing: To adjust to a norm or standard.

Not obvious: One criterion (along with "new" and "useful") that an invention must meet to be patentable.

Productivity: The efficiency with which resources are employed within an economy or industry, measured as labor or multifactor productivity. Labor productivity is measured by gross domestic product (GDP) or output per unit of labor. Multifactor productivity is measured by GDP or output per combined unit of labor and capital.

Purchasing power parity (PPP): Procedure that normalizes currency exchange rates based on the funds required to purchase an equivalent market basket of goods in different countries.

R&D intensity: The proportion of R&D expenditures to the number of technical people employed (e.g., scientists, engineers, and technicians) or the value of revenues.

Triadic patent: A patent for which patent protection has been applied within the three major world markets: the United States, Europe, and Japan.

Utility patent: A type of patent issued by the U.S. Patent and Trademark Office for inventions, including new and useful processes, machines, manufactured goods, or composition of matter.

Value added: A measure of industry production that is the amount contributed by a country, firm, or other entity to the value of the good or service. It excludes the country, industry, firm, or other entity's purchases of domestic and imported supplies and inputs from other countries, industries, firms, and other entities.

Value chain: A chain of activities to produce goods and services that may extend across firms or countries. These activities include design, production, marketing and sales, logistics, and maintenance.

Venture capitalist: Venture capitalists manage the pooled investments of others (typically wealthy investors, investment banks, and other financial institutions) in a professionally managed fund. In return, venture capitalists receive ownership equity and almost always participate in managerial decisions.

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Chapter 7

Science and Technology: Public Attitudes and Understanding

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Highlights

Interest, Information Sources, and Involvement

Four out of five Americans say they are interested in “new scientific discoveries.”

- ♦ Other science and technology (S&T) related issues also interest many Americans; these include new medical discoveries, environmental pollution, and new inventions and technologies.
- ♦ A survey of the United States and 10 European countries, including the 5 largest, suggests that interest in S&T in the United States is somewhat higher than in Europe.

The Internet has surpassed television as Americans’ primary source for information about S&T.

- ♦ About 4 in 10 Americans cited the Internet as their primary source of S&T information in 2012 compared with about one-third in 2010. The percentage of Americans saying they relied on television as their primary source of S&T information dropped between 2010 and 2012.
- ♦ Most of those who used the Internet for S&T information said they used online editions of newspapers.

A majority of Americans said they had visited a zoo or aquarium, natural history museum, or S&T museum in 2012.

- ♦ Reported attendance at informal science and cultural institutions in 2012 was down slightly from 2008. The primary drop was for zoos and aquariums.
- ♦ Attendance at informal science institutions was associated with higher education and income.

Public Knowledge about S&T

Americans correctly answered 5.8 out of 9 factual knowledge questions in 2012, a score similar to those in recent years.

- ♦ A survey experiment showed that 48% of respondents said they thought it was true that “human beings, as we know them today, developed from earlier species of animals,” but 72% gave this response when the same statement was prefaced by “according to the theory of evolution.” Similarly, 39% of respondents said that “the universe began with a huge explosion,” but 60% gave this response when the statement was prefaced by “according to astronomers.”
- ♦ Levels of factual knowledge in the United States are comparable to those in Europe and are generally higher than levels in countries in other parts of the world.
- ♦ Americans with more formal education do better on science knowledge questions.
- ♦ Men do better on questions focused on the physical sciences, but there are few differences between men and women in terms of responses to questions focused on the biological sciences.

Most Americans could correctly answer two multiple-choice questions dealing with probability in the context of medical treatment and the best way to conduct a drug trial but had difficulty providing a rationale for the use of a control group or describing what makes something scientific.

- ♦ Americans performed better than the average for residents of 10 European countries on a similar multiple-choice measure of probability, although the residents of several individual countries had better scores than U.S. residents.

Fewer Americans rejected astrology in 2012 than in recent years.

- ♦ In 2012, slightly more than half of Americans said that astrology was “not at all scientific,” whereas nearly two-thirds gave this response in 2010. The comparable percentage has not been this low since 1983.

Public Attitudes about S&T in General

Most Americans continue to say that the benefits of science outweigh the potential harms and that the federal government should fund research that “advances the frontiers of knowledge.”

- ♦ As in past years, about 4 in 10 Americans said the government was spending “too little on research.” In 2012, about half of respondents said government spending on scientific research was “about right,” and about 1 in 10 said there was too much research spending.
- ♦ Americans are most likely to say that education has remained the area in which the government spends too little money. Majorities have also consistently said that they believe health, “alternative energy,” and environmental improvement and protection receive too little funding. The only area in which majorities say government spends “too much” is on “assistance to other countries.”

Americans are more likely to have a “great deal of confidence” in leaders of both the scientific community and the medical community than in leaders of any group except the military.

- ♦ The scientific and medical communities are also among the most highly regarded groups in most other countries surveyed.

Americans hold positive views about both scientists and engineers. Attitudes are similar to those expressed about scientists in 1983 and 2001.

- Less than half of Americans say they have an "excellent" or "good" understanding of what scientists and engineers do at work. Americans say they have a better understanding of engineers' work than scientists' work.
- Many Americans say they think that "scientific work" and "engineering work" are "dangerous," although scientific work is seen as more dangerous than engineering work.
- Most Americans see scientists and engineers as "dedicated people who work for the good of humanity."

Americans see many traditional research fields, as well as a range of applied fields, as "scientific."

- Only about half of Americans see the social science fields of economics and sociology as scientific. More Americans see applied activities such as computer programming, farming, and firefighting as scientific.

Public Attitudes about Specific S&T-Related Issues

Americans are about as concerned about the overall environment as respondents in many other developed countries.

- In 2010, about one-third of Americans said they worried about "the quality of the environment." Responses to this question have been similar in recent years.

Americans remain divided on views about climate change and hold views that are different from those of citizens of other countries.

- A majority of Americans worried "a great deal" or a "fair amount" about climate change in 2013.
- About 3 in 10 Americans say that "dealing with global warming" should be a priority for the president and Congress. In recent years, dealing with climate issues has been near the bottom of Americans' list of potential priorities.
- Many of the other countries surveyed show more concern than the United States about climate change.
- Americans are more likely than residents of other countries to say they believe that any apparent change in temperatures is the result of natural rather than man-made causes.

Americans' support for oil and nuclear energy has rebounded or stabilized following declines associated with major accidents.

- About two-thirds of Americans supported "allowing more offshore oil and gas drilling" in 2012. Less than half of Americans supported drilling in a survey conducted in 2010, shortly after the *Deepwater Horizon* oil spill in the Gulf of Mexico.
- Most Americans continue to express support for nuclear energy as "one of the ways to provide electricity," although support remains lower than before the 2011 nuclear accident in Fukushima, Japan.
- Americans are more supportive of nuclear energy than residents of most other countries.

Americans are less concerned about "modifying the genes of certain crops" than residents of most other countries surveyed, although most still see potential danger.

- In 2010, about one-quarter of U.S. respondents said that modification could be "very" or "extremely dangerous." Belgium was the only country where residents saw less danger.

Most Americans see using stem cells from human embryos in medical research as "morally acceptable."

- In 2013, 6 in 10 of Americans saw using stem cells from human embryos as acceptable. This percentage has stayed relatively stable since 2005.

Introduction

Chapter Overview

Science and technology (S&T) is central to American life. Whether at home, work, school, or out in our communities, S&T affects our daily activities and how we interact in a host of different ways. Many Americans work in jobs in which they innovate using S&T, whereas others use these innovations to produce the goods and services that improve and reshape our lives. S&T gives us new opportunities to get healthy and stay healthy. It affects what and how we eat while providing technologies that keep us entertained and connected. S&T also gives us things to talk about, whether as part of political discussions or simply because so much about S&T can be interesting and important to how the world works. Such conversations are common because S&T is integral to American society. This centrality means that Americans' attitudes and understanding about S&T matter a great deal.

Sometimes S&T debates involve potential risks to health or the environment or changes to what it takes for individuals or companies to succeed. Societies can do a better job addressing potential concerns when these concerns are well understood, even if some concerns turn out to be unfounded. Americans' ability to deal with potential risks may affect what kinds of S&T development occurs within the country as well as whether we can take advantage of the S&T that already exists. Individuals may also choose where to focus their careers based on both their personal interests as well as where they feel they can make a meaningful impact.

Given the centrality of S&T to life in the United States, this chapter presents indicators about interest in S&T news, where people encounter S&T in the media, trend data regarding knowledge of S&T, and indicators of people's attitudes about S&T-related issues. To put U.S. data in context, the chapter examines trend indicators for past years and comparative indicators for other countries.

Chapter Organization

This chapter is divided into four main sections. The first includes indicators of the public's interest in S&T news, sources of information, and involvement in informal S&T activities. The second section reports indicators of public knowledge, including trend measures of factual knowledge of S&T and people's understanding of the scientific process. This second section also includes the way individuals respond to knowledge questions. The third and fourth sections of the chapter describe public attitudes toward S&T. The third section presents data on attitudes about S&T in general, including support for government funding of basic research, confidence in the leadership of the scientific community, and perceptions of scientists and engineers. Also included is a focus on the degree to which the public views various fields and activities as "scientific." The fourth section addresses attitudes on public issues in which S&T plays an important role, such as the environment, climate change, energy, nuclear power, and the use of animals in scientific research. It also includes indicators of public opinion about several emerging lines of research and new technologies, including nanotechnology, genetically modified (GM) food, stem cell research, and cloning.

A Note about Data and Terminology

This chapter emphasizes trends over time, patterns of variation within the U.S. population, and international patterns. It reviews recent survey data from national samples with sound, representative sampling designs. The emphasis in the text is on the trends and patterns in the data.

Like all survey data, the data in this chapter are subject to numerous sources of error and random variation that should be kept in mind when interpreting the findings. Caution is especially warranted for data from surveys that omit significant portions of the target population, have low response rates, or have topics that are particularly sensitive to subtle differences in question wording (see sidebars "U.S. Survey Data Sources" and "International Survey Data Sources"). Also, although many of the international comparisons involve identical questions asked in different countries, these comparisons can be affected by language and cultural differences that cause survey respondents to interpret questions differently. International comparisons therefore require careful consideration.

S&T questions asked in the biennial General Social Survey (GSS) are a major source of data for this chapter. The GSS is a high-quality, nationally representative data source on attitudes and behavior of the U.S. population. Questions about S&T information, knowledge, and attitudes have been included in the GSS since 2006 and have formed the basis of this chapter in *Science and Engineering Indicators* since 2008. The GSS collects data primarily through in-person interviews. Comparable survey data collected between 1982 and 2004 used telephone interviewing; prior to 1982, these data were collected via in-person interviews. Changes in data collection methods over these years, particularly prior to 2006, may affect comparisons over time.

Another important limitation is that recent, high-quality, relevant data are not always available. In some cases, there are large gaps between data collections or only a small number of questions on any given topic. This challenge is particularly acute when it comes to international data. There is a substantial amount of survey work on S&T in Europe, but these data are not collected as regularly as data from the GSS. Asian data are collected even less frequently. Data from Africa and South America are also limited. In general, the current chapter focuses on surveys that have become public after the preparation of the 2012 *Indicators* report. Earlier data can be found in past editions of *Indicators*. In addition, Bauer, Shukla, and Allum (2012) summarize survey data up to 2006 from a range of countries and regions.

U.S. Survey Data Sources

Sponsoring organization	Title	Years used	Information used	Data collection method	Respondents (n); margin of error of general population estimates
National Science Foundation (NSF)	Survey of Public Attitudes Toward and Understanding of Science and Technology (1979–2001); University of Michigan Survey of Consumer Attitudes (2004)	1979–2001, 2004	Information sources; interest; visits to informal science institutions; general attitudes; attitudes toward government spending, science/mathematics education, and animal research	Telephone interviews	n = 1,574–2,041; ± 2.5%–3.0%
National Opinion Research Center (NORC) at the University of Chicago	General Social Survey (GSS)	1973–2012	Attitudes toward government spending, confidence in institutional leaders	Face-to-face interviews, supplemented by telephone interviews	Government spending (2000–12): n = 1,372–4,510; ± 2.8%–3.9% Confidence in institutional leaders (1973–2012): n = 876–2,223; ± 2.5%–4.4%
NORC at the University of Chicago	GSS environment module	1993–94, 2000, 2010	Attitudes toward environment	Face-to-face interviews, supplemented by telephone interviews	n = 1,276–1,557; ± 2.5%–3.3%
NORC at the University of Chicago	GSS Science and Technology (S&T) module	2006, 2008, 2010, 2012	Information sources; interest; visits to informal science institutions; science knowledge; general attitudes; attitudes toward government spending, science/mathematics education, animal research, and nanotechnology	Face-to-face interviews, supplemented by telephone interviews	n = 1,864–2,256; ± 2.5%–3.3%
National Survey of American Public Opinion on Climate Change	American Belief in Climate Change	2012	Attitudes toward climate change	Telephone interviews	n = 726; ± 4.0%
Gallup	Various ongoing surveys	1982–2013	Federal priorities; attitudes toward environmental protection, climate change, nuclear energy, alternative energy, animal research, stem cell research, and quality of science/mathematics education in U.S. public schools	Telephone interviews	n = ~ 1,000; ± 3.0%–4.0%
GfK Roper/Bisconti Research	U.S. Public Opinion Survey	1983–2013	Attitudes toward nuclear energy	Telephone interviews	n = ~ 1,000; ± 3.0%
Harris Interactive	The Harris Poll	1977–2009	Views on occupational prestige	Telephone interviews	n = ~ 1,000 (~ 500 asked about each occupation)
Pew Initiative on Food and Biotechnology, The Pew Charitable Trusts	Poll on consumer attitudes toward genetically modified foods and genetic engineering	2001–06	Attitudes toward genetically modified foods	Telephone interviews	n = 1,000; ± 3.1%
Pew Internet & American Life Project, Pew Research Center	Pew Internet & American Life Survey	2006, 2012	Information sources, interest, involvement, Internet use, library use	Telephone interviews	2006: n = 2,000; ± 3.0% 2012: n = 2,252; ± 2.3%
Pew Research Center	Biennial News Consumption Survey	1994–2012	Information sources, interest, credibility of information sources, top stories, time spent following the news	Telephone interviews	1994, 1998–2012: n = 3,000–3,667; ± 2.0%–2.5% 1996: n = 1,751; ± 3.0%
Pew Research Center	General Public Science Survey	2009	Public's beliefs about S&T-related issues and benefits of science to well-being of society	Telephone interviews	n = 2,001; ± 2.5%
Pew Research Center	Media surveys (various)	1985–2012	Attitudes toward news media, media believability	Telephone interviews	n = ~ 1,000–1,505; ± 3.4%–4.0%
Pew Research Center	Political surveys (various)	2008–13	Information sources; Internet use; attitudes toward national policy on environment, climate change, and energy; attitudes toward government spending for scientific research	Telephone interviews	n = ~ 1,000–2,250; ± 2.5%–3.5%
Thomson Reuters	National Survey of Healthcare Consumers: Genetically Engineered Food	2010	Attitudes toward genetically modified foods	Telephone interviews	n = 3,025; ± 1.8%
Virginia Commonwealth University (VCU)	VCU Life Sciences Survey	2001–08, 2010	Attitudes toward animal research, stem cell research, and cloning technology	Telephone interviews	n = ~ 1,000; ± 3.0%–3.8%

U.S. Survey Data Sources—continued

Sponsoring organization	Title	Years used	Information used	Data collection method	Respondents (*n*); margin of error of general population estimates
Yale Project on Climate Change Communication and the George Mason University Center for Climate Change Communication	Climate Change in the American Mind	2008–12	Attitudes toward climate change	Online (probability-based sample)	*n* = ~ 1,000; ± 4.0%

NOTES: All surveys are national in scope and based on probability sampling methods. Statistics on the number of respondents and the margin of error are as reported by the sponsoring organization. When a margin of error is not cited, none was given by the sponsor.

International Survey Data Sources

Sponsoring organization	Title	Years used	Information used	Data collection method	Respondents (*n*); margin of error of general population estimates
BBVA Foundation (Fundación BBVA)	BBVA Foundation International Study on Scientific Culture	2011	Media use, various knowledge and attitudes items	Face-to-face interviews	*n* = 1,500 for each of 15 countries; ± 2.6%
British Council, Russia	Survey of Public Attitudes Toward Science and Technology in Russia	2003	Various knowledge items	Paper questionnaires	*n* = 2,107
Chinese Association for Science and Technology, China Research Institute for Science Popularization	Chinese National Survey of Public Scientific Literacy	2007, 2010	Interest, various knowledge and attitude items, information sources, visits to informal science institutions, views on occupational prestige	Face-to-face interviews	2007: *n* = 10,059 2010: *n* = 68,416
European Commission	Special Eurobarometer 52.2: *The Europeans and Biotechnology* (1999)	1999	Attitudes toward nuclear energy	Face-to-face interviews	(EU total) *n* = 16,082; (Germany) 2,000; (UK) 1,300; (Luxembourg) 600; (12 other countries) ~ 1,000
	Special Eurobarometer 224/ Wave 63.1: *Europeans, Science and Technology* (2005)	2005	Views on academic fields, visits to informal science institutions		(EU total) *n* = 26,403; (Germany) 1,507; (UK) 1,307; (Slovakia) 1,241; (19 other countries) ~ 1,000; (3 other countries) ~ 500
	Special Eurobarometer 224/ Wave 64.3: *Europeans and Biotechnology in 2005: Patterns and Trends* (2006)	2005	Various knowledge items		(EU total) *n* = ~ 25,000; (each member country/state) ~ 1,000
	Special Eurobarometer 300/ Wave 69.2: *Europeans' Attitudes Towards Climate Change* (2008)	2008	Attitudes toward climate change		(EU total) *n* = ~ 26,661; (Germany) 1,534; (UK) 1,306; (22 other countries) ~ 1,000; (3 other countries) ~ 500
	Special Eurobarometer 340/ Wave 73.1: *Science and Technology Report* (2010)	2010	Attitudes toward science and technology, animal research		(EU total) *n* = ~ 26,671; (Germany) 1,531; (UK) 1,311; (22 other countries) ~ 1,000; (3 other countries) ~ 500
	Special Eurobarometer 341/ Wave 73.1: *Biotechnology* (2010)	2010	Attitudes toward cloning and nuclear energy		(EU total) *n* = ~ 26,676; (Germany) 1,531; (UK) 1,316; (22 other countries) ~ 1,000; (3 other countries) ~ 500
	Special Eurobarometer 365/ Wave 75.2: *Attitudes of European Citizens Toward the Environment*	2011	Attitudes toward the environment		(EU total) *n* = ~ 26,825; (Germany) 1,588; (UK) 1,317; (22 other countries) ~ 1,000; (3 other countries) ~ 500

International Survey Data Sources—continued

Sponsoring organization	Title	Years used	Information used	Data collection method	Respondents (*n*); margin of error of general population estimates
Gallup	Global Gallup Reports	2007–08, 2010	Attitudes toward climate change	Face-to-face interviews Telephone interviews	2007–08: (Total) *n* = 206,193; ± 1.0%–6.0% (United States and 127 other countries) ~ 2,000 in most countries 2010: (Total) *n* = ~ 111,000; ± 1.7%–5.7% (United States and 110 other countries) ~ 1,000 each
India National Council of Applied Economic Research	National Science Survey	2004	Various knowledge items, visits to informal science institutions, information sources	Face-to-face interviews	*n* = 30,255
International Social Survey Programme	Environment Module	1993, 2000, 2010	Various environment and science items	Face-to-face interviews Paper questionnaires	1993: (Total) *n* = 28,301; (United States) 1,430; (22 other countries) 767–1,931 2000: (Total) *n* = 31,042; (United States) 1,276; (37 other countries) 527–1,609 2010: (Total) *n* = 45,199; (United States) 2,044; (31 other countries) 527–1,609
Japanese Cabinet Office	A Public Opinion Poll on Science, Technology, and Society (except 1998, when it is "…Science and Technology in the Future")	1990, 1995, 1998, 2004, 2007, 2010	Interest	Face-to-face interviews	1990, 1995, 1998, 2004, 2010: *n* = ~ 1,900–2,200 2007: *n* = 1,667
Japan National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology	Survey of Public Attitudes Toward and Understanding of Science and Technology in Japan	2001, 2011	Interest, various knowledge and attitude items, information sources, visits to informal science institutions	Face-to-face interviews	2001: *n* = 2,146 2011 (July): *n* =1,010 2011 (Dec.): *n* =1,208
Korea Foundation for the Advancement of Science and Creativity (formerly Korea Science Foundation)	Survey of Public Attitudes Toward and Understanding of Science and Technology	2004, 2008, 2010	Interest, various knowledge and attitude items, information sources, funding, visits to informal science institutions	Face-to-face interviews	*n* = 1,000; ± 3.0%–3.1%
Malaysian Science and Technology Information Center, Ministry of Science, Technology and Innovation	Survey of the Public's Awareness of Science and Technology: Malaysia	2008	Interest, awareness, various knowledge and attitude items, information sources, visits to informal science institutions	Face-to-face interviews	*n* = 18,447; ± 1.0%
Ministry of Science and Technology of Brazil	Public Perceptions of Science and Technology	2010	Attitudes toward government spending	Face-to-face interviews	*n* = ~ 2,000; ± 2.2%
Pew Global Attitudes Project, Pew Research Center	Global Attitudes Survey	2010	Climate change concerns	(Varies by country) Face-to-face interviews Telephone interviews	(United States) *n* = 1,002; ± 4.0% (21 other countries) *n* = 700–3,262; ± 2.5%–5.0%

EU = European Union; UK = United Kingdom.

NOTES: All surveys are national in scope and based on probability sampling methods. Statistics on the number of respondents and margin of error are as reported by the sponsoring organization. When a margin of error is not cited, none was given by the sponsor.

Throughout this chapter, the terminology used in the text reflects the wording in corresponding survey questions. In general, survey questions asking respondents about their primary sources of information, interest in issues in the news, and general attitudes use the phrase “science and technology.” Thus, *S&T* is used when discussing these data. Survey questions asking respondents about their confidence in institutional leaders, the prestige of occupations, and their views on different disciplines use terms such as “scientific community,” “scientists,” “researchers,” and “engineers,” so *S&E* is used when examining issues related to occupations, careers, and fields of research. Although science and engineering are distinct fields, national survey data that make this distinction are scarce. The term *Americans*, as well as equivalent terms for other countries, is meant to refer to U.S. residents included in a national survey. However, not all respondents were citizens of the countries in which they were surveyed.

Interest, Information Sources, and Involvement

Americans’ understanding and attitudes about topics such as S&T depend, in part, on how much exposure they get to such content throughout their life, as well as how much attention they pay to such content (Slater, Hayes, and Ford 2007). Exposure and attention to S&T can make residents more informed, shape attitudes, and help them make decisions that are better for themselves, their families, and their communities. Media use can also spur interest in S&T issues and foster a desire to seek out and consider new information.

This section reviews overall expressed interest in media reports about S&T, the sources of material about S&T that are available to the public, and the type of S&T-related content the public uses. It concludes with indicators of behavioral involvement in S&T through visits to museums and other cultural institutions.

Public Interest in S&T

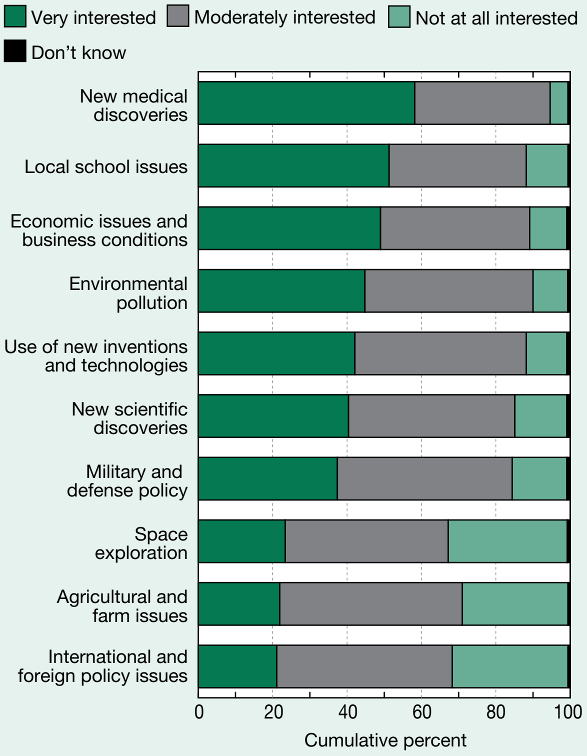
U.S. Patterns and Trends

Most Americans say they are interested in science news, although several other subjects draw more interest. Less than half of Americans (40%) in 2012 said that they were “very interested” in news about “new scientific discoveries,” which is about the same as the percentage who expressed high levels of interest in news about “military and defense policy” (37%) and the “use of new inventions and technologies” (42%). Interest in other issues that touch on S&T ranged from a high of 58% for “new medical discoveries” to a low of 23% for “space exploration.” “Environmental pollution” issues (45%) were also popular (figure 7-1; appendix tables 7-1 and 7-2).[1]

Current findings for science news are within their historical range. For 2012, the percentage of Americans who said they find news about scientific discovery “very” interesting stayed stable from 2010, but the percentage saying they are “not at all interested” in scientific discovery climbed from 8% in 2010 to 14%. Between 1981 and 2012, the percentage of uninterested respondents has ranged between 17% (1981) and 8% (2001), whereas the percentage of “very interested” respondents has ranged between 37% (1981) and 49% (1997). The topic of medical discoveries has consistently stayed at the top of the list alongside nonscience issues such as local school issues and economic issues. Space exploration has remained near the bottom alongside nonscience subjects such as international affairs (figure 7-2; appendix tables 7-1 and 7-2).

Also, although most Americans may say they have an interest in S&T, Pew Research data show that the percentage of Americans who actually followed news about “Science and Technology” “very closely” was just 16% in 2012 and has stayed between 13% and 18% since 2000. The 2012 percentage is down from highs of 20% and 22% in 1996 and 1998, respectively. Weather is the most common subject respondents say they follow “very closely” (52%). About the same percentage of people paid close attention to S&T as paid close attention

Figure 7-1
Public interest in selected issues: 2012



NOTE: Responses to *There are a lot of issues in the news, and it is hard to keep up with every area. I’m going to read you a short list of issues, and for each one I would like you to tell me if you are very interested, moderately interested, or not at all interested.*

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix table 7-1.

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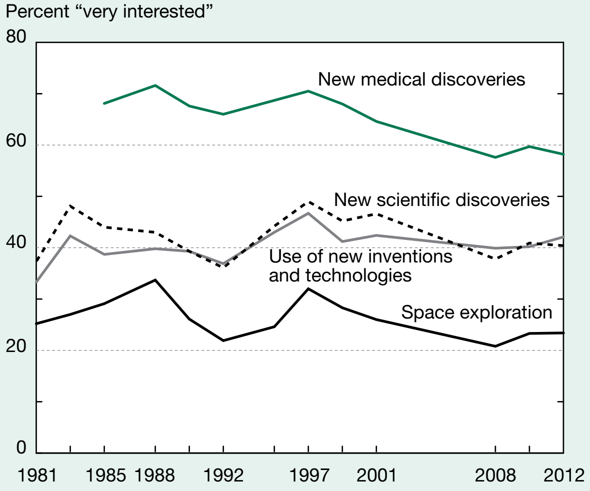
Figure 7-2
Public interest in selected science-related issues: 1981–2012



NOTE: Responses to *There are a lot of issues in the news, and it is hard to keep up with every area. I'm going to read you a short list of issues, and for each one I would like you to tell me if you are very interested, moderately interested, or not at all interested.*

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1981–2001); University of Chicago, National Opinion Research Center, General Social Survey (2008–12). See appendix table 7-1.

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to politics, business and finance, and international affairs. Although some issues have stayed relatively stable, most issues have seen at least small declines in the percentage of Americans who say they follow that topic closely. One of the largest declines has been in the percentage of Americans interested in health news (Pew Research Center 2012a) (table 7-1).

International Comparisons

Americans generally report higher levels of interest in S&T issues than do residents of many European countries. A survey conducted by the BBVA Foundation in the United States and 10 European countries—including the 5 largest (France, Germany, Italy, Spain, and the United Kingdom) and 5 others (Austria, the Czech Republic, Denmark, the Netherlands, and Poland)—asked respondents to use a 0-to-10–point scale to rate their interest in six issues. These included three S&T-related issues ("scientific issues," "environmental issues," and "health issues") and three non-S&T issues ("economic issues," "international issues," and "political issues"). For scientific issues, the United States had an average interest level of 6.0, which was greater than the 10-country European average of 5.6. The Netherlands had the highest score (6.4), and several countries were in the same general range as the United States. The U.S. average for interest in environmental issues (6.9) tied the Netherlands, the highest of the included European countries, but was only a little higher than the overall average of 6.6. For health issues, the U.S. average of 7.8 was just below

Table 7-1
News followed "very closely" by American public: 1996–2012
(Percent)

Type of news	1996	1998	2000	2002	2004	2006	2008	2012
Weather	NA	NA	NA	NA	53	50	48	52
Crime	41	36	30	30	32	29	28	28
Community	35	34	26	31	28	26	22	26
Sports	26	27	27	25	25	23	20	26
Health news	34	34	29	26	26	24	20	23
Local government	24	23	20	22	22	20	20	21
Politics/Washington news	16	19	17	21	24	17	21	17
Science and technology	20	22	18	17	16	15	13	16
Business and finance	13	17	14	15	14	14	16	15
International affairs	16	16	14	21	24	17	16	14
Entertainment	15	16	15	14	15	12	10	11
Education	NA	NA	NA	NA	NA	NA	23	NA
Environment	NA	NA	NA	NA	NA	NA	21	NA
Religion	17	18	21	19	20	16	17	NA
Consumer news	14	15	12	12	13	12	13	NA
Culture and arts	9	12	10	9	10	9	11	NA
Celebrity news	NA	NA	NA	NA	NA	NA	7	NA
Travel	NA	NA	NA	NA	NA	NA	6	NA

NA = not available, question not asked.

NOTE: Data reflect respondents who said they followed a type of news "very closely."

SOURCES: Pew Research Center for the People and the Press, *Audience Segments in a Changing News Environment: Key News Audiences Now Blend Online and Traditional Sources* (17 August 2008), p. 39; Biennial News Consumption Survey (30 April–1 June 2008), http://www.people-press.org/reports/pdf/444.pdf, accessed 21 September 2009; Biennial News Consumption Survey (9 May–3 June 2012), http://www.people-press.org/files/legacy-questionnaires/News%20Consumption%20topline%20for%20release.pdf, accessed 25 January 2013.

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that of Spain (7.9%), which had the highest average of the European countries. The overall European average for health issues was quite high at 7.4. The U.S. averages for non-S&T issues were also relatively high (BBVA Foundation 2012b).[2]

A separate 2010 all-European survey found that 30% of respondents across 27 European nations reported being "very interested" in new scientific discoveries and technological developments, 49% were "moderately interested," and 20% were "not interested." Thus, again, expressed interest in S&T appears lower in the European Union (EU) than in the United States, where 40% of Americans in 2010 reported being "very interested" in S&T. However, several European countries—the Netherlands (48%), the United Kingdom (43%), Sweden (43%), Luxembourg (42%), France (41%), and Hungary (41%)—had percentages similar to the U.S. percentage (European Commission 2010a).[3]

A majority of residents of China, Japan, and Korea report interest in science and technology, although the varied questions and survey structures used make direct comparisons with the United States unwise. In 2010, 72% of Chinese respondents said they were "interested" in "new scientific discoveries," and 68% said they were interested in "new inventions and technologies" (CRISP 2010). Interest in both topics appears to be up from a 2007 survey (NSB 2010). In Japan, the percentage saying they were interested in "science and technology" climbed from 63% in January of 2010 to 76% in July of 2011, before and after the major earthquake that damaged the nuclear energy plant in Fukushima. It dropped back to 65% in December of 2011. Japanese interest in S&T was in the mid-50% range from 1990 to 2004 (NISTEP 2012). In Korea, a 2010 survey found that 51% of respondents said they had an interest in "new inventions and technologies," and 49% had an interest in "new scientific discoveries" (KOFAC 2011). Korean interest in scientific discovery was up from 24% in a 2008 survey (NSB 2012). Respondents in China and Korea were asked about both S&T and non-S&T topics, whereas the Japanese surveys addressed only S&T topics.

The 2011 BBVA Foundation survey, as well as the 2010 Chinese survey, reported two novel indicators of science interest and involvement: how much people discussed science and whether they knew someone who was a scientist. Interpersonal discussion and contact with opinion leaders within one's social network influence views about S&T issues (Hwang and Southwell 2007; Nisbet and Kotcher 2009). About 36% of Americans said that S&T issues were "part of [their] conversations with family members, friends, or work colleagues" "very often" or "quite often." The 10-country European average was 27%, although countries such as Denmark (50%), the United Kingdom (38%), and the Netherlands (37%) had scores at or above the U.S. level. The percentage of Americans who said they are "personally acquainted with someone who is a scientist" (44%) was close to the 10-country European average of 40% but lower than those of a number of countries, including the Netherlands (74%), Denmark (67%), the United Kingdom (55%), and Germany (53%). In total, 1 in 5 Americans (20%) reported having a friend who was a scientist. This was about the same as the 10-country European average (22%) but once again was less than the scores for the Netherlands (34%), Denmark (30%), and the United Kingdom (28%) (BBVA Foundation 2012a). In China, 43% of respondents said that "conversations with people" were a main source of S&T information. Further, 61% said they had "often" or "sometimes" engaged in talk about S&T with "relatives, friends, and colleagues," and 14% said they had been involved in "discussions or hearings" related to S&T.

Availability of S&T News in the Media

Americans' knowledge and attitudes about S&T, particularly in areas of emerging knowledge, partially depend on the availability of S&T news. Media coverage often sets the public agenda (Soroka 2002) and frames the debate related to scientific issues (Nisbet and Scheufele 2009). A range of social processes associated with journalism, science, and public decision making determine which issues get attention from journalists at particular periods of time (Nisbet and Huge 2006). For example, natural or human disasters may increase the likelihood that relevant S&T issues are covered by the news while decreasing the likelihood that unrelated issues are covered. Quantity and prominence of coverage may also affect topical knowledge within society (Barabas and Jerit 2009). Other research suggests that different types of media have different effects on attitudes, with newspaper and Internet use being associated with more favorable attitudes than television (e.g., Dudo et al. 2011). Given the potential impact of media use, indicators that address how much and what kinds of S&T news coverage are available in the media can be important for understanding the development of views about S&T.

The Project for Excellence in Journalism (PEJ 2012) conducted an extensive content analysis of media coverage between January 2007 and May 2012 using 52 outlets in the following media sectors: print, Internet, network television, cable television, and radio. Each week, stories were classified into 1 of 26 broad topic areas, including S&T, the environment, and "health and medicine."[4]

Special tabulations of PEJ data show that S&T coverage made up a small percentage of the total amount of news in the traditional media—less than 2% annually—between 2007 and 2012. News coverage of the environment made up a similarly small percentage of the news, dropping to 1.0% of all coverage in 2011 and 1.2% in the first part of 2012. Coverage of health and medicine consistently made up a greater percentage of the news, ranging from 3.1% in 2011 to 8.9% in 2009 (table 7-2).[5]

Many issues that dominated coverage in previous years remained prominent in 2011 and early 2012. For S&T, "cyberspace" issues have been near the top of the media agenda since 2009 (NSB 2010, 2012). The National Aeronautics and Space Administration (NASA) led coverage in 2011 with

Table 7-2
Traditional media coverage of science and technology, by topic area: 2007–12
(Percent)

Year	Number of stories	Science and technology	Environment	Health and medicine
2007	70,737	1.3	1.6	3.6
2008	69,942	1.1	1.3	2.7
2009	68,717	1.8	1.5	8.9
2010	52,613	1.5	1.6	5.0
2011	48,555	1.4	1.0	3.1
2012 (January–May)	20,452	1.2	1.2	4.1

NOTES: Data reflect the percentage of news stories in each topic area that are based on content analysis of coverage by media outlets in five sectors: print, Internet, network television, cable television, and radio. Data for 2012 reflect only the first 5 months of the year; data were not collected after May 2012.

SOURCE: Project for Excellence in Journalism, News Coverage Index, special tabulations (21 March 2011, 10 December 2012), received via e-mail. For methodology, see http://www.journalism.org/commentary_backgrounder/new_media_index_methodology, accessed 18 January 2013.

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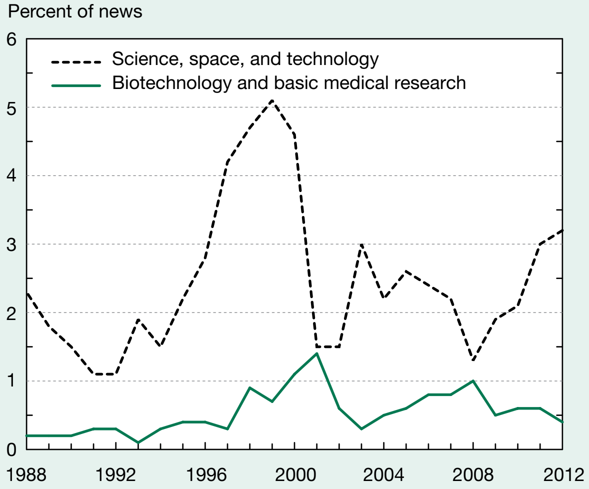
the final launch of the Space Shuttle *Atlantis* and the end of the shuttle program. (table 7-3) (NSB 2012). The most prominent environmental issue in the news has varied over recent years. The energy debate and global warming/climate change, as well as the oil spill in the Gulf of Mexico, have all received prominent coverage in recent years (NSB 2012).

News programming on the three major broadcast networks (ABC, CBS, and NBC) shows a similar pattern. The Tyndall Report has tracked the content of the three major broadcast networks for more than 20 years. Tyndall tabulates the amount of airtime devoted to different topics using 18 different categories (Tyndall Report 2013). Two categories with large science, engineering, and technology components are “science, space, and technology” and “biotechnology and basic medical research.”[6] Neither category has ever occupied a large percentage of the approximately 15,000 minutes of annual nightly weekday newscast coverage on the networks. The airtime devoted to “science, space, and technology” averaged about 2% of broadcast news between 2000 and 2012. Time devoted to “biotechnology and basic medical research” was even lower, almost always 1% or less of broadcast news (figure 7-3).

The leading stories in these two science-related categories on nightly news broadcasts in 2011 were the death of Apple chief executive officer and technology innovator Steve Jobs and the end of NASA’s Space Shuttle program. In 2012, the social networking site Facebook’s initial public offering of stock led technology coverage. NASA stayed in the news with its *Curiosity* rover mission to Mars as well as additional coverage of the end of the space shuttle program. In the category of “biotechnology and basic medical research,” cancer research garnered the most coverage in both 2011 and 2012 (table 7-4). Since 2006, cancer research has received more attention than other medical research topics (NSB 2008, 2010, 2012).

The PEJ also tracked new media and social media—a segment of the Internet that continues to grow at high rates around the world (Pew Research Global Attitudes Project 2012)—between January 2009 and June 2012. The New Media Index focused specifically on the five main topics linked to by blog and Twitter posts from Monday to Friday of each week.[7] Discussion of specific technology companies (e.g., Apple, Google, Samsung, Facebook, and Twitter) dominated both blogs and Twitter. In 2012, technology companies remained among the most common topics of discussion on blogs, but other subjects dominated Twitter (table 7-5). The one environmental issue that made the top five list multiple times was “global warming.”

Figure 7-3
Network nightly news coverage of science and technology: 1988–2012



NOTES: Data reflect the percentage of approximately 15,000 total annual minutes of weekday nightly newscasts on ABC, CBS, and NBC that were spent on science, space, and technology and on biotechnology and basic medical research. Excluded from science, space, and technology are stories on forensic science and media content. Excluded from biotechnology and basic medical research are stories on clinical research and medical technology.

SOURCE: Tyndall Report, special tabulations (21 March 2011, 12 January 2013, 22 January 2013).

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Entertainment television can also shape views. However, one recent study showed that, between 2000 and 2008, scientists represented just 1% of characters on prime-time network shows. Of these scientists, 7 out of 10 were men and almost 9 of 10 were white. Medical professionals were 8% of the characters. Generic “professionals” were the most common type of character (21%). In general, about 8 of 10 scientists were coded as being “good” (Dudo et al. 2011).[8]

Table 7-3

Leading traditional media story lines on science and technology, by topic area: 2011 and 2012

(Percent of news in each topic area)

Topic area/leading story line	2011	Topic area/leading story line	January–May 2012
Science, space, and technology (*n* = 693 stories)		Science, space, and technology (*n* = 255 stories)	
NASA/shuttle missions	26.2	Cyberspace issues	12.7
Cyberspace issues	13.2	Online piracy legislation	12.6
Apple news	7.2	Facebook/Zuckerberg news	7.8
Supreme Court actions	3.4	NASA/shuttle missions	7.3
Facebook/Zuckerberg news	2.4	SpaceX rocket launch	4.5
Texting and driving/multitasking	1.9	Google news	4.2
Gabrielle Giffords shooting	1.7	*Kony 2012* viral video	3.9
Google news	1.2	Apple news	3.1
Iran	1.1	Texting and driving/multitasking	2.2
Economy	0.9	Education system/debate	1.8
Japan earthquake/tsunami (March 2011)	0.9	Japan earthquake/tsunami (March 2011)	0.8
Nobel prizes	0.8	New Year celebrations	0.8
Pollution/emissions/going green	0.8	Economy	0.6
Education system/debate	0.8		
		Environment (*n* = 244 stories)	
Environment (*n* = 467 stories)		Energy debate	30.4
Energy debate	28.0	Keystone oil pipeline	13.1
Japan earthquake/tsunami (March 2011)	14.1	Gas/oil prices	11.0
Pollution/emissions/going green	13.3	Global warming	10.3
Global warming	7.1	Pollution/emissions/going green	6.9
Solyndra scandal	6.8	Nuclear policy	3.7
Gas/oil prices	5.5	BP oil spill in the Gulf of Mexico	2.3
BP oil spill in the Gulf of Mexico	5.2	Japan earthquake/tsunami (March 2011)	1.9
Economy	2.1	Solyndra scandal	1.4
2012 presidential election	1.4	2012 presidential election	1.2
District of Columbia–area earthquake	0.6	Economy	1.2
		Supreme Court actions	0.8
Health and medicine (*n* = 1,499 stories)			
Health care reform debate	42.8	Health and medicine (*n* = 839 stories)	
2012 presidential election	2.9	Health care reform debate	60.3
Economy	2.7	2012 presidential election	3.7
Gabrielle Giffords shooting	1.8	Autism research	1.5
Cigarette warning labels	1.4	Heart disease research	1.2
World AIDS Day 2011	1.2	Truvada™—promising HIV/AIDS medication	1.0
Japan earthquake/tsunami (March 2011)	1.1	Flesh-eating bacteria	0.9
Education system/debate	1.0	Bloomberg big soda ban	0.9
Stem cell controversy	1.0	Education system/debate	0.9
Avastin® loses FDA approval	0.9	U.S. airline industry	0.8
Listeria-tainted melons	0.8	Stem cell controversy	0.6
WHO cell phone study (June 2011)	0.8	Trayvon Martin shooting	0.6
Heart disease research	0.8		
Dr. Oz and apple juice	0.8		
HPV cervical cancer vaccine	0.6		
German *E. coli* outbreak	0.5		

FDA = Food and Drug Administration; HPV = human papillomavirus; NASA = National Aeronautics and Space Administration; WHO = World Health Organization.

NOTES: Data reflect story lines with the greatest percentage of news in each topic area based on content analysis of coverage by media outlets in five sectors: print, Internet, network television, cable television, and radio. Data for 2012 reflect only the first 5 months of the year; data were not collected after May 2012.

SOURCE: Project for Excellence in Journalism, News Coverage Index, special tabulations (10 December 2012). For methodology, see http://www.journalism.org/commentary_backgrounder/new_media_index_methodology, accessed 18 January 2013.

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S&T Information Sources

U.S. Patterns and Trends

The media environment has changed repeatedly over the last century. The available data show clear trends in what sources Americans say they use to get news about current events and S&T, as well as where they would look for new S&T information. Overall, Pew Research reports that Americans said they spent 67 minutes with the news per day in 2012, similar to previous years. The main difference was a clear shift toward online sources (Pew Research Center 2012a).

For news about current events, television remains the primary source of information for 43% of Americans. Substantial percentages also reported in 2012 that most of their current event news comes from the Internet (33%) or newspapers (13%) (figure 7-4). The percentage of Americans getting information about current events from the Internet has increased steadily since about 2001, and the percentage using newspapers for current events has declined. Television use declined for several years but has held steady at current levels since about 2008 (figure 7-5; appendix table 7-3).

For news specifically about S&T, Americans are now more likely to rely on the Internet than on television. In 2012, 42% of Americans cited the Internet as their primary source of S&T information, up from 35% in 2010. The percentage citing the Internet as their primary source of S&T information has also grown steadily since 2001. Conversely, reliance on television has dropped; about 32% of Americans reported that television was their primary source of S&T news in 2012, down from 39% in 2008. Some 7% said they get their S&T information from newspapers, and another 8% said they get their S&T information from magazines (figure 7-5; appendix table 7-4).

Table 7-4
Leading nightly news story lines on science and technology, by topic area: 2011 and 2012
(Annual minutes of coverage)

Topic area/leading story line	2011
Science, space, and technology	
Computer CEO Steve Jobs of Apple dies at age 56	68
NASA Space Shuttle program discontinued	62
Cellular telephone/computer combination: smartphones	27
Cellular telephone radiation safety worries	20
Computer networks targeted by coordinated hackers	15
Cellular telephone billing abuses, surcharges	14
NASA research satellite falls out of orbit	14
Internet online commerce volume increases	13
Immigrant quotas on work visas for high-technology jobs	11
Computer flat-screen tablet technology innovation	10
NASA *Apollo* manned moon missions remembered	9
International Space Station program	9
Inventions/innovations in technology surveyed	9
Asteroids/astronomy: rock to pass close to Earth	8
Internet used for social networking: Facebook grows	8
Mars astronomy: search for signs of life	8
NASA Space Shuttle *Challenger* disaster 25th anniversary	8
Air safety: in-cabin cellular telephone use risks	8
Internet BlackBerry e-mail service is addictive	7
Science and mathematics education in schools	5
Space transportation to use privatized rockets	5
Flash mobs assemble via instant message networks	5
Telecommunications billing consumer fraud: crammed surcharges	5
Biotechnology and basic medical research	
War on cancer research efforts	59
Spinal cord injuries and paralysis research	16

Topic area/leading story line	2012
Science, space, and technology	
Internet social network Facebook launches IPO	69
Mars astronomy: NASA *Curiosity* rover mission	34
NASA Space Shuttle program ends as a museum piece	31
Solar astronomy: storms, flares, Northern Lights	22
Computer networks targeted by coordinated hackers	18
Space transportation uses privatized rockets	16
Cellular telephone/computer combination: smartphones	14
Computer flat-screen tablet technology innovation	10
Computer manufacturer Apple posts record profits	10
Science and mathematics education in schools	9
International Space Station program	9
NASA manned space flights from the 1960s	9
Teenage girl is a science achiever despite homelessness	9
Internet search engine Google monitors browsing	9
Highway safety: drivers' cell phone use dangers	8
Internet online commerce volume increases	8
Physicists build supercollider, search for particle	7
High school science fair competitions held for students	7
Solar eclipses visible in western states, Australia	7
Internet copyright piracy crackdown proposed	6
Internet social network photographs from Instagram	6
NASA *Apollo* manned moon missions remembered	6
Telemarketing abuses: automated robocalls increase	6
Venus astronomy: transit visible across the face of the sun	6
NASA Space Shuttle astronaut Sally Ride dies at age 61	6
Computer systems are vulnerable to viruses, worms	5
NASA *Apollo* astronaut Neil Armstrong dies at age 82	5
Air safety: in-cabin use of electronic devices	5
Asteroids/astronomy: rock passes close to Earth	5
Digital surveillance spycams are miniaturized	5
Biotechnology and basic medical research	
War on cancer research efforts	28
Bone marrow stem cell transplants save lives	9
Spinal cord injuries and paralysis research	5

CEO = chief executive officer; IPO = initial public offering; NASA = National Aeronautics and Space Administration.

NOTES: Data reflect annual minutes of story coverage on these topics by major networks ABC, CBS, and NBC, out of approximately 15,000 total annual minutes on weekday nightly newscasts. Story lines receiving at least 5 minutes of coverage in 2011 or 2012 are shown. Excluded from science, space, and technology are stories on forensic science and media content. Excluded from biotechnology and basic medical research are stories on clinical research and medical technology.

SOURCE: Tyndall Report, special tabulations (12 January 2013, 22 January 2013).

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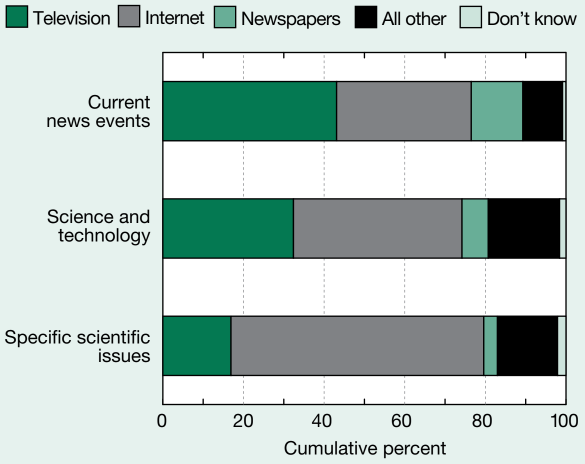
In 2012, the GSS also included questions aimed at unpacking what people mean when they say they go online for S&T information and whether people are using traditional media sources' online content. These analyses point to the importance of newspapers' online presence. Of the 42% who said they go online for S&T news, 63% indicated they used online newspapers. Of the 7% who said newspapers were the primary source of S&T information, about one-sixth (16%) said they used an online edition. Combined, this means that 33% got S&T news from newspapers, with 27% getting their newspaper online and 6% getting it in traditional form. It also means that newspaper content is described as a primary S&T source by about the same percentage of people who said television was their primary source of S&T information (32%). Another 11% said their online source was magazines. This represents about 5% of all respondents and means that about 13% of all S&T media use was from magazines. All other potential online sources—which might include blogs and other forms of social media—were chosen by less than 10% of respondents who indicated they went online for S&T news. The data do not address attention to individual issues.

Since at least 2001, the Internet has also been the most common resource that respondents say they would use to seek out information about specific scientific issues. In 2012, the highest ever percentage of Americans (63%) said they would go online to find information about a specific S&T issue. Another 17% said they would turn to television and just 3% said they would use newspapers (figure 7-5; appendix table 7-5).

Generally, newspaper reliance is more common for relatively older respondents, and Internet reliance is more common for relatively younger and higher earning respondents. Television use is also somewhat less common for younger respondents, although the pattern is not nearly as pronounced. Those with lower incomes and lower levels of

Figure 7-4
Primary source of information about current news events, science and technology, and specific scientific issues: 2012



NOTE: "All other" includes radio, magazines, books, government agencies, family, and friends/colleagues.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix tables 7-3–7-5.

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Table 7-5
Most-discussed subjects in the new media: 2011 and 2012

	2011[a]			2012[b]	
Subject	Weeks in top 5 (*n*)	Weeks in top 5 (%)	Subject	Weeks in top 5 (*n*)	Weeks in top 5 (%)
Blogs			Blogs		
Apple	20	40	Apple	16	70
2012 presidential election	13	26	Google	11	48
Google	12	24	Search engine optimization	10	43
California budget	6	12	2012 presidential election	6	26
Samsung	5	10	Application programming interfaces (tie)	4	17
			Samsung Galaxy (tie)	4	17
Twitter					
Facebook	19	38	Twitter		
Google	19	38	One Direction (music)	16	70
Twitter	18	36	Justin Bieber (music)	10	43
Apple	16	32	Super Junior (music)	10	43
Justin Bieber (music)	11	22	@The90sLife	4	17
			Lady Gaga (music) (tie)	3	13
			Trayvon Martin shooting (tie)	3	13

[a] Blogs and Twitter content analysis for 2011 is based on 50 weeks in the year.

[b] Blogs and Twitter content analysis for 2012 is based on the first 23 weeks in the year.

NOTES: Data reflect the number and percentage of weeks a subject appeared in the Project for Excellence in Journalism's (PEJ's) New Media Index. PEJ stopped regularly producing the New Media Index in June 2012.

SOURCE: PEJ New Media Index, special tabulations (January–February 2013), http://www.journalism.org/news_index/100, accessed 8 February 2013.

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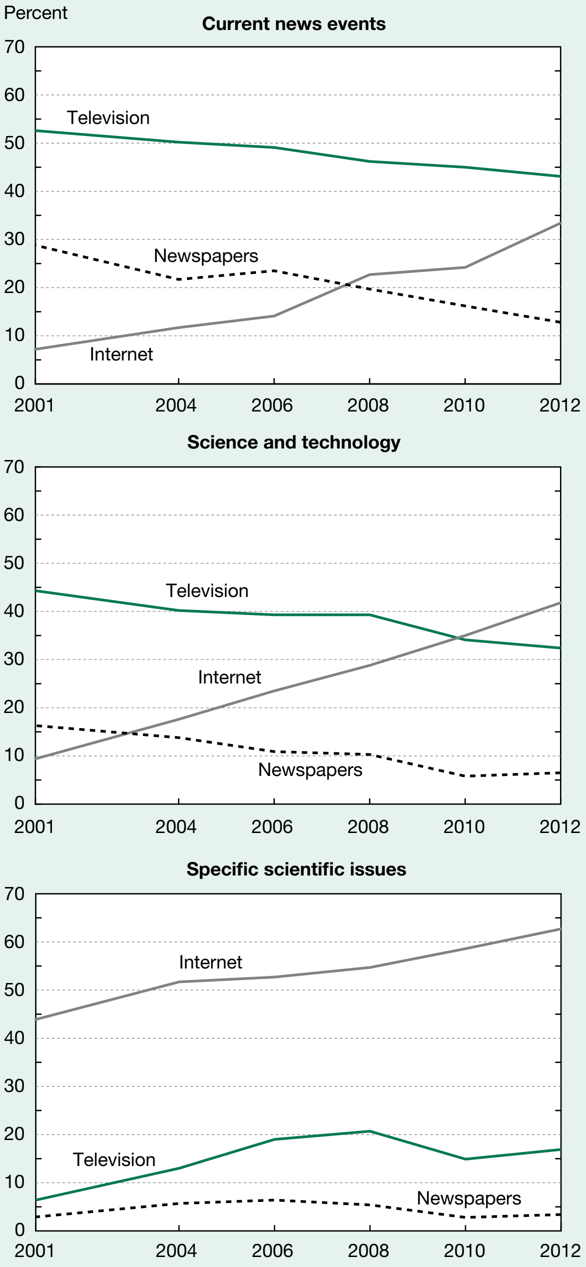
education are more likely to say they get their news, including S&T-related news, from television, whereas those with more education and income get their news from newspapers, television, and the Internet (appendix tables 7-3–7-5).

Figure 7-5
Primary source of information about current news events, science and technology, and specific scientific issues: 2001–12



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006–12). See appendix tables 7-3–7-5.

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Blending traditional and online news sources was also addressed in the context of S&T for the 2012 *Indicators* report based on 2010 GSS data. That survey asked half of the sample a question with response options that distinguished between online and print-format sources for newspapers and magazines. Overall, there was a clear pattern of increasing reliance on online sources for increasingly specific content (NSB 2012). More recent information on what other online sources people may use for S&T information and the degree to which people encounter S&T information as a byproduct of attention to other issues is not available.[9]

Another important aspect to understanding media use is to recognize that people make choices about what media to use based partially on the degree to which they trust that source. Both Pew Research and Gallup data suggest that Americans trust the media less than they did in previous years (Morales 2012; Pew Research Center 2011a, 2012b). Evidence about how Americans judge the credibility of S&T-specific media is, however, scant. A 2006 Pew Internet & American Life Project study of how Americans acquire science information indicates that Internet users who seek science information online do not always assume that the information they find there is accurate. The vast majority reported that they checked information by comparing it to other information they found online, comparing it to offline sources (e.g., science journals, encyclopedia) or by looking up the original source of the information (Horrigan 2006; NSB 2008).

International Comparisons

The 2011 BBVA Foundation survey found that residents of all countries made similar uses of television, newspapers, the Internet, and radio to acquire S&T content. The survey found that 47% of Americans watched television programs addressing S&T topics "very" or "quite" often. The average of the 10 European countries surveyed was 41% but residents of two countries—the United Kingdom (54%) and Denmark (54%)—watched more S&T television than Americans. About one-third (34%) of Americans said they read news items about S&T "very" or "quite" often in newspapers. This was similar to the 10-country European average of 32%. Residents of the Netherlands were the most likely to say they often read S&T news in newspapers (52%), although Denmark (48%) and the United Kingdom (43%) also had relatively high S&T readership. About 32% of Americans said they often read S&T news online, which was a percentage comparable to those of the largest European countries and substantially above the 10-country European average of 24% (BBVA Foundation 2012a). Although these data, compared with the GSS information on media use, may suggest a less prominent role for the Internet, this may reflect a difference in the questions on the two surveys. Whereas the GSS asks people for their primary source of information, the BBVA Foundation survey asked about overall use for each channel.

Outside of Europe and North America, research has also suggested that television is the leading source of S&T

information; newspapers are generally second, and relatively fewer survey respondents cite the Internet as an important source of S&T information. This was true in countries such as Malaysia (MASTIC 2010) and India (Shukla 2005). A 2010 Chinese survey allowed respondents to choose up to three sources of information. About 88% of Chinese indicated that television was a primary source of their S&T information, 59% said newspapers, and 27% said the Internet (CRISP 2010). However, in more widely connected South Korea, a 2010 survey found that more respondents named the Internet (23%) as their primary source of S&T information than newspapers (12%). About 57% said television was their primary source of S&T information. A separate set of measures show that 30% said they "almost never" get S&T information from television. About 53% said they rarely get S&T information from newspapers, and 56% said they rarely get S&T information from the Internet (KOFAC 2011).

Americans and Europeans also appear to differentiate the degree to which they trust scientific information provided by various sources. The 2011 BBVA Foundation survey of 10 European countries and the United States asked respondents to score a range of different groups on an 11-point scale, where "0" meant they did "not trust it at all" and "10" meant they trusted it a "great deal." The results suggest substantial agreement over who should be trusted as an information source. In the United States, professional medical associations were the most trusted, with a mean score of 7.6, but universities (7.4), science museums (7.2), and government (7.2) were also highly trusted. In Europe, universities were the most trusted information sources, with a mean score of 7.2, but medical associations (7.0) and science museums (6.9) were also highly regarded. The score for government was about a point lower in Europe (6.1) than in the United States (7.2) but varied widely across countries. The news media was the least trusted source in both the United States (4.8) and Europe (5.1), but again scores varied widely in Europe. Consumer organizations and environmental organizations had midrange scores in both the United States (6.1 and 6.2, respectively) and in the European countries surveyed (both 6.3) (BBVA Foundation 2012b).

Although the media received relatively low trust scores on the BBVA Foundation S&T survey, a 2011 U.S. survey by Pew Research suggested the media was among the most trusted sources of general information (Pew Research Center 2011a). This difference may reflect the comparison groups involved in the two studies. The Pew Research study asked about the trustworthiness of information from the media versus various actors typically involved in political decision making, and the BBVA study asked about actors from a broader range of sources. The Pew Research study also focused on general media trust, whereas the BBVA Foundation study focused specifically on science.

Involvement

U.S. Patterns and Trends

U.S. residents may also come in contact with S&T through America's rich and diverse informal science and cultural institutions. Many of these institutions actively try to broaden and deepen Americans' intellectual and emotional engagement with science (Bell, Lewenstein, Shouse, and Feder 2009).[10] By offering visitors the flexibility to pursue individual curiosity, such institutions provide exposure to S&T that is well-suited to helping people develop their interests and improve their knowledge, and such institutions can sometimes even change patrons' attitudes.

The 2012 GSS shows that reported attendance at informal science and cultural institutions was down slightly from 2008, although the changes were all quite small.[11] Zoos and aquariums were the most popular type of informal science institutions with 47% of Americans saying they had visited such an organization in the previous year. This represents a drop from 52% in 2008 and 58% in 2001. The Association for Zoos and Aquariums' member surveys have also consistently shown that about half of Americans visit a zoo or aquarium in any given year, but their numbers suggest that attendance stayed relatively stable between 2008 and 2011 at about 175 million visitors and then climbed to 181 million in 2012.[12] According to the GSS, natural history museums (28%) and science and technology museums (25%) continued to attract about the same percentage of people in 2012 as they did in 2008, although these percentages are also down from 2001. In total, 58% of Americans said they had visited at least one of these three types of cultural institutions in the 12 months prior to the 2012 survey, down from 61% in 2008 and 66% in 2001.[13]

The public library remains a widely used resource in communities across America, with 60% of respondents saying that they had visited a library in the previous 12 months. This number was down from 2008 (64%) and 2001 (75%). The percentage visiting art museums (33%)—the other cultural institution in the survey—stayed essentially unchanged from 2008 (34%) and the earlier 2001 survey (32%) (table 7-6; appendix table 7-6).

Americans with more years of formal education are more likely than others to engage in these informal science activities. Those in higher income brackets are more likely to have visited a zoo or aquarium, a natural history or S&T museum, or an art museum but are just as likely as those in the lowest income bracket to have visited a public library. In general, visits to informal science institutions are less common among Americans who are 45 or older (appendix table 7-7).

A 2012 Pew Research study focused on libraries found similar results. It found that 53% of Americans aged 16 or older said they had visited a library in the "past year" and that women (59%) and residents aged 16–17 (62%) were most likely to have done so. Almost everyone (91%) agreed that libraries are "very" or "somewhat" important to their "community as a whole." Many also said they used the library for activities such as researching a "topic of interest" (54%), using a "research database" (46%), and attending a "class, program or lecture for adults" (21%) (Pew Internet & American Life Project 2013).

International Comparisons

The available data—some of which are relatively dated—suggest that Americans are particularly active in the degree to which they make use of a range of informal science and cultural institutions.

China and Japan are the only countries where zoo and aquarium attendance is similar to that in the United States, and China also has similar levels of S&T and natural history museum attendance. Chinese attendance at these types of institutions also appears to be growing, with average attendance up about 8% from 2007 across the five types of cultural institutions measured (NSB 2012) (table 7-6).

The 2011 BBVA Foundation survey of 10 European countries and the United States asked slightly different questions and found that attendance varies greatly between countries. About 32% of Americans said they had visited an S&T museum or exhibition in the previous 12 months. This was higher than the 10-country European average of 25% but similar to the rate of attendance by residents of several specific countries such as Germany (35%), the Netherlands (32%), Denmark (29%), Austria (29%), and France (29%). Also, about 12% of Americans said they had attended a "conference or talk on science or technology topics." This was about the same as the European average (12%) but substantially lower than for countries such as the Netherlands (25%) and Denmark (27%). Americans were, however, nearly twice as likely as those in the 10 European countries surveyed to have made a "virtual visit to a science and technology museum via the Internet." About 20% of Americans said they had made such a "visit" in the previous 12 months, whereas the 10-country European average was 8%, and the highest percentage for an individual country was for Denmark (12%) (BBVA Foundation 2012a). As noted previously, the BBVA Foundation also found that both Americans and Europeans in the 10 countries surveyed see science information from museums as more trustworthy than information from many other groups (BBVA Foundation 2012b).

Table 7-6
Visits to informal science and other cultural institutions, by country/region: Most recent year
(Percent)

Institution	United States (2012)	Brazil (2010)	China (2010)	EU (2005)	India (2004)	Japan (2001)	Malaysia (2008)	South Korea (2010)
Zoo/aquarium[a]	47	22	58	27	35	43	30	28
Natural history museum	28	NA	22	NA	NA	19	NA	NA
Science/technology museum[b]	25	8	27	16	12	12	11	9
Public library[c]	60	29	50	34	27	46	NA	27
Art museum[d]	33	14	27	23	22	34	30	27

NA = not available, question not asked.

EU = European Union; data are not available for Bulgaria and Romania.

[a] "Zoo" for Brazil, India, and Malaysia; "Zoo, aquarium, botanical garden" for China.
[b] "Science museums or technology museums or science centers" for EU; "Science parks" for India; "National Science Centre" for Malaysia; "Science museum or exhibition" for South Korea.
[c] "Library" for Brazil and India.
[d] "Art gallery or exhibition hall" for China; "Museum" for India and Malaysia; "Museum/art gallery" for South Korea.

NOTES: Responses to (United States, Japan) *I am going to read you a short list of places and ask you to tell me how many times you visited each type of place during the last year, that is, the last 12 months* (percentage includes those who visited each institution one or more times); (Brazil, China, EU) *Which of the following have you visited in the last 12 months?* (multiple answers possible); (India) *How frequently did you visit the following during the last 12 months?* (percentage includes those who visited each institution one or more times); (Malaysia, South Korea) *In the past year, how many times did you visit the following places?* (percentage includes those who visited each institution one or more times).

SOURCES: United States—University of Chicago, National Opinion Research Center, General Social Survey (2012); Brazil—Ministry of Science and Technology of Brazil, Public Perceptions of Science and Technology (2010); China—Chinese Association for Science and Technology/China Research Institute for Science Popularization, Chinese National Survey of Public Scientific Literacy (2010); EU—European Commission, Eurobarometer 224/Wave 63.1: Europeans, Science and Technology (2005); India—National Council of Applied Economic Research, National Science Survey (2004); Japan—National Institute of Science and Technology Policy/Ministry of Education, Culture, Sports, Science and Technology, Survey of Public Attitudes Toward and Understanding of Science and Technology in Japan (2001); Malaysia—Malaysian Science and Technology Information Center/Ministry of Science, Technology and Innovation, Survey of the Public's Awareness of Science and Technology: Malaysia (2008); South Korea—Korea Foundation for the Advancement of Science and Creativity, Survey of Public Understanding of Science and Technology (2010). See appendix table 7-6 for U.S. trends.

Science and Engineering Indicators 2014

Public Knowledge about S&T

Science and Engineering Indicators has been assessing Americans' knowledge about science and technology since 1979. Initial questions focused on the proper design of a scientific study and views about whether pseudoscientific belief systems, such as astrology, could be considered scientific. Questions focused on an understanding of probability and an understanding of basic constructs were added in the late 1980s and early 1990s (Miller 2004). These later questions remain the core of the available data on trends in adult Americans' knowledge of science.

Researchers have questioned both the degree to which scientific literacy has a substantial impact on how people make decisions in their public and private lives (see, for example, NSB 2012:7-27; Bauer, Allum, and Miller 2007) and whether a short battery of questions can assess scientific literacy. Despite the limitations of these indicators, evidence suggests that knowledge about science, as measured by the GSS, has a small but meaningful impact on attitudes and behaviors (Allum et al. 2008). In addition, adult responses to an expanded list of knowledge questions drawn from tests given to students nationwide indicate that people who "answered the additional factual questions accurately also tended to provide correct answers to the trend factual knowledge questions" included in the GSS (NSB 2010:7-20). This finding suggests that the trend questions used in this report represent a reasonable indicator of basic science knowledge. At the same time, in light of the limitations of using a small number of questions largely keyed to knowledge taught in school, generalizations about Americans' knowledge of science should be made cautiously. Toumey et al. (2010) recommended additional research aimed at developing a measure of S&T literacy focused on how people actually use S&T knowledge. Similar challenges confront attempts to study health literacy (Berkman, Davis, and McCormack 2010) and political literacy (Delli Carpini and Keeter 1996). More generally, in developing measures for what is often termed *scientific literacy* across nations, the Organisation for Economic Co-operation and Development (OECD 2003) emphasizes that scientific literacy is a matter of degree and that people cannot be classified as either literate or not literate. The OECD noted that literacy had several components:

> Current thinking about the desired outcomes of science education for all citizens emphasizes the development of a general understanding of important concepts and explanatory frameworks of science, of the methods by which science derives evidence to support claims for its knowledge, and of the strengths and limitations of science in the real world. It values the ability to apply this understanding to real situations involving science in which claims need to be assessed and decisions made…
>
> Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. (OECD 2003:132–33)

The degree to which respondents demonstrate an understanding of basic scientific terms, concepts, and facts; an ability to comprehend how S&T generates and assesses evidence; and a capacity to distinguish science from pseudoscience are widely used indicators of basic scientific literacy.

The 2012 GSS continues to show that many Americans provide multiple incorrect answers to basic questions about scientific facts and do not apply appropriate reasoning strategies to questions about selected scientific issues. Residents of other countries, including highly developed ones, appear to perform no better, on balance, when asked similar questions.

Understanding Scientific Terms and Concepts

U.S. Patterns and Trends

A primary indicator of public understanding of science in the United States comes from a nine-question index of factual knowledge questions included in the GSS. In 2012, Americans were able to correctly answer an average of 5.8 of the 9 items (65%), which is slightly up from 2010 (5.6 of 9 items, or 63%) (appendix table 7-8).

The public's level of factual knowledge about science has not changed much over the past two decades (figure 7-6). Since 2001, the average number of correct answers to a series of nine questions for which fully comparable data have been collected has ranged from 5.6 to 5.8 correct responses, although scores for individual questions have varied somewhat over time (appendix tables 7-8 and 7-9). Pew Research used several of the same questions in a 2013 survey and received nearly identical results (Pew Research Center 2013a).

Factual knowledge of science is strongly related to people's level of formal schooling and the number of science and mathematics courses completed. For example, those who had not completed high school answered 45% of the nine questions correctly, and those who had completed a bachelor's degree answered 78% of the questions correctly. The average percentage correct rose to 83% among those who had taken three or more science and mathematics courses in college (figure 7-7). Respondents aged 65 or older are less likely than younger Americans to answer the factual science questions correctly (appendix table 7-8). Younger generations have had more formal education, on average, than Americans coming into adulthood some 50 years ago; these long-term societal changes make it difficult to know whether the association between age and factual knowledge is due primarily to aging processes, cohort differences in education, or other factors. Analyses of surveys conducted between 1979 and 2006 concluded that public understanding of science has increased over time and by generation, even after controlling for formal education levels (Losh 2010, 2012).

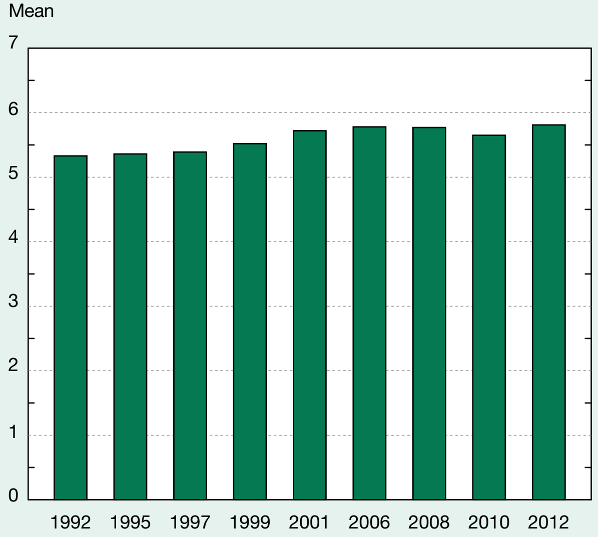
Factual knowledge about science is also associated with sex of the respondent. On average, men tend to answer more factual science knowledge questions correctly (70% correct) than do women (60% correct) (figure 7-7). However, this pattern depends on the science domain referenced in the question. Men typically score higher than women on questions in the physical sciences but not on questions in the biological sciences. Women tend to score at least equally as high as men on the biological science questions and often a bit higher (table 7-7; appendix table 7-10).

Evolution and the Big Bang

The GSS survey includes two additional true-or-false science questions that are not included in the index calculation because Americans' responses appear to reflect factors beyond unfamiliarity with basic elements of science. One of these questions addresses evolution, and the other addresses the origins of the universe. To better understand Americans' responses, the 2012 GSS replicated an experiment first conducted in 2004 (NSB 2006). Half of the survey respondents were randomly assigned to receive questions focused on information about the natural world ("human beings, as we know them today, developed from earlier species of animals" and "the universe began with a big explosion"). The other half were asked the questions with a preface that focused on conclusions that the scientific community has drawn about the natural world ("according to the theory of evolution, human beings, as we know them today, developed from earlier species of animals" and "according to astronomers, the universe began with a big explosion").

In 2012, respondents were much more likely to answer both questions correctly if the questions were framed as being about scientific theories or ideas rather than about natural world facts. For evolution, 48% of Americans answered "true" when presented with the statement that human beings evolved from earlier species with no preface, whereas 72% of those who received the preface said "true," a 24 percentage point difference.[14] These results replicate the pattern from 2004, when the percentage answering "true" went from 42% to 74%, a 32 percentage point difference (NSB 2008). For the big bang question, the pattern was very similar: in 2012, 39% of Americans answered "true" when presented with the statement about the origin of the universe without the preface, whereas 60% of those who heard the statement with the preface answered "true." This represents a 21 percentage point difference. The 2004 experiment found that including the preface increased the percentage who answered correctly

Figure 7-6
Mean number of correct answers to trend factual knowledge of science scale: 1992–2012



NOTES: Mean number of correct answers to the nine questions that are included in the trend factual knowledge of science scale; see appendix table 7-8 for explanation, list of questions, and percentage of questions answered correctly. See appendix tables 7-9 and 7-10 for responses to individual questions.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1992–2001); University of Chicago, National Opinion Research Center, General Social Survey (2006–12).

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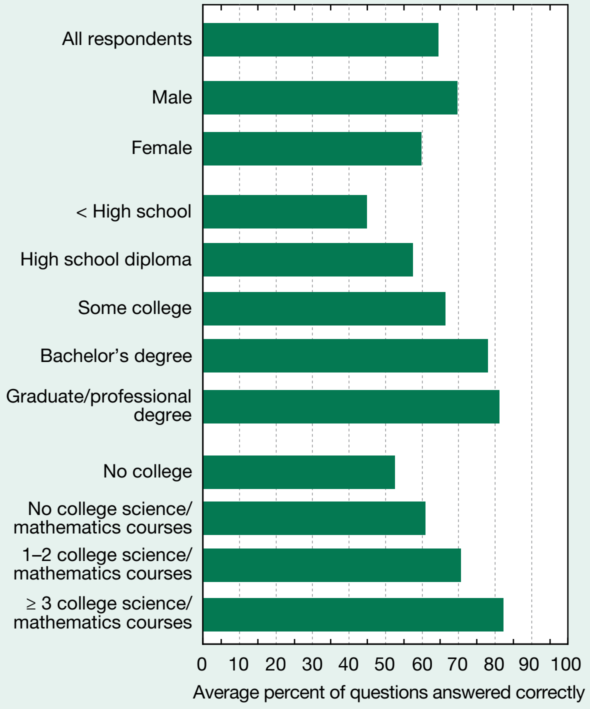
Figure 7-7
Correct answers to trend factual knowledge of science scale, by respondent characteristic: 2012



NOTES: Data reflect the average percentage of nine questions answered correctly. "Don't know" responses and refusals to respond are counted as incorrect. See appendix table 7-8 for explanation, list of questions, and additional respondent characteristics. See appendix tables 7-9 and 7-10 for responses to individual questions.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012).

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from 33% to 62%, a 29 percentage point difference (NSB 2008). Residents of other countries have been more likely than Americans to answer "true" to the evolution question.[15]

International Comparisons

Researchers in a range of countries have asked adults in their countries identical or substantially similar questions to test their factual knowledge of science in past years. Knowledge scores for individual items vary from country to country, and no country consistently outperforms the others. For the physical science and biological science questions, knowledge scores are relatively low in China, Russia, and Malaysia. Compared with scores in the United States and the EU overall, scores in Japan are also relatively low for several questions (table 7-8).[16]

Science knowledge scores have also varied across Europe, with northern European countries, led by Sweden, scoring the highest on a set of 13 questions. For a smaller set of four questions, administered in 12 European countries in 1992 and 2005, each country performed better in 2005. In contrast, U.S. data on science knowledge did not show upward trends over the same period. In Europe, as in the United States, men, younger adults, and more highly educated people tend to score higher on these questions (NSB 2008).

The 2011 BBVA Foundation survey of 10 European countries and the United States included a set of 22 knowledge questions that were mostly different from those that have traditionally been included in *Indicators*. On average, the United States—with a mean score of 14.3 correct answers—performed similarly to many of the European countries surveyed, with a score close to the European average (13.4). The highest scoring countries were Denmark (15.6) and the Netherlands (15.3). Germany (14.8), the Czech Republic (14.6), Austria (14.2), the United Kingdom (14.1), and France (13.8) all had scores similar to those of the United States.

There were some questions on which Europeans, however, did much better than Americans. For example, for the statement, "the earliest humans lived at the same time as the dinosaurs," about 43% of Americans correctly answered "false," whereas 61% of Europeans in the 10 countries surveyed gave the correct response. Another question on which Americans did substantially worse focused on nuclear energy. About 47% of Americans correctly indicated that the "greenhouse effect" is not caused by the use of nuclear energy, in comparison to 58% of Europeans. Conversely, there were several questions on which Americans did substantially better (BBVA Foundation 2012a).[17]

Table 7-7

Correct answers to factual knowledge and scientific process questions in physical and biological sciences, by sex: 1999–2012

(Average percent correct)

Science topic/sex	1999	2001	2004	2006	2008	2010	2012
Physical science index[a]							
Male	72	73	73	74	74	73	75
Female	57	59	55	59	61	60	61
Biological science index[b]							
Male	59	61	62	63	60	62	59
Female	61	65	65	66	64	64	62

[a] Physical science index includes five questions:
- *The center of the Earth is very hot*. (True)
- *All radioactivity is man-made*. (False)
- *Lasers work by focusing sound waves*. (False)
- *Electrons are smaller than atoms*. (True)
- *The continents have been moving their location for millions of years and will continue to move*. (True)

[b] Biological science index includes six questions (questions 3 and 4 have two parts):
- *It is the father's gene that decides whether the baby is a boy or a girl*. (True)
- *Antibiotics kill viruses as well as bacteria*. (False)
- *A doctor tells a couple that their genetic makeup means that they've got one in four chances of having a child with an inherited illness.* (1) *Does this mean that if their first child has the illness, the next three will not?* (No); (2) *Does this mean that each of the couple's children will have the same risk of suffering from the illness?* (Yes) Data represent a composite of correct responses to both questions.
- *Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many of them experience lower blood pressure levels. The second scientist wants to give the drug to 500 people with high blood pressure and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug? Why is it better to test the drug this way?* (The second way because a control group is used for comparison.) Data represent a composite of correct responses to both questions.

NOTES: Data reflect the average percentage of questions in the index answered correctly. "Don't know" responses and refusals to respond are counted as incorrect.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1999, 2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006–12). See appendix tables 7-9 and 7-10 for factual knowledge questions. See appendix tables 7-11 and 7-12 for scientific process questions (probability and experiment).

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Little international polling is done on the question of evolution or the big bang. However, residents of other countries have typically been more likely than Americans to say they believe that “human beings, as we know them today, developed from an earlier species of animals.” For example, 70% of European respondents in 2005 (NSB 2006) and 76% of Japanese respondents in 2011 (NISTEP 2012) gave this response.

Reasoning and Understanding the Scientific Process

U.S. Patterns and Trends

Another indicator of public understanding of science focuses on understanding of how science generates and assesses evidence, rather than knowledge of particular facts. Such measures reflect recognition that knowledge of specific

Table 7-8
Correct answers to factual knowledge questions in physical and biological sciences, by country/region: Most recent year
(Percent giving correct answer)

Question	United States[a] (2012)	China (2010)	EU (2005)	India (2004)	Japan (2011)	Malaysia (2008)	Russia (2003)	South Korea (2004)
Physical science								
The center of the Earth is very hot. (True)	84	56	86	57	84	66	NA	87
The continents have been moving their location for millions of years and will continue to move. (True)	83	50	87	32	88	44	40	87
Does the Earth go around the Sun, or does the Sun go around the Earth? (Earth around Sun)	74	NA	66	70	NA	72	NA	86
All radioactivity is man-made. (False)	72	48	59	NA	69	14	35	48
Electrons are smaller than atoms. (True)	53	27	46	30	32	33	44	46
Lasers work by focusing sound waves. (False)	47	23	47	NA	32	16	24	31
The universe began with a huge explosion. (True)	39	NA	NA	34	NA	NA	35	67
Biological science								
It is the father’s gene that decides whether the baby is a boy or a girl.[b] (True)	63	58	64	38	29	40	22	59
Antibiotics kill viruses as well as bacteria.[c] (False)	51	28	46	39	33	8	18	30
Human beings, as we know them today, developed from earlier species of animals. (True)	48	66	70	56	76	NA	44	64

NA = not available, question not asked.

EU = European Union; data are not available for Bulgaria and Romania.

[a] See appendix table 7-9 for U.S. trends.
[b] China and Europe surveys asked about “mother’s gene” instead of “father’s gene.”
[c] Japan survey asked about “antibodies” instead of “antibiotics.”

SOURCES: United States—University of Chicago, National Opinion Research Center, General Social Survey (2012); China—Chinese Association for Science and Technology/China Research Institute for Science Popularization, Chinese National Survey of Public Scientific Literacy (2010); EU—European Commission, Eurobarometer 224/Wave 63.1: Europeans, Science and Technology (2005), and Eurobarometer 224/Wave 64.3: Europeans and Biotechnology in 2005: Patterns and Trends (2006); India—National Council of Applied Economic Research, National Science Survey (2004); Japan—National Institute of Science and Technology Policy/Ministry of Education, Culture, Sports, Science and Technology, Survey of Public Attitudes Toward and Understanding of Science and Technology in Japan (2011); Malaysia—Malaysian Science and Technology Information Centre/Ministry of Science, Technology and Innovation, Survey of the Public’s Awareness of Science and Technology: Malaysia (2008); Russia—Gokhberg L, Shuvalova O, Russian Public Opinion of the Knowledge Economy: Science, Innovation, Information Technology and Education as Drivers of Economic Growth and Quality of Life, British Council, Russia (2004); South Korea—Korea Science Foundation (now Korea Foundation for the Advancement of Science and Creativity), Survey of Public Attitudes Toward and Understanding of Science and Technology (2004).

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S&T facts is conceptually different from knowledge about the overall scientific processes (Miller 1998).

Data on three general topics—probability, experimental design, and the scientific method—show trends in Americans' understanding of the process of scientific inquiry. One set of questions tests how well respondents apply the principles of probabilistic reasoning to a series of questions about a couple whose children have a 1 in 4 chance of suffering from an inherited disease. A second set of questions deals with the logic of experimental design, asking respondents about the best way to design a test of a new drug for high blood pressure. A third, open-ended question probes what respondents think it means to "study something scientifically." Because probability, experimental design, and the scientific method are all central to scientific research, these questions are relevant to how respondents evaluate scientific evidence. These measures are reviewed separately and then as a combined indicator of public understanding about scientific inquiry.

With regard to probability, 82% of Americans in 2012 correctly indicated that the fact that a couple's first child has the illness has no relationship to whether three future children will have the illness. About 72% of Americans correctly responded that the odds of a genetic illness are equal for all of a couple's children. Overall, 65% got both probability questions correct. Understanding of probability has been fairly stable over time, with the percentage giving both correct responses ranging from 64% to 69% since 1999 and going no lower than 61% dating back to 1990 (table 7-9; appendix tables 7-11 and 7-12).[18]

With regard to understanding experiments, one-third (34%) of Americans were able to answer a question about how to test a drug and then provide a correct response to an open-ended question that required them to explain the rationale for an experimental design (i.e., giving 500 people a drug while not giving the drug to 500 additional people as a control group). A smaller percentage of people were able to answer this set of questions in 2012 than were in 2010, when 51% answered correctly (table 7-9). However, this change should be treated with particular caution because of the way these types of survey responses rely on human coders to categorize responses and because the 2010 figure represents an historical high.[19]

The percentage of people the 2012 GSS judged as understanding what it means to study something scientifically was more consistent with previous surveys. About 20% of Americans were scored as correctly answering the GSS question on this topic. When describing the scientific method, these respondents mentioned that it involves at least one of the following: testing a theory using hypotheses, conducting an experiment with a control group, or making rigorous and systematic comparisons. The percentage of Americans providing at least one of these acceptable answers has declined somewhat from a high of 26% in 2001, although the 2012 result is similar to percentages in recent years.

Table 7-9
Correct answers to scientific process questions: Selected years, 1999–2012
(Percent)

Question	1999	2001	2004	2006	2008	2010	2012
Understanding of scientific inquiry scale[a]	32	40	39	41	36	42	33
Components of understanding scientific inquiry scale							
Understanding of probability[b]	64	67	64	69	64	66	65
Understanding of experiment[c]	34	40	46	42	38	51	34
Understanding of scientific study[d]	21	26	23	25	23	18	20

[a] To be classified as understanding scientific inquiry, the survey respondent had to (1) answer correctly the two probability questions stated in footnote b and (2) either provide a theory-testing response to the open-ended question about what it means to study something scientifically (see footnote d) or a correct response to the open-ended question about experiment (i.e., explain why it is better to test a drug using a control group [see footnote c]).

[b] To be classified as understanding probability, the survey respondent had to answer correctly *A doctor tells a couple that their genetic makeup means that they've got one in four chances of having a child with an inherited illness.* (1) *Does this mean that if their first child has the illness, the next three will not have the illness?* (No); and (2) *Does this mean that each of the couple's children will have the same risk of suffering from the illness?* (Yes).

[c] To be classified as understanding experiment, the survey respondent had to answer correctly (1) *Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many of them experience lower blood pressure levels. The second scientist wants to give the drug to 500 people with high blood pressure and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug?* and (2) *Why is it better to test the drug this way?* (The second way because a control group is used for comparison).

[d] To be classified as understanding scientific study, the survey respondent had to answer correctly (1) *When you read news stories, you see certain sets of words and terms. We are interested in how many people recognize certain kinds of terms. First, some articles refer to the results of a scientific study. When you read or hear the term scientific study, do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means?* and (2) (If "clear understanding" or "general sense" response) *In your own words, could you tell me what it means to study something scientifically?* (Formulation of theories/test hypothesis, experiments/control group, or rigorous/systematic comparison).

NOTES: Data reflect the percentage of survey respondents who gave a correct response to each concept. "Don't know" responses and refusals to respond are counted as incorrect and are not shown. See appendix table 7-11 for more detail on the probability questions and for years before 1999.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1999, 2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006–12).

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Overall, when these questions are combined into an overall measure of "understanding of scientific inquiry," the 2012 results are relatively low compared with those from other years. About 33% of Americans could both correctly respond to the two questions about probability and provide a correct response to at least one of the open-ended questions about experimental design or what it means to study something scientifically. The 2010 survey represents a high point (42%), and the current result is closest to scores seen in the late 1990s but lower than scores in the other surveys conducted since 2001 (table 7-9; appendix table 7-11). In general, respondents with more education did better on the scientific inquiry questions (figure 7-8; appendix table 7-12).

International Comparisons

The 2011 BBVA Foundation survey of 10 European countries and the United States included the standard question about probability in the context of genetic disease. In this instance, 61% of Americans could correctly indicate that a child's susceptibility to a genetic disease was unaffected by whether the child's siblings suffered from the disease. This percentage is substantially lower than the 82% found in the 2012 GSS (see previous section). The 10-country European average was 49%, but residents of both Denmark (81%) and the Netherlands (79%) did better on this question than Americans. UK residents (60%) had a score nearly identical to that of U.S. residents (BBVA Foundation 2012a).

Recent surveys from Asia also touch on reasoning and understanding. A 2010 Chinese survey reported that 49% understood the idea of probability, 20% understood the need for comparisons in research, and 31% understood the idea of "scientific research" (CRISP 2010). The exact wording of the questions used was not available, but given that much of the survey replicated past U.S. questions reported in *Science and Engineering Indicators*, it seems likely that these questions were similar to those asked in the United States. In a July 2011 Japanese survey, 62% correctly answered a multiple choice question about the use of control groups in research experiments, whereas 57% answered correctly in a follow-up December 2011 survey (NISTEP 2012). A Korean survey used self-report measures of knowledge. Koreans were most likely to say they knew "well" or "very well" about diseases (54%) and least likely to say they knew about nanotechnology (14%). Koreans were also unlikely to say they knew about stem cell research (15%) and genetic modification (20%) (KOFAC 2011).

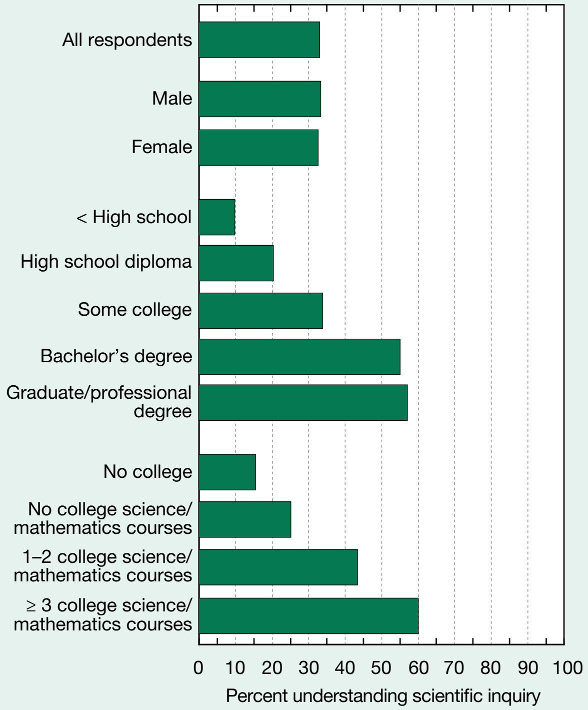
Comparisons of Adult and K–12 Student Understanding

The 2008 GSS included several additional questions on the scientific process that also indicated that many Americans lack an understanding of experimental design.[20] Between 29% and 57% of Americans responded correctly to various questions measuring the concepts of scientific experiment and controlling variables. Only 12% of Americans responded correctly to all the questions on this topic, and nearly 20% did not respond correctly to any of them (NSB 2010). These data raise further questions about how well Americans can reliably apply a generalized understanding of experimental design across different situations. Responses to these questions also allowed a comparison between adults' understanding of experimentation and that of middle school students tested on the same questions. On the three experimental knowledge questions in which direct comparison is possible, adults' scores were similar to a national sample of middle school students on one question but were lower on two others (NSB 2010).

Pseudoscience

Another indicator of public understanding about S&T comes from a measure focused on the public's capacity to distinguish science from pseudoscience. Since 1979, surveys have asked Americans whether they view astrology as being scientific. In 2012, about half of Americans (55%) said astrology is "not at all scientific." One-third (32%) said they thought astrology was "sort of scientific," and 10% said it was "very scientific." About 4% said they did not know. In comparison, in 2010, 62% of Americans said that astrology was not scientific, and this percentage has hovered between 55% (2012) and 66% (2004) since 1985. The only years

Figure 7-8
Understanding scientific inquiry, by respondent characteristic: 2012



NOTES: See appendix table 7-11 for an explanation of understanding scientific inquiry and questions included in the index. See appendix table 7-12 for additional respondent characteristics.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012).

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when a smaller percentage of respondents said that astrology was not at all scientific were in 1979, when 50% gave this response, and in 1983, when 51% gave this response.

Respondents with more years of formal education and higher income were less likely to see astrology as scientific. For example, in 2012, 72% of those with graduate degrees indicated that astrology is "not at all scientific," compared with 34% of those who did not graduate from high school. Between 2010 and 2012, responses to the astrology question changed more among Americans with less education and factual knowledge than among other Americans. For example, in 2010, 79% of those high in factual knowledge said astrology was "not at all scientific," which was only 5% more than the 74% who gave this response in 2012. In contrast, 52% of those with the lowest factual knowledge said astrology was unscientific in 2010 compared with 35% in 2012, which is a 17% change.

Age was also related to perceptions of astrology. Younger respondents, in particular, were the least likely to regard astrology as unscientific, with 42% of the youngest age group (18–24) saying that astrology is "not at all scientific." The largest change, however, occurred in the 35–44 age group. In 2010, 64% of respondents in this group said that astrology was not scientific, whereas 51% gave this response in 2012, which is a 13% change (appendix table 7-13).[21]

International Comparisons

A 2010 Chinese survey had multiple questions about superstition. It found that 80% of respondents did not believe in "fortune telling sticks," 82% did not believe in face reading, 87% did not believe in dream interpretation, 92% did not believe in horoscopes, and 95% did not believe in "computer fortune telling" (CRISP 2010).

Perceived Knowledge about Causes and Solutions to Environmental Problems

U.S. Patterns and Trends

Along with actual knowledge, perceived knowledge may also affect individuals' attitudes and behaviors (Ladwig et al. 2012; Griffin, Dunwoody, and Yang 2013). The 2010 GSS included two questions about how much Americans believed they personally knew about the causes of and solutions to environmental problems. These questions used a 5-point scale that went from "1" for "know nothing at all" to "5" for "know a great deal." About 27% of Americans chose a "4" or "5" when asked to assess their knowledge of the causes of environmental problems, and 14% chose "4" or "5" to describe their knowledge of environmental solutions (figure 7-9; appendix tables 7-14 and 7-15).

International Comparisons

The 2010 International Social Survey Programme (ISSP) allows for international comparisons of perceived science knowledge. The 2010 ISSP asked questions in 31 countries, including the United States, about perceived knowledge bearing on environmental issues. The results show that residents of most other countries surveyed expressed more confidence than Americans about their knowledge of the causes of and solutions to environmental problems. The country with the highest percentage of survey takers choosing "4" or "5" on the 5-point scale for perceived knowledge of the causes of environmental problems was Norway (50%). The United States (27%) had a much lower percentage, although its percentage was similar to that of many other countries. Only Slovak Republic respondents reported less knowledge, on average, than U.S. respondents about causes of environmental problems. Residents of more than half of the countries surveyed gave responses that suggested they knew more. On the subject of environmental solutions, the top countries saw about one-third of residents saying they understood the solutions to environmental problems. The United States (14%) was among the countries with the lowest percentages of residents who said they understood the solutions to environmental problems. Only the Russians (13%) reported less knowledge, on average, than the Americans about environmental solutions. It is also noteworthy that no country's citizens thought they knew more about solutions than causes but that the difference in mean scores for the two questions was almost always less than half a point on the 5-point scale used by the ISSP (figure 7-9; appendix tables 7-14 and 7-15).

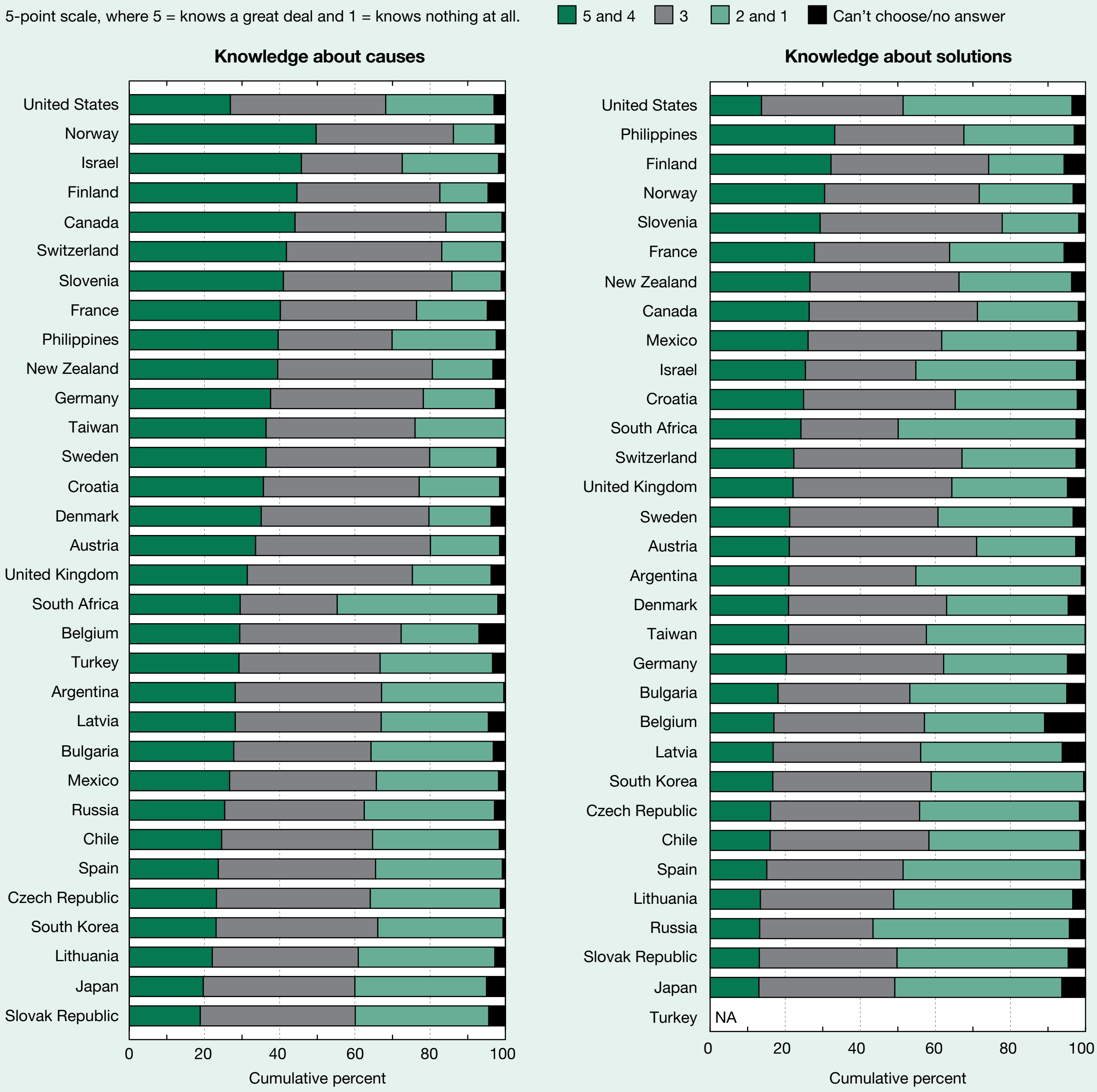
Public Attitudes about S&T in General

How people perceive science can matter in a range of different ways. It can affect the public's willingness to fund S&T through public investment, young people's willingness to enter into S&T training and choose jobs in S&T, and parents' willingness to encourage such career paths. Committing resources—whether time or money—to S&T means trusting that our commitment will pay off over the long term for ourselves, our families, and our communities. General views about S&T may also affect our views about specific technologies and research programs that could enhance our lives or pose new risks.

This section presents general indicators of public attitudes and orientations toward S&T in the United States and other countries. It covers views on the promises of S&T and reservations about science, overall support for government funding of research, confidence in scientific community leaders, views of science and engineering as occupations, and views about the degree to which specific fields and work activities are scientific. Overall, the data make it clear that Americans support both S&T and the people involved in S&T.

Figure 7-9

Public self-assessment of knowledge about causes of and solutions to environmental problems, by country/economy: 2010



NA = not available.

NOTES: Responses to *How much do you feel you know about the causes of/solutions to these sorts of environmental problems, where 1 indicates you feel you know nothing at all and 5 indicates you feel you know a great deal?* Percentages may not add to 100% because of rounding.

SOURCE: International Social Survey Program, Environment Module (2010). See appendix tables 7-14 and 7-15.

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Promises and Reservations about S&T

U.S. Patterns and Trends

Overall, Americans remain strong believers in the benefits of S&T even while seeing potential risks. Surveys since at least 1979 show that roughly 7 in 10 Americans see the effects of scientific research as more positive than negative for society. In 2012, this included 50% who said they believed the benefits "strongly" outweigh the negatives and 22% who said the benefits slightly outweigh the potential harms (appendix table 7-16). About 7% said science creates more harms than benefits. These numbers are generally consistent with earlier surveys; Americans saying the benefits strongly or slightly outweigh the harmful results have ranged from 68% to 80% since this question was initially asked in the 1970s (figure 7-10).

Americans with more education, income, and scientific knowledge hold a stronger belief in the benefits of science than others. For example, 55% of those who had not completed high school said they believe science does more good than harm, but 89% of those with bachelor's degrees and 92% of those with graduate degrees expressed this view. Similarly, 86% of those in the top income quartile saw more benefits than harms from science, whereas 60% of those in the lowest bracket expressed this view. Almost all (87%) of those in the top knowledge quartile said they saw more benefits than harms, but just half (50%) of those in the lowest knowledge quartile gave this response (appendix table 7-16).[22]

Americans also overwhelmingly agree that S&T will foster "more opportunities for the next generation" but continue to express worry that it may make life change too quickly. In 2012, about 87% of Americans "agreed" or "strongly agreed" that S&T will create more opportunities (appendix table 7-17). This was down very slightly from the 2006 through 2010 surveys, during which time 89%–91% agreed about the relative value of S&T (NSB 2008, 2010, 2012). Fewer Americans, however, said they were worried about the pace of change. In 2012, 42% of Americans agreed that "science makes our way of life change too fast" (appendix table 7-18). This represents a substantial drop from 2010, when 51% expressed worry about the pace of change (NSB 2012). It also represents a shift in the trend line as worry had previously increased steadily from 33% in 2004 (NSB 2006, 2008, 2010).

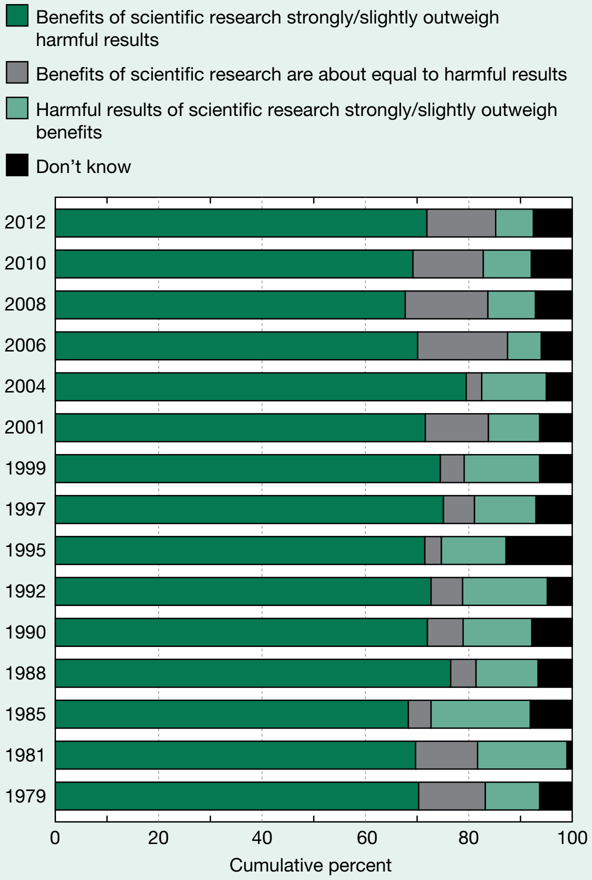
International Comparisons

The 2010 ISSP also included two questions about the promises of science. It asked respondents in 31 countries whether they thought that societies were putting too much faith in science and whether science may do more harm than good. Comparable data were also collected by the ISSP program in multiple countries in 1993 and 2000.

In 2010, about 41% of U.S. residents "agreed" or "strongly agreed" that "we believe too often in science, and not enough in feelings and faith." The average response of U.S. residents put the United States in the middle range of countries. Over time, Americans have become more likely to disagree with the statement, along with several other countries (figure 7-11; appendix table 7-19). A small proportion of Americans (14%) also said they "strongly agreed" or "agreed" that "modern science does more harm than good" in 2010 (figure 7-11). The average response has remained relatively stable across the three survey years in most countries, and most other countries surveyed also expressed more negative views toward science (appendix table 7-20).

The 2011 BBVA Foundation survey also asked a range of questions about general attitudes toward science. It found

Figure 7-10
Public assessment of scientific research: 2012–1979



NOTES: Responses to *People have frequently noted that scientific research has produced benefits and harmful results. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?* In this figure, "Benefits...outweigh harmful results" and "Harmful results...outweigh benefits" each combine responses of "strongly outweigh" and "slightly outweigh." Figure includes all years for which data were collected. Percentages may not add to 100% because of rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1979–2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006–12). See appendix table 7-16.

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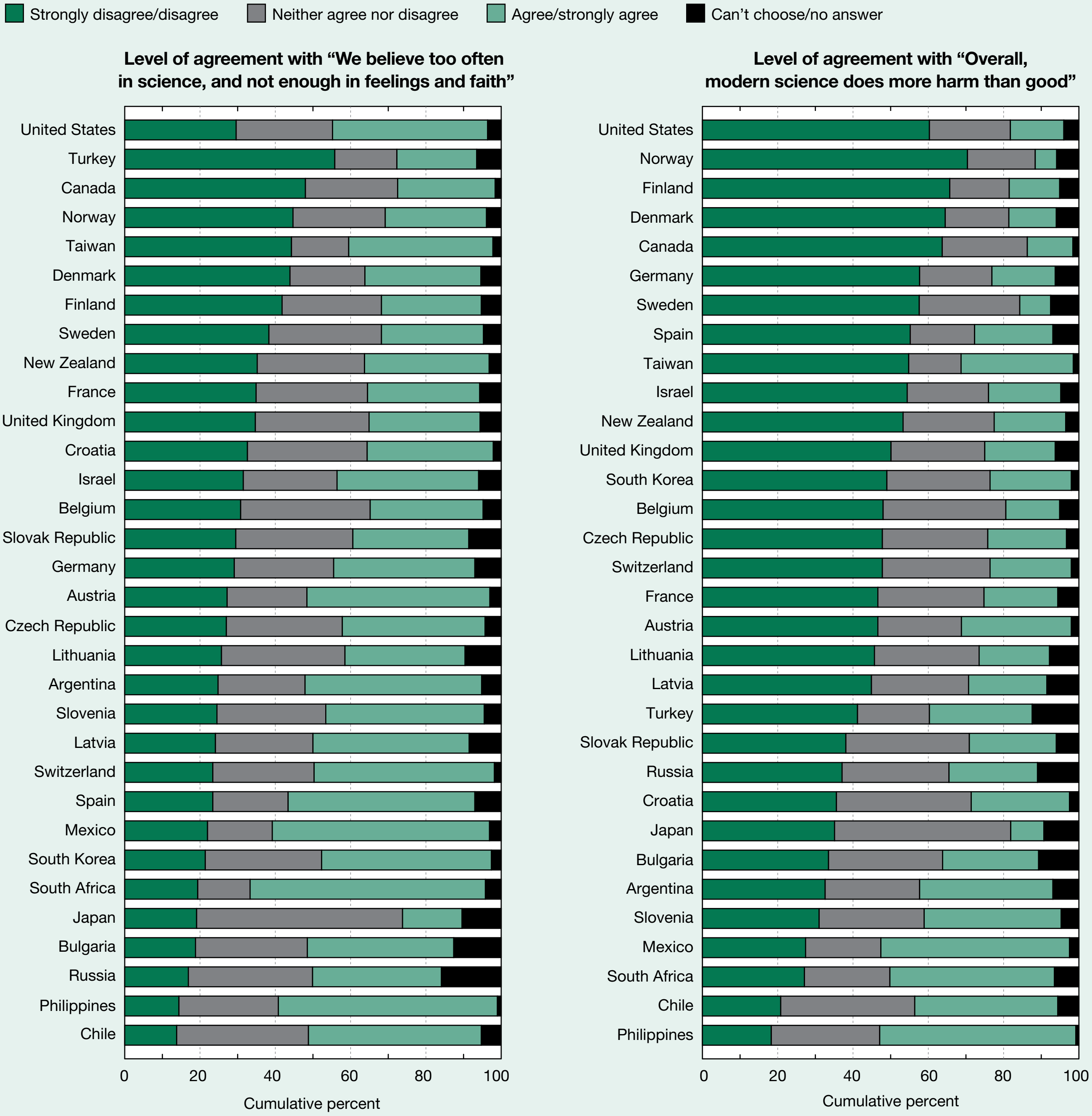
that Europeans and Americans were similar in endorsing the benefits of science but that Europeans in the 10 countries surveyed expressed more reservations. The survey used an 11-point scale that went from "totally disagree" at "0" to "totally agree" at "10" for all questions. Seven questions assessed perceptions about the "positive facets of science," and 11 questions addressed reservations (appendix table 7-21).

As noted, it appears that Americans hold similar views to the 10-country European average and, in some cases,

Figure 7-11

Public assessment of belief in science versus faith, and whether science does more harm than good, by country/economy: 2010



NOTES: Responses to *How much do you agree or disagree with the statements: We believe too often in science, and not enough in feelings and faith* and *Overall, modern science does more harm than good?* Percentages may not add to 100% because of rounding.

SOURCE: International Social Survey Program, Environment Module (2010). See appendix tables 7-19 and 7-20.

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see less promise for science than the residents of the other countries surveyed. For example, survey recipients were asked whether they disagreed or agreed with the statement that “science is the motor of progress.” The U.S. average agreement was 6.9, lower than the European average of 7.4 and tied with the United Kingdom for the lowest average. The Czech Republic (7.9) and Poland (7.9) had the highest average agreement. Another statement addressed whether “science is central to a society’s culture.” The U.S. average was 6.3, lower than the overall European average of 6.8, although a few European countries had lower scores. The lowest was Denmark, with an average score of 5.3, and the highest was Germany, with an average score of 7.3.

On several questions, however, Americans expressed fewer reservations than Europeans. For example, fewer Americans agreed that “people would be better off if they lived a simpler life, without so much science and technology.” Americans had an average score of 4.4 on this question, whereas the 10-country European average was 5.1. Germany (4.0) and Denmark (3.4) were the only countries that provided a more pro-science response than the United States. Indeed, Denmark and Germany were the only two countries that were consistently as positive, or more positive, than the United States. The United Kingdom was also often similar to the United States. Americans were the most likely to disagree that “science drives out religion” and that “science makes our way of life change too fast.” The U.S. score on the religion question was 3.9, whereas the 10-country European average was 4.9. The U.S. score on the “way of life question” was 4.7, whereas the 10-country European average was 6.0 (BBVA Foundation 2012b).

Within Asia, different question wording makes comparisons difficult, but most respondents appeared to support S&T. In 2010, 75% of Chinese respondents “fully” or “basically” agreed that S&T brings more advantages than disadvantages, whereas only one-fifth (20%) said they thought that “we are too dependent on science such that we overlook belief” (CRISP 2010). In 2011, 54% of Japanese respondents said “there are more pluses” or “on the whole, there are more pluses” to S&T development (NISTEP 2012). Koreans were asked separate questions about the risks and benefits of S&T. About 78% “agreed” or “somewhat agreed” that S&T promotes a “healthy and convenient life,” and 76% agreed that S&T “helps in everyday life.” However, 65% also agreed that S&T “creates problems” (KOFAC 2011).

Federal Funding of Scientific Research

U.S. Patterns and Trends

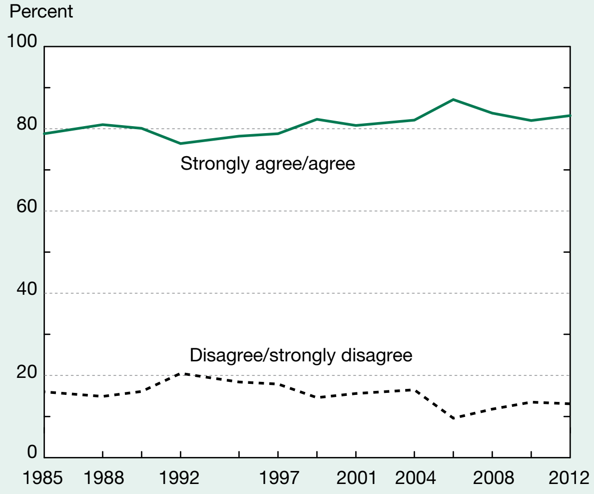
U.S. public opinion consistently and strongly supports federal spending on basic scientific research. In 2012, 83% of Americans “agreed” or “strongly agreed” that “even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government.” This is similar to both 2010 (82%) and 2008 (84%). Since 1985, agreement with this statement has ranged from a low of 76% in 1992 to a high of 87% in 2006 (figure 7-12; appendix table 7-22).

Americans with relatively higher levels of education and more science knowledge are particularly likely to support funding scientific research. For example, 75% of those who had not completed high school agreed that funding was needed, but 94% of those with graduate degrees expressed this view. Also, 73% of those in the lowest quartile of S&T knowledge agreed that support was needed, whereas 88% of those in the highest knowledge quartile expressed this view (appendix table 7-23).

Another indicator of views about S&T is the percentage of Americans who say they think the government is spending too little on scientific research. In 2012, 38% of respondents said government was spending “too little,” 45% said the amount was “about right,” and 12% said it was “too much.” The percentage who said they thought the government spent too little on science gradually increased from 1981 to 2006, fluctuating between 29% and 34% in the 1980s, between 30% and 37% in the 1990s, and between 34% and 41% in the 2000s and 2010s (figure 7-13; appendix table 7-24). Pew Research also found that about one-third of Americans support more spending on scientific research (Pew Research Center 2011b). Other research showed that more than half of Americans reject cuts to science (Pew Research Center

Figure 7-12

Public opinion on whether the federal government should fund basic scientific research: 1985–2012



NOTES: Responses to *Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government. Do you strongly agree, agree, disagree, or strongly disagree?* Responses of “don’t know” are not shown.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1985–2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006–12). See appendix tables 7-22 and 7-23.

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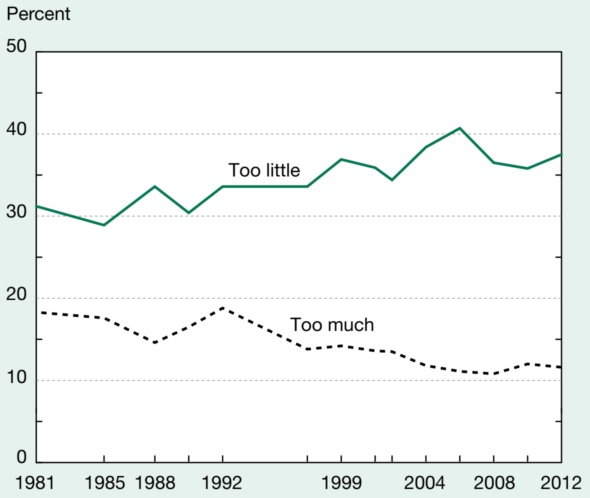
2012c) and nearly three-quarters of Americans expect that spending on scientific research will pay off in the long term (Pew Research Center 2009).

Compared with support for government spending in other areas, however, support for spending on scientific research is not especially strong, according to the GSS. Americans are more likely to say several other areas need government spending more than S&T. Education (75%) consistently receives the most support from Americans, compared with about 6 in 10 who say that government should spend more on assistance to the poor (61%), health (61%), development of alternative energy sources (60%), and environmental protection (58%). Support for increased spending on scientific research (38%) is roughly comparable to that for spending on improving mass transportation (38%) but garners more support than parks and recreation (31%), national defense (24%), space exploration (22%), and assistance to foreign countries (7%) (figure 7-14; appendix table 7-24).[23]

International Comparisons

In other countries where similar, although not identical, questions have been asked, respondents also express strong support for government spending on scientific research. In 2010, 72% of EU residents agreed that “even if it brings no immediate benefits, scientific research which adds to knowledge should be supported by government,” and only 9% disagreed (European Commission 2010a). In 2010, 77% of Chinese agreed to a similar statement regarding the need for support (CRISP 2010). Although the comparable U.S. percentages for agreement with the need for support are nominally higher (83%), the absence of a middle option (e.g., “neither agree nor disagree”) rather than a difference in underlying opinions may account for this difference. Levels of agreement in South Korea, Malaysia, Japan, and Brazil

Figure 7-13
Public assessment of amount of government spending for scientific research: 1981–2012



NOTES: Responses to *We are faced with many problems in this country, none of which can be solved easily or inexpensively. I’m going to name some of these problems, and for each one, I’d like you to tell me if you think that the government is spending too little money on it, about the right amount, or too much: [supporting scientific research].* Responses of “right amount” and “don’t know” are not shown.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1981–2001); University of Chicago, National Opinion Research Center, General Social Survey (2002–12). See appendix table 7-24.

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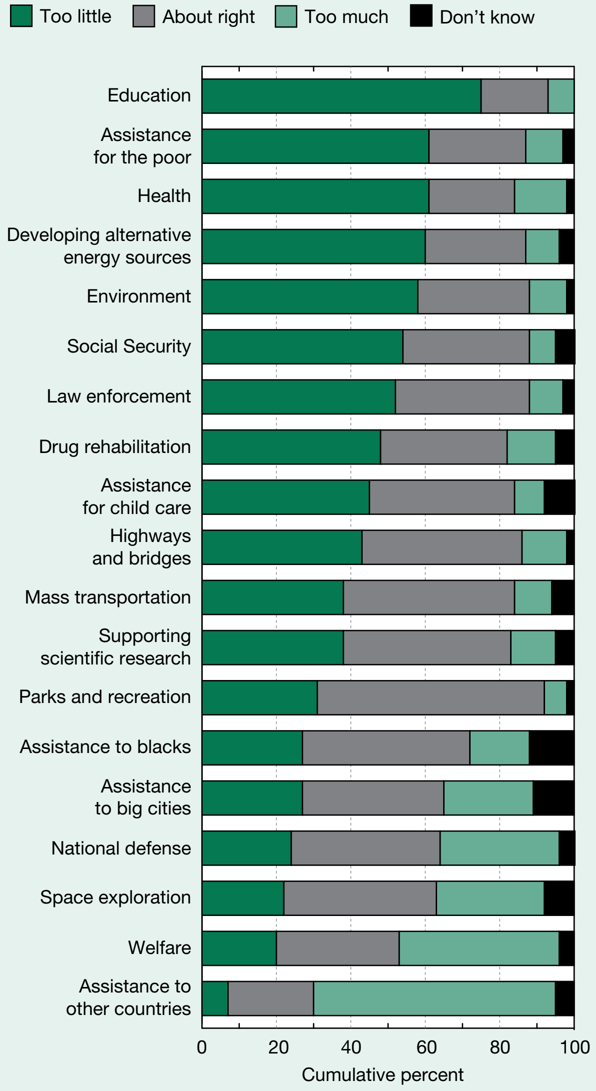
Figure 7-14
Public assessment of government spending in various policy areas: 2012



NOTE: Responses to *We are faced with many problems in this country, none of which can be solved easily or inexpensively. I’m going to name some of these problems, and for each one, I’d like you to tell me if you think that the government is spending too little money on it, about the right amount, or too much.*

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix table 7-24.

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have also been similar to the United States and Europe (NSB 2012). In 2010, 64% of Koreans said S&T “requires public support,” and 35% said they wanted to see more investment in S&T research (KOFAC 2011).

Confidence in the Science Community’s Leadership

U.S. Patterns and Trends

Few members of the public have the background knowledge or resources to fully evaluate scientific questions in the public sphere. People, therefore, often rely on how they perceive decision makers as a decision aid (Earle, Siegrist, and Gutscher 2007; Kahan, Jenkins-Smith, and Braman 2011). Public confidence in leaders of the scientific community can therefore affect public acceptance of findings and conclusions based on scientific research. Since 1973, the GSS has tracked public confidence in the leadership of various institutions, including the scientific community. The GSS asks respondents whether they have “a great deal of confidence,” “only some confidence,” or “hardly any confidence at all” in the leaders of different institutions. In 2012, 41% of Americans expressed “a great deal of confidence” in leaders of the scientific community, nearly half (49%) expressed “some confidence,” and fewer than 1 in 10 (7%) expressed “hardly any confidence at all” (figure 7-15).

These results suggest that leaders of the scientific community compare well to leaders of other institutions in America. Only military leaders generated greater public confidence in 2012, with 53% of Americans saying they had a “great deal of confidence” in them. The scientific community (41%) and the medical community (40%) shared about equal levels of confidence. Since at least the 1970s, a similar percentage of Americans have said they place a “great deal of confidence” in the scientific community, whereas the percentage saying this about the medical community has fallen from highs of 61% in the mid-1970s (appendix table 7-25).

International Comparisons

The 2011 BBVA Foundation survey also found that scientists were among the most positively viewed groups in both the United States and the 10 European countries surveyed. Teachers and engineers were also viewed positively. The survey used an 11-point scale in which “0” means the respondent believed “that [the] group does not contribute at all to the welfare and progress of society” and “10” means “it contributes a great deal.” Doctors scored 8.4 in the United States and 8.2 in Europe. Scientists scored 8.1 in the United States and 7.9 in Europe. Teachers were more positively viewed in the United States (8.5) than in the 10 countries surveyed in Europe (7.6), but they were still near the top for both locations. Engineers received scores of 7.9 in the United States and 7.6 in Europe (BBVA Foundation 2012b).

Levels of reported trust varied in two Asian surveys that used different questions. A 2010 Korean survey found that 32% “strongly agreed” or “agreed” that “scientists can always be trusted” (KOFAC 2011). In contrast, a 2011 survey in Japan found that 69% of respondents said scientists could be “trusted” or “somewhat trusted.” Even more respondents (77%) said engineers could be trusted (NISTEP 2012).

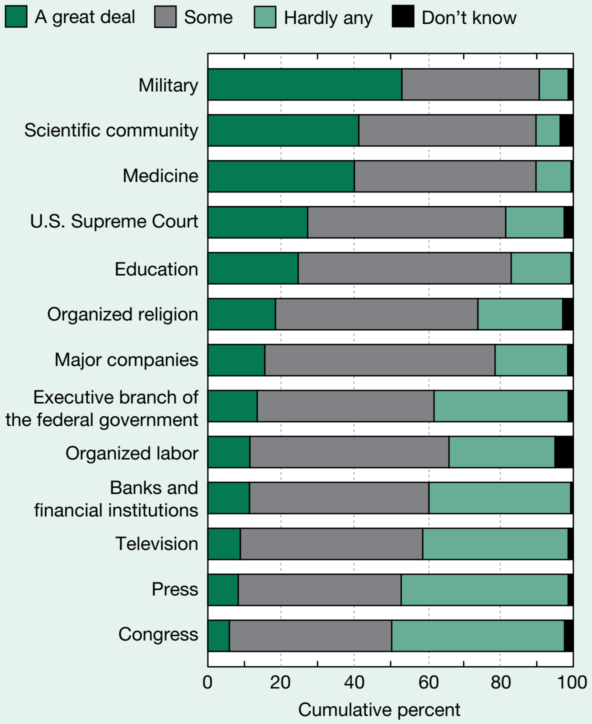
Views of S&E Occupations

U.S. Patterns and Trends

Data on public esteem for S&E occupations are an indicator of the attractiveness of these occupations and their ability to recruit talented people into their ranks. Such data may therefore have a bearing on the degree to which S&E affects the nation’s well-being in the future. Perceptions of specific occupations may also provide a picture of the degree to which people have confidence in those involved in S&E. Past research shows that when people—especially children—are asked to “draw a scientist,” they often rely on relatively unflattering stereotypes (Losh, Wilke, and Pop 2008).

The 2012 GSS included questions aimed at assessing how people view scientists and engineers. Half of the respondents were asked questions about scientists, and half were asked identical questions about engineers. Many of

Figure 7-15
Public confidence in institutional leaders, by type of institution: 2012



NOTE: Responses to *As far as the people running these institutions are concerned, would you say that you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?*

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix table 7-25.

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the scientist-focused questions were also asked in 1983 and 2001. An analysis of these earlier surveys concluded that views about scientists were shaped by a range of factors; older respondents, women, and those who believe society relies too much on science had more negative views about scientists. In contrast, those with more education and more college courses in science were more positive about scientists (Losh 2010).

More Americans said they had an "excellent" or "good" understanding of what engineers (42%) than of what scientists (35%) do in their jobs. In contrast, more respondents said they had "considered working" in a science-related (33%) than in an engineering-related (26%) career. The percentage interested in a science career was down from 41% in 2001 and similar to the 34% who gave this response in 1983. There were few clear demographic patterns, although younger and older respondents were both less likely to say they understood S&E careers, and more education and knowledge were generally associated with more self-reported understanding (figure 7-16; appendix table 7-26).

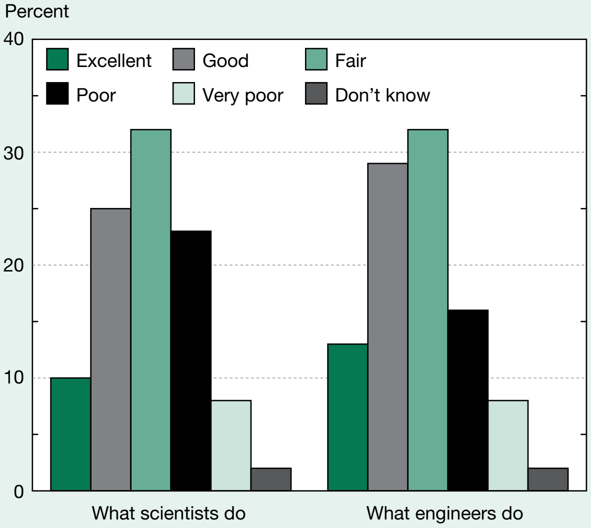
Almost all Americans said they would be "happy" if their son or daughter were to become a scientist or engineer. In 2012, four out of five Americans (80%) said they would be happy if their son or daughter became a scientist, and even more would be happy to see their child become an engineer (84% for daughters and 85% for sons). The 2001 survey similarly found that 80% of Americans would be happy about a scientific career for their child, up from 67% for both sexes in 1983 (figure 7-17).[24]

In general, these patterns were consistent across demographic groups, although those who scored well on the test of science knowledge were somewhat more likely to be happy if their son or daughter were to become an engineer than those who scored relatively less well. For example, in 2012, 79% of respondents in the bottom quartile for science knowledge said they would be happy if their son became an engineer, whereas 88% of those in the top quartile gave this response. This pattern was not apparent in those asked about scientists (appendix table 7-27).

Americans' views about specific facets of S&E occupations are also quite positive. Americans generally believe that both scientists and engineers have a positive impact on society, and these beliefs appear to have remained stable over the past decade. Americans almost universally "strongly agree" or "agree" that scientists (95%) and engineers (91%) "are helping to solve challenging problems."

Figure 7-16

Public self-assessment of knowledge of what scientists and engineers do day-to-day on their jobs: 2012



NOTES: Responses to *Would you say your knowledge of what scientists/engineers do day-to-day on their jobs is excellent, good, fair, poor, or very poor?* Percentages may not add to 100% because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix table 7-26.

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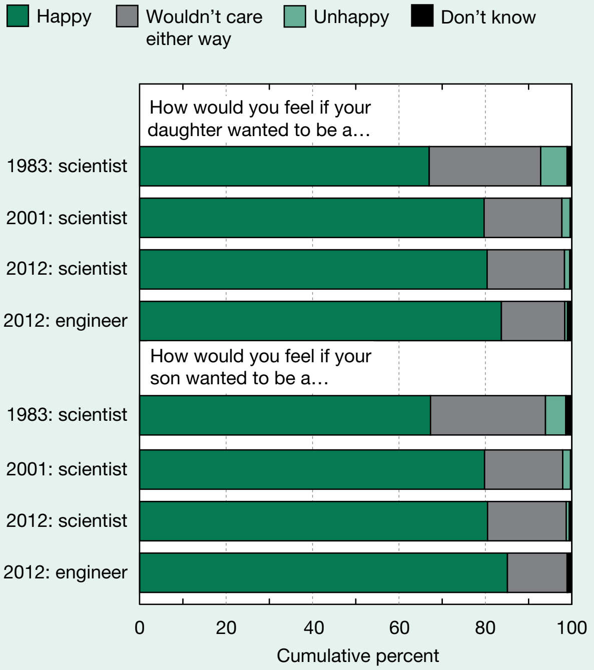
Figure 7-17

Public opinion on science and engineering careers for one's children: 1983, 2001, and 2012



NOTES: Responses to *If you had a daughter/son, how would you feel if she/he wanted to be a scientist/engineer—would you feel happy, unhappy, or would you not care one way or the other?* Percentages may not add to 100% because of rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1983, 2001); University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix table 7-27.

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This is similar to the 96% who gave such responses in 2001 when asked only about scientists (NSB 2002). Americans also believe these groups are made up of “dedicated people who work for the good of humanity.” Although both groups are seen positively, more respondents agreed that this description fits scientists (88%) than agreed that this description fits engineers (79%). The finding for scientists is also similar to that in 2001, when 86% of respondents gave this answer (NSB 2002). There is no meaningful difference in Americans’ belief that scientists (86%) and engineers (86%) “work on things that will make life better for the average person” (table 7-10). About 89% also said this about scientists in 2001.

Americans’ views about S&E careers include several elements that could be perceived by some as negative. Respondents were more likely to provide such comments when asked about scientists rather than engineers. Specifically, 50% of respondents said they “strongly agree” or “agree” with the statement that “scientific work is dangerous,” but just 38% said they thought engineering work is dangerous. The percentage seeing scientific work as dangerous is essentially unchanged from 2001, when 53% of respondents gave this response. In 2012, more Americans saw scientists than saw engineers as not likely “to be very religious people” (33%, compared with 15% for engineers); as having “few other interests but their work” (28%, compared with 16% for engineers); and as likely to “earn less than other people with equally demanding jobs” (17%, compared with 9% for engineers). These numbers are also similar to those from 2001, when 30% said they thought scientists were unlikely to be religious and 29% said they believed scientists were too interested in work. About one-third of Americans saw scientists and engineers as “apt to be odd and peculiar people” (36% for scientists, compared with 28% for engineers). This percentage rose for scientists from 25% in 2001 (NSB 2002), but it is not far from the 31% response in 1983 (table 7-10; appendix table 7-28).

Americans saw few differences between scientists and engineers in 2012 for some of the less common negative ideas about which they were asked. Few Americans said they believe that scientists and engineers “don’t get as much fun out of life as other people do” (19% for scientists, compared with 16% for engineers); that scientists or engineers “usually work alone” (20% for scientists, compared with 23% for engineers); or that being a scientist or engineer “would be boring” (17% for scientists, compared with 14% for engineers) (table 7-10). The percentage of people who believed that scientists have less fun was 20% in 2001 and 24% in 1983. The percentage of people who believed that scientists work alone was lower in 2001 (16%) and similar in 1983 (21%). In previous surveys, respondents were not asked about whether science was boring (appendix table 7-28).

It is also noteworthy that the Harris Poll (Harris Interactive 2009) asked about the prestige of a large number of occupations, including scientists and engineers, over a period of about 30 years. In 2009, the last year for which data are available, 57% of Americans said that scientists had “very great prestige,” and 39% expressed this view about engineers. Most occupations in the surveys were rated well below engineers.[25] In recent years, scientists’ ratings were comparable to those of nurses, doctors, firefighters, and teachers and ahead of those of military and police officers. Engineers’ standing was comparable to those of occupations clustered just below the top group of occupations rated, including clergy, military officers, farmers, and police officers (NSB 2012).

International Comparisons

Elsewhere, S&E occupations are also highly regarded. The BBVA Foundation research in Europe and the United States found that both groups reject negative portrayals of scientists and embrace positive ones. The 2011 BBVA Foundation survey presented respondents with the idea that “films often use particular images to portray scientists” and then asked if the respondents believed these portrayals “reflect what scientists are like.” About 42% of Americans and 46% of residents of the 10 European countries surveyed said they thought that a depiction of scientists as “people doing research beyond the bounds of what is morally acceptable” would reflect scientists “fairly well” or “very well.” Fewer respondents—27% of Americans and 29% of Europeans—said that depictions of scientists as “people who lie about their research for personal gain” would be accurate. Even fewer—23% of Americans and 25% of Europeans—said they believed that depictions of scientists as “dangerous people” would be accurate. Americans and Europeans diverged on the degree to which residents said they believed that scientists were “people with a lot of power” or “absent-minded people.” About 53% of Americans and 45% of Europeans said that they thought depictions of scientists as powerful would accurately reflect scientists. Also, 22% of Americans said they thought an absent-minded depiction would be accurate, but 35% of Europeans held this view (BBVA Foundation 2012b).

The BBVA Foundation survey also found that more Americans had “considered the possibility of taking up a career related to science” than most other countries in the survey. One-third of Americans (33%) said they had considered such a career, but only 17% of those surveyed in the other 10 European countries said they had considered this option (BBVA Foundation 2012b).

Earlier data from other countries indicate that scientists are well regarded. Chinese respondents were asked in 2010 to choose up to three occupations that they thought were the most prestigious and three that they would like their child to choose. Scientist (44%) rated close to doctor (44%) as an occupation that was among the most “prestigious,” although both were behind teacher (55%). Engineering was seen as a prestigious career by 22% of Chinese respondents. When it came to careers, 36% said they would like their child to become a scientist. Teacher (51%) and doctor (49%) were the only occupations more preferred. About 17% said they would like their child to become an engineer (CRISP 2010). A 2010 Korean survey also included questions about scientists and found that 56% of respondents “strongly” or “somewhat” agreed that scientists “serve the interests of humankind,” 38% agreed scientists are “neutral and objective,” and 32% agreed scientists are “unique and different people.” Overall, 24% said they would “strongly support” their children in pursuing an S&E career, although most (66%) indicated they would let their children choose their own path (KOFAC 2011). In 2006, the majority of Israelis said they would be pleased if their children became scientists (77%), engineers (78%), or physicians (78%) (Yaar 2006).

Which Fields and Activities Are Seen as Scientific

U.S. Patterns and Trends

The 2012 GSS included a series of questions about the degree to which Americans see various fields of research and practical activities as scientific. Such questions are important because they can provide an indicator of the degree that Americans see a role for science in everyday life. Some of these questions were also asked in the 2006 GSS as well as in a 2005 EU survey. The new data include both the earlier list of fields as well as an additional list of activities, many

Table 7-10
Public perceptions of science and engineering occupations: 2012
(Percent)

	Level of agreement					
Field/work activity	Strongly agree	Agree	Disagree	Strongly disagree	Don’t know	Mean score
Scientists are helping to solve challenging problems	21	74	1	1	3	3.2
Engineers are helping to solve challenging problems	19	72	3	*	6	3.2
Scientific researchers are dedicated people who work for the good of humanity	19	69	6	1	5	3.1
Engineering researchers are dedicated people who work for the good of humanity	11	68	11	1	9	3.0
Most scientists want to work on things that will make life better for the average person	14	72	8	1	5	3.0
Most engineers want to work on things that will make life better for the average person	11	75	7	*	7	3.0
Scientific work is dangerous	6	44	39	4	6	2.6
Engineering work is dangerous	6	32	48	5	9	2.4
Scientists are apt to be odd and peculiar people	4	32	51	6	8	2.4
Engineers are apt to be odd and peculiar people	4	24	55	7	10	2.3
Scientists are not likely to be very religious people	4	29	47	6	13	2.4
Engineers are not likely to be very religious people	1	14	57	6	22	2.1
Scientists have few other interests but their work	2	26	55	5	11	2.3
Engineers have few other interests but their work	2	14	63	6	14	2.2
A scientist usually works alone	3	17	64	10	7	2.1
An engineer usually works alone	3	20	57	11	9	2.2
Scientists don’t get as much fun out of life as other people do	2	17	59	11	11	2.1
Engineers don’t get as much fun out of life as other people do	2	14	63	10	12	2.1
Scientists earn less than other people with equally demanding jobs	2	15	60	4	19	2.2
Engineers earn less than other people with equally demanding jobs	1	8	69	7	14	2.0
A job as a scientist would be boring	2	15	66	11	6	2.1
A job as an engineer would be boring	2	12	68	8	11	2.1

* = < 0.5% responded.

NOTES: Responses to *Now I’d like to read you some statements about scientists/engineers. Please tell me if you agree or disagree with each one. If you feel especially strongly about a statement, please say that you strongly agree or strongly disagree*. Mean agreement score is based on a 4-point scale, where 4 = strongly agree, 3 = agree, 2 = disagree, and 1 = strongly disagree. Percentages may not add to 100% because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix table 7-28.

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of which require practical applications of S&T knowledge, such as farming, computer programming, and counseling. Engineering was included as both a field and an activity. The results clearly show that Americans differentiate between different fields and activities.

Many of the fields and activities that Americans saw as scientific are those where the S&T element is clear. Medicine (94%) and medical treatment (96%) were the most likely to be seen as "very" or "pretty scientific." The percentage for medicine was down slightly from 97% in 2006. Many also saw the fields of physics (88%), biology (90%), and engineering (80%)—as well as the activities of engineering (90%) and architecture (75%)—as scientific. Biology was down slightly from 94% in 2006, and physics was down from 90%. Engineering (as a field) was about the same (77%) in 2006, whereas architecture was not included in the earlier survey. Respondents saw engineering as more scientific when grouped with other "activities" than when grouped with "fields." The fact that "engineering" followed "medicine" in the list of fields on the underlying GSS survey but followed "law enforcement" in the list of activities, may have contributed to this difference in perceptions (table 7-11; appendix table 7-29).

Three fields were seen as marginally scientific. About half of Americans saw the social science fields of economics (45%) and sociology (45%) as "very scientific" or "pretty scientific." These are down slightly from 2006 when economics had been at 51% and sociology at 49%. About one-third of respondents (31%) said they saw history as scientific in 2012, which is about the same as in 2006 (30%).

Americans also saw many activities as scientific and distinguished these from other activities that they saw as unscientific. Most respondents saw computer programming (85%) and farming (72%) as scientific, whereas about half of respondents saw firefighting (57%) and law enforcement (44%) as scientific.

In general, respondents with more education and more scientific knowledge were more likely to see almost all fields and activities as at least somewhat scientific. Patterns are also apparent in the percentage describing certain fields or activities as "pretty scientific." For example, the percentage of respondents saying that economics is "pretty scientific" climbs from 20% for the lowest knowledge quartile to 44% for the highest knowledge quartile. No such pattern is apparent when looking at the "very scientific" percentage for economics. Similarly, 21% of those who had not completed

Table 7-11

Public perceptions of degree to which certain fields and work activities are scientific: 2012

(Percent)

Field/work activity	Very scientific	Pretty scientific	Not too scientific	Not scientific at all	Haven't heard of it	Mean score
Field						
Medicine	80	14	2	1	3	3.8
Physics	69	19	4	2	6	3.7
Biology	67	23	4	1	5	3.6
Engineering	49	31	10	6	5	3.3
Economics	15	30	31	18	6	2.5
Sociology	9	36	33	8	13	2.5
History	9	22	41	24	4	2.2
Accounting	8	19	35	33	5	2.0
Work activity						
Medical treatment	77	19	2	1	1	3.7
Engineering	59	31	5	3	2	3.5
Computer programming	52	33	10	3	2	3.4
Architecture	35	40	15	7	3	3.1
Farming	18	54	20	5	2	2.9
Firefighting	17	40	28	13	2	2.6
Law enforcement	12	32	33	21	2	2.3
Financial counseling	8	25	36	28	3	2.1
Journalism	4	16	46	29	4	2.0
Marriage counseling	7	18	33	39	3	1.9
Salesmanship	4	12	39	42	3	1.8

NOTES: Responses to *How scientific are each of the following fields/work activities? If you have not heard of a particular field/work activity, just say you haven't heard of it. Is [field/work activity] very scientific, pretty scientific, not too scientific, or not scientific at all?* Mean scientific score is based on a 4-point scale, where 4 = very scientific, 3 = pretty scientific, 2 = not too scientific, and 1 = not scientific at all. Percentages may not add to 100% because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix table 7-29.

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high school said they thought law enforcement was "very scientific," but only 4% of those with graduate degrees gave this opinion. In contrast, 18% of those with less than a high school diploma viewed law enforcement as "pretty scientific," but 47% of those with bachelor's degrees gave this response. Similar patterns are apparent for education and/or literacy measures applied to occupations such as farming, firefighting, marriage counseling, law enforcement, and financial counseling. These results suggest that Americans with more understanding of science may be more likely to recognize a partial natural- or social-scientific element to fields or activities in which S&T plays a supporting role.[26]

International Comparisons

The pattern of results in the 2012 GSS remains similar to those found in a 2005 survey of EU countries. This survey used a five-point scale anchored by "not at all scientific" and "very scientific." Some 89% of Europeans chose one of the two highest categories for medicine (i.e., above the midpoint). About 83% gave such a score for physics, and 75% gave such a score for biology. About 40% indicated they believed economics was scientific, and 34% said they saw history as scientific (European Commission 2005).

Influence of Scientific Experts on Public Issues

U.S. Patterns and Trends

The 2010 GSS included a battery of questions that focused on what role the public wants scientists and others to play in policy decision making. These questions were also asked in 2006. In 2010, the survey focused on four issues: global climate change,[27] research using human embryonic stem cells, federal income taxes, and nuclear power.[28] In 2006, the issues included GM foods but not nuclear power. Respondents were asked how much influence a group of scientists or engineers with relevant expertise (e.g., medical researchers, economists, nuclear engineers) should have in deciding about each issue, how well the experts understood the issue, and to what extent each would "support what is best for the country as a whole versus what serves their own narrow interests." The same questions were asked about elected officials and either religious leaders (for stem cell research) or business leaders (for the other issues). Thus, the questions allow a comparison among leadership groups at a single point in time as well as a comparison of perceptions about these groups over time.

The 2010 GSS data indicate that most Americans believe that scientists and engineers should have either a "great deal" or "a fair amount" of influence on these public decisions. More said that scientists and engineers should have a "great deal" of influence about these issues than said the same about other groups when it comes to global warming, stem cell research, nuclear power, and GM foods. Americans also gave scientists relatively high marks for understanding each issue and for being relatively impartial. For all issues, compared with other leadership groups, S&E groups were more likely to be seen as supporting what is best for the country rather than their own narrow interests. Nonetheless, the 2010 GSS also assessed perceived consensus among scientists and found that the public thought that scientists disagreed among themselves on most issues. The public perceived the greatest consensus on stem cells and nuclear energy and the least consensus on taxes. Past research suggests that a lack of perceived consensus may limit the influence of the scientific community (Krosnick et al. 2006; NSB 2010). Americans with more education and more science knowledge tended to have more favorable perceptions of the knowledge, impartiality, and level of agreement among scientists.

Public Attitudes about Specific S&T-Related Issues

In addition to general views about S&T, most people also develop views about specific issues, and these views can shape personal and political decisions. Such specific attitudes are usually associated with general attitudes and knowledge and may come from a range of experiences. Both general and specific views about S&T may affect what people decide to study, what they decide to consume, and whom they trust. Likewise, attitudes about emerging areas of research and new technologies may influence innovation activity in important ways. The climate of opinion concerning new research areas can shape public and private investment in related technological innovations and, eventually, the adoption of new technologies and the growth of industries based on these technologies.

Even in democratic societies, public opinion about new S&T developments rarely translates directly into actions or policy. Instead, institutions selectively assess what the public believes and may magnify or minimize the effects of divisions in public opinion on public discourse and government policy (Jasanoff 2005). It is noteworthy that the public's attitudes about specific S&T issues such as climate change and biotechnology can differ markedly from the views of scientists (Pew Research Center 2009). This is partly because attitudes toward S&T involve a multitude of factors, not just knowledge or understanding of relevant science. Values, morals, judgments of prudence, and numerous other factors come into play; judgments about scientific fact are often secondary (Kahan, Jenkins-Smith, and Braman 2011).

This section describes data about views on environmental issues, including global climate change, nuclear power, and energy development; nanotechnology; agricultural biotechnology (i.e., GM food); cloning and stem cell research; and teaching evolution in schools. It concludes with recent data on attitudes toward scientific research on animals and toward science and mathematics education.

Environment

U.S. Patterns and Trends

Environmental issues—especially climate change and energy technologies—are often the subject of both public policy debate and news interest. The massive 2010 oil spill in the United States was followed by a 2011 nuclear accident in Japan and attendant calls for the development of new energy alternatives. Recent years also saw the reemergence of a domestic natural gas industry as new technologies made hydraulic fracturing ("fracking") technologically and economically feasible. A review of general public views about the environment and specific environmental issues follows, along with reviews of views about climate change and energy technologies.

Concern about Environmental Quality

The environment is important to many Americans, but other issues rate higher on their list of priorities. A 2012 Gallup survey on Americans' concerns for the nation shows "worry" about the environment rebounded slightly after tying record lows in 2010 and 2011. The 2012 poll found that 37% said they worry "a great deal" about "the quality of the environment," compared with 34% in 2010 and 2011. The percentage that worries "a great deal" has, however, fluctuated within a 9% range (34% to 43%) since Gallup began asking the question in 2001. These most recent figures are well within that range, suggesting long-term stability (figure 7-18). Overall, environmental concerns are relatively low on the list of issues about which Gallup respondents worry (Saad 2012), and in 2013, just 47% of respondents said the government is doing "too little" in terms of protecting the environment. This was down from 51% in 2012 and relatively low compared with data going back to 1983 (Newport 2013). Similar results from Pew Research said 86% of Americans think "strengthening the nation's economy" should be a top priority for the President and Congress for the year, whereas 56% said "protecting the environment" should be a top priority. About 45% said "dealing with the nation's energy problem" should be a top priority. Both environmental protection and energy issues have also fluctuated within a relatively narrow range in past polls (Pew Research Center 2013b). Another way survey researchers assess what issues are most salient in the public mind is to ask an open-ended question about what respondents believe to be "the most important problem facing the country" at the beginning of a survey. Neither Gallup (Jones and Saad 2013) nor the Pew Research Center (2012e) have found that more than about 1% of respondents offer environmental or energy issues as the country's biggest problem in recent years.

International Comparisons

The availability of the 2010 ISSP also makes it possible to provide a number of international comparisons related to environmental issues. Particularly relevant to general environmental concerns is one general question that asked respondents "how concerned" they were "about environmental issues." It asked them to respond on a five-point scale where 1 meant "not at all concerned" and 5 meant "very concerned." About 63% of American respondents chose 4 or 5. The U.S. average score in 2010 was relatively low—residents of more than a dozen countries were more concerned about such issues—but also was statistically similar to the scores of many large, developed countries (figure 7-19; appendix table 7-30).[29] Also, in 2010, about one-quarter of Americans (23%) said they "strongly agreed" or "agreed" that "modern science will solve our environmental problems with little change to our way of life." Americans were again in the middle range of countries. In many of the countries where multiple years of data (i.e., 1993 and 2000) were available, confidence increased over time (figure 7-20; appendix table 7-31).

Within Europe alone, a 2011 Eurobarometer found that 95% of EU residents said that "protecting the environment" was personally "very important" or "important" (European Commission 2011). This figure was essentially unchanged from 2007, when it was at 96%. Further, 76% of EU residents agreed that "environmental problems" have a "direct effect" on their lives; this, too, was similar to 2007 (78%) (European Commission 2011).

Assessment of Specific Environmental Problems

The U.S. public's perceptions of hazards to the environment have been mostly stable over the past two decades. Responses to a series of questions on GSS surveys conducted in 1993, 2000, and 2010 show that Americans consider pollution of America's rivers, lakes, and streams to be more dangerous to the environment than any of several other

Figure 7-18
Worry about quality of environment: 2001–12

NOTES: Responses to *How much do you personally worry about the quality of the environment: a great deal, a fair amount, only a little, or not at all?* Poll is conducted annually in March.

SOURCE: Saad L, *Economic Issues Still Dominate Americans' National Worries*, The Gallup Poll (28 March 2012), http://www.gallup.com/poll/153485/Economic-Issues-Dominate-Americans-National-Worries.aspx, accessed 25 January 2013.

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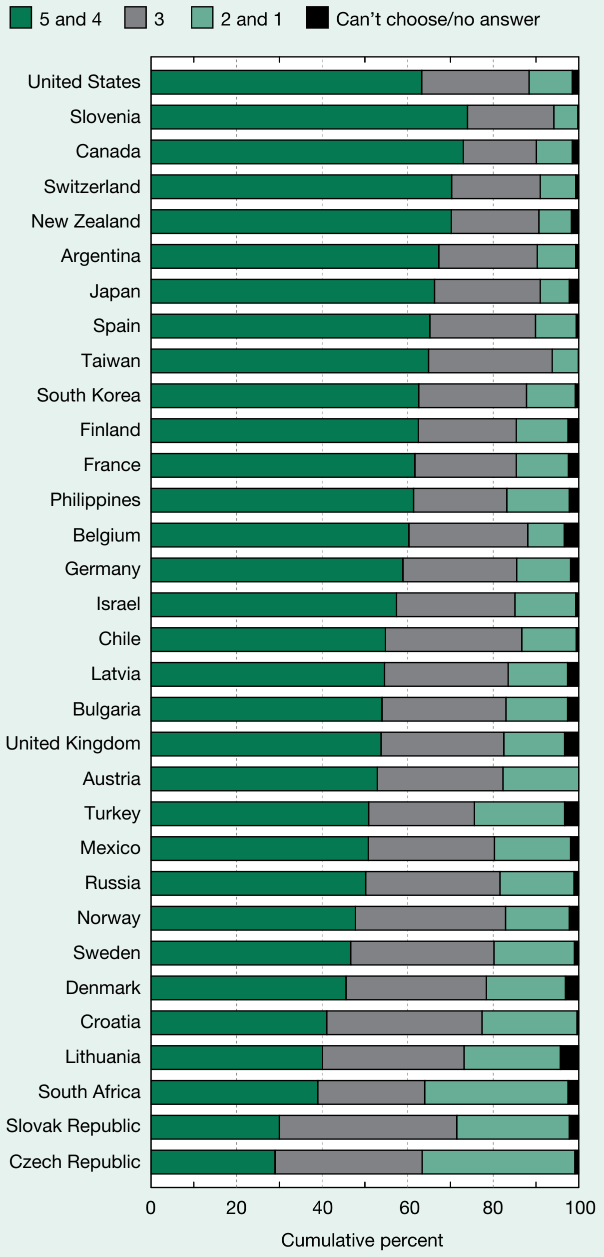
potential problems; in 2010, 68% considered water pollution to be very or extremely dangerous. Air pollution caused by industry was considered very or extremely dangerous to the environment by 62%, whereas air pollution caused by cars was less likely to be considered very or extremely dangerous to the environment (43%). Assessments of environmental

Figure 7-19
Public concern about environmental issues, by country/economy: 2010

5-point scale, where 5 = very concerned and 1 = not concerned at all



NOTES: Responses to *Generally speaking, how concerned are you about environmental issues, where 1 means you are not at all concerned and 5 means you are very concerned?* Percentages may not add to 100% because of rounding.

SOURCE: International Social Survey Program, Environment Module (2010). See appendix table 7-30.

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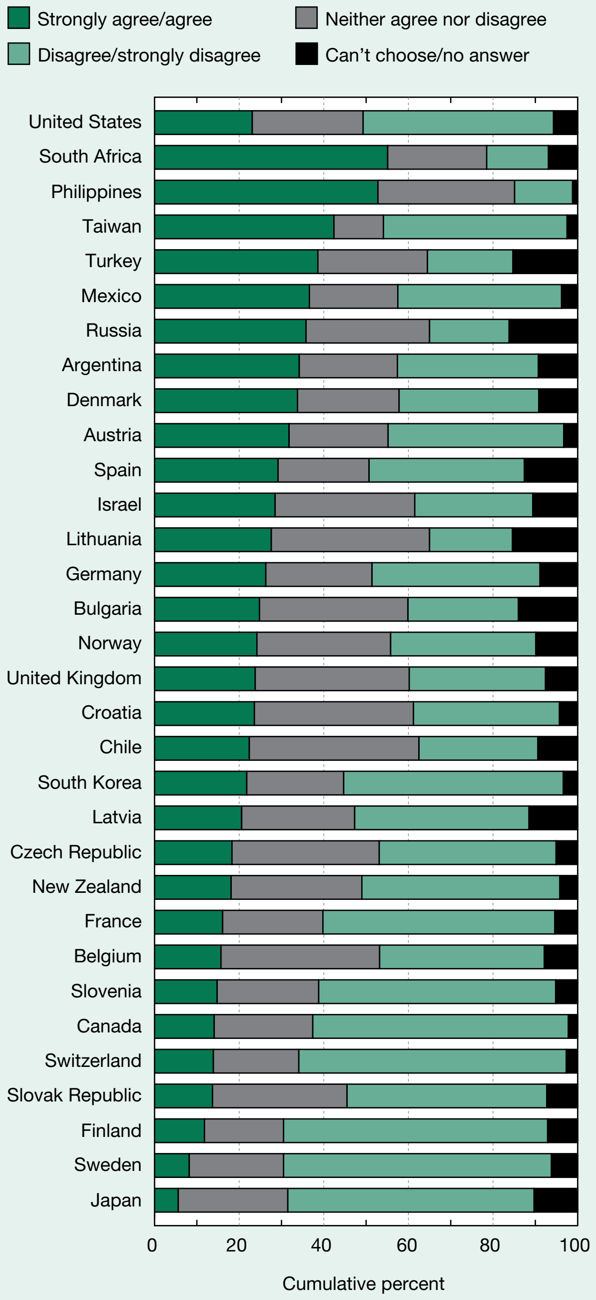
Figure 7-20
Public assessment of science's ability to solve environmental problems, by country/economy: 2010



NOTES: Responses to *How much do you agree or disagree with the statement: Modern science will solve our environmental problems with little change to our way of life?* Percentages may not add to 100% because of rounding.

SOURCE: International Social Survey Program, Environment Module (2010). See appendix table 7-31.

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dangers changed substantially on only one issue—pesticides and chemicals used in farming. About half of Americans (51%) called these very or extremely dangerous to the environment in 2010, up from 37% in 1993.

The 2010 ISSP data also allow U.S. concerns about specific issues to be compared with concerns in other countries. In 2010, the United States sat in the middle range of concern on most issues. As in the United States, the only clear trend for most other countries surveyed in multiple years was that, over time, people viewed agricultural pesticides and chemicals as more dangerous (appendix tables 7-32–7-35).

Climate Change

U.S. Patterns and Trends

Climate change (sometimes referred to as *global warming*) has become a central environmental issue for the American public. It has also been the subject of widespread polling in recent years, with evidence showing clear shifts in views.[30]

Gallup has polled on "global warming" since 1989, when it found that 63% of Americans "worry a great deal" or "a fair amount" about the issue. In March 2013, the comparable statistic was 58%, but this percentage has risen and fallen multiple times. A much smaller percentage (34%), however, told Gallup that they believed "global warming would pose a serious threat" to their "way of life" during their lifetime. As with the question about "worry," responses to this question have fluctuated over time (Saad 2013). Data from other sources show similar fluctuations (Pew Research Center 2012f; Leiserowitz et al. 2012), and these shifts come alongside shifts in the percentage of Americans who say "there is solid evidence that the average temperature on earth has been getting warmer over the past few decades" (Pew Research Center 2012f). The Brookings Institution found that people were increasingly pointing to changes in weather patterns as "the primary factor" that has led them to conclude "that temperatures on earth are increasing" (Borick and Rabe 2012).

Within the subset of Americans who believe the earth is getting warmer (i.e., 67% of Americans), about two-thirds (42% of all respondents) said it was likely because of "human activity such as burning fossil fuels," whereas the remaining third (19% of all respondents) attributed the change to "natural patterns in the earth's environment."[31] The percentage attributing perceived change to human activity reached a high of 50% in July 2006 but declined to as low as 36% in October 2009 (Pew Research Center 2012f).

Despite widespread concern, Pew Research Center also reports that "dealing with global warming" has been at, or near, the bottom of the public's priorities for the president and Congress since at least 2007. About 28% of Americans said it should be a priority in 2013, which is down from 38% in 2007 (Pew Research Center 2013b). Pew Research's September 2012 survey also found, however, that most Americans said they believe that the threat of climate change is relatively distant from their lives (Pew Research Center 2012f). Risk researchers have long known that people often see risks as more likely to harm others than themselves (Spence, Poortinga, and Pidgeon 2012).

Both Pew Research and Gallup have also asked questions about the degree to which Americans believe there is a scientific consensus around climate change. Gallup reported that, in 2013, 62% of Americans said that "most scientists believe that global warming is occurring." Gallup's research also shows that the percentage saying a consensus exists rose from 48% in 1998 to a high of 65% in 2008 before falling again (Saad 2013). Several other surveys report similar findings (Pew Research Center 2012f; Leiserowitz et al. 2012).

Survey organizations that collect public opinion data on climate change consistently find views on this topic to be related to party affiliation (Pew Research Center 2012f; Saad 2013).

International Comparisons

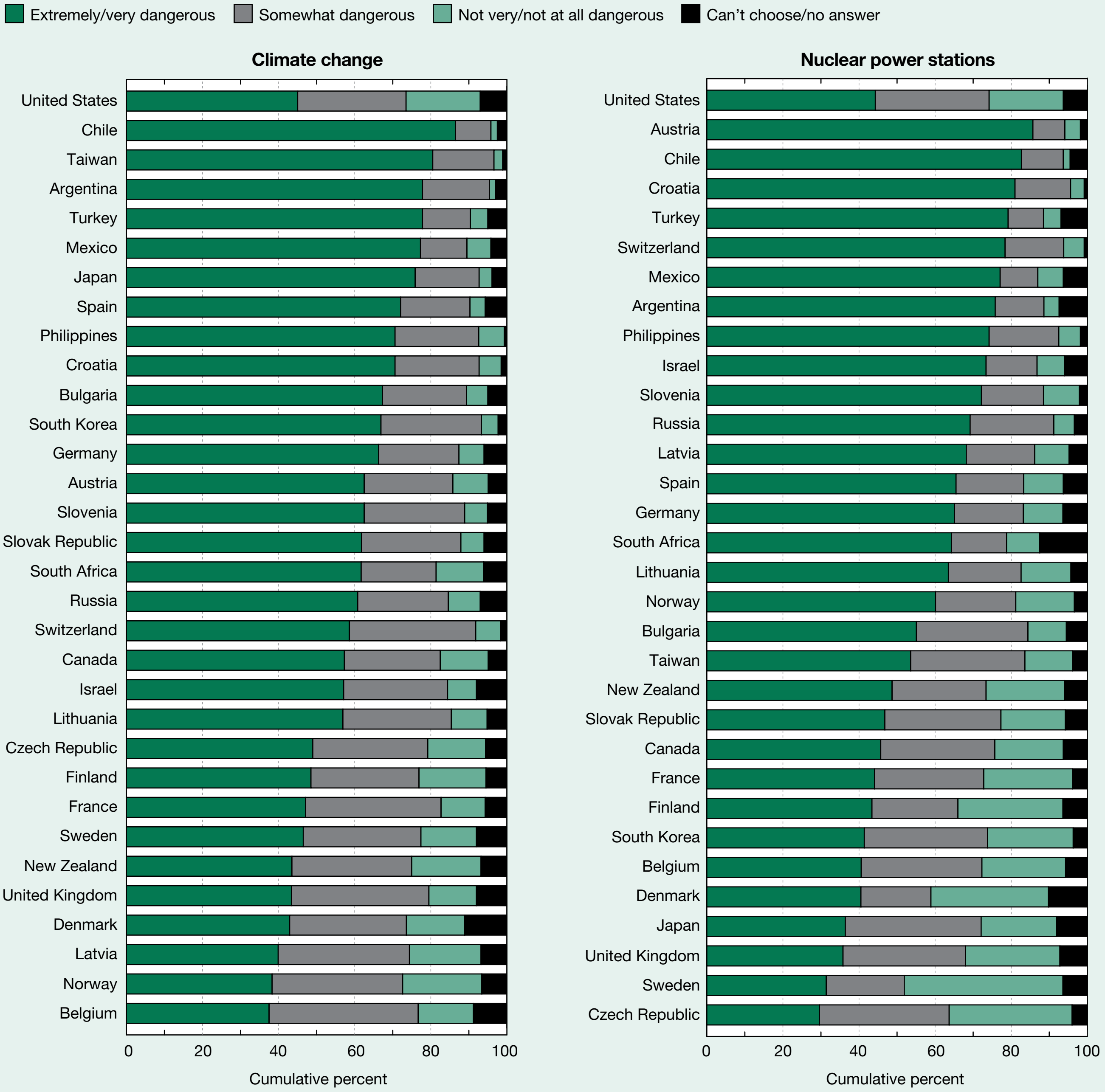
The most recent internationally comparable, representative data on public views about climate change are from 2010, a year in which Americans were at (or near) relative lows in their concerns about climate change.

The 2010 ISSP indicated that the United States is among the countries with the least concern about climate change (figure 7-21). There was no clear pattern, however, between countries over time, with some countries becoming more concerned (e.g., Japan and Spain) and others becoming less concerned (e.g., the Czech Republic and New Zealand) between 1993 and 2010 (appendix table 7-36). Almost half (45%) of Americans said climate change was "very" or "extremely dangerous" in 2010 (NSB 2012).

Gallup similarly reported that, in 2010, 53% of Americans saw global warming as a "very" or "somewhat" serious threat to themselves and their families, putting it in the middle range of the 111 countries/economies Gallup polled. The average for Western Europe was 56%. Higher percentages of respondents were concerned in Southern and Eastern Europe (60%), Canada (71%), Latin America (73%), and the developed parts of Asia (74%) than in the United States. Conversely, residents of less developed areas were less concerned than those in the United States, including those in the Commonwealth of Independent States (44%), the Middle East and North Africa (37%), Sub-Saharan Africa (34%), and developing countries in Asia (31%). Gallup also reported that the perceived threat of climate change declined between 2007–08 and 2010 in many developed countries (Ray and Pugliese 2011a).

Americans were also more likely than residents of any other country surveyed to say they believe rising temperatures are "a result of natural causes." About 47% of U.S. respondents gave this response, whereas 35% said that temperature rises are "a result of human activity." Another 14% volunteered that they believed both human and natural causes are at play (i.e., they were not explicitly given that choice but offered the opinion anyway). The next closest country to the United States was the United Kingdom, where 39% said climate change is due to natural causes, 37% said human causes, and 18% said both. Gallup reported that the average in "developed Asia" was 76%. About 49% of Western Europeans and 46% of Eastern Europeans said they think climate change is a result of human factors (Ray and Pugliese 2011b). Pew Research has also reported that Americans express less concern about climate change than people in many other countries (Pew Research Global Attitudes Project 2010).

Figure 7-21
Public assessment of danger to environment of climate change and nuclear power stations, by country/economy: 2010



NOTES: Responses to *Do you think that a rise in the world's temperature caused by climate change is extremely dangerous for the environment, very dangerous, somewhat dangerous, not very dangerous, or not dangerous at all for the environment?* and *Do you think that nuclear power stations are...?* Percentages may not add to 100% because of rounding.

SOURCE: International Social Survey Program, Environment Module (2010). See appendix tables 7-36 and 7-37.

Science and Engineering Indicators 2014

Nuclear Power and Other Energy Sources

U.S. Patterns and Trends

Accidents such as the 2010 *Deepwater Horizon* oil spill in the Gulf of Mexico and the 2011 nuclear accident in Fukushima, Japan, have put energy decisions at the center of policy debates. Questions about the health, environmental, and social impacts of hydraulic fracturing ("fracking") have also emerged in many parts of the country. Overall, public opinion about energy appears to change temporarily in response to new events, while showing no consistent trend over time (see sidebar, "Nuclear Energy and the Fukushima Accident").

About half of Americans support the use of nuclear energy. Gallup reports that 57% of Americans said they "strongly" or "somewhat" favored nuclear energy in 2012 (Newport 2012b), while the Pew Research Center (2012d) put the level of support at 44%.

For other energy issues, Gallup reports that Americans are about equally divided over whether "protection of the environment should be given a priority, even at the risk of limiting the amount of energy supplies—such as oil, gas, and coal—which the U.S. produces" or whether the "development of U.S. energy supplies…should be given priority, even if the environment suffers to some extent." Environmental protection was clearly more favored by respondents in 2001, when 52% chose environmental protection, and this percentage rose to 58% in 2007. However, 41% and 44% of respondents chose environmental protection in 2011 and 2012, respectively. Respondents were also asked how they thought the country should deal with "the nation's energy problems." The percentage of people choosing "more conservation by consumers of existing energy supplies" over producing "more oil, gas and coal supplies" has remained about evenly divided since 2010. Preference for conservation climbed from 56% in 2001 up to 64% in 2007 before falling back to 48% in 2011 and 51% in 2012 (Jones 2012).

The majority of Americans support both offshore energy development and alternative energy spending, but opinion on these topics has shifted in recent years. About two-thirds (67%) of Americans said they supported "allowing more offshore oil and gas drilling" in September 2008. This dropped to a low of 44% in June 2010, after the *Deepwater Horizon* spill, but climbed back to 65% by March 2012. In contrast, the percentage that favored "increasing federal spending for research on wind, solar and hydrogen technology" has steadily declined from highs of 82% in polls

Nuclear Energy and the Fukushima Accident

The combination of the 2011 Fukushima accident and a 2012 decision by the U.S. Nuclear Regulatory Commission to grant its first new license to build a new nuclear plant in decades (Wald 2012) has made nuclear energy a vibrant area of public opinion research. The Fukushima accident had a small impact on public opinion, but Americans' views appear to be relatively resilient, with more than half of Americans continuing to support nuclear energy.

Survey research by Gallup from March 2001 had about equal numbers of respondents favoring (46%) and opposing (48%) "nuclear energy as one of the ways to provide electricity for the U.S." Support climbed to 62% favoring by March 2010, a year before the Fukushima accident. Gallup conducted a poll about a month after the accident and saw favorability drop to 57%. It was still at 57% a year later, in March 2012 (Newport 2012b). A similar pattern—but with even higher levels of support for nuclear energy—was found by a GfK Roper survey that used a similar question between 1983 and 2013 (Bisconti Research 2013).

Pew Research's polling indicated a similar pattern. Support for "promoting the increased use of nuclear power" started at 39% in September 2005 and then moved upward to 52% in February 2010 before falling back to about 45% in October 2010. A poll in March 2011, about a month after Fukushima, and then another in November 2011 saw support down to 39%. A more recent March 2012 poll had support for nuclear energy back to 44%.

Question wording might explain the differences in expressed support for nuclear energy. Gallup and GfK Roper asked about nuclear energy "as one of the ways," while Pew Research asked about "promoting" nuclear energy. A comprehensive review of nuclear energy polling showed that opposition to nuclear energy declined from the 1970s, stabilized through the 1980s, and then began to rise in the 2000s (Bolsen and Cook 2008).

A Swiss study that surveyed the same people both before and after the Fukushima accident found that acceptance of nuclear energy, perceived benefits of nuclear energy, and trust in nuclear energy operators declined as a result of the accident, while risk perceptions increased. This research argued that the key drivers of acceptance stayed the same over time, and it was the decline in trust and benefits perceptions, as well as the increase in risk perceptions, that changed the level of nuclear acceptance (Visschers and Siegrist 2012). Some studies have also shown high levels of support in areas that already have nuclear facilities (Besley 2010; Greenberg and Truelove 2011).

from February 2006 and April 2009. Support reached lows of 68% in November 2011 and 69% in March 2012 (Pew Research Center 2012d).

Beyond government support, however, Americans say they would like the United States “as a country” to put “more emphasis” on “producing domestic energy” from renewable sources. About 76% of respondents told Gallup they would like more emphasis on solar power, and 71% said they would like more emphasis on wind power. In contrast, 65% would like more emphasis on natural gas, 46% would like more emphasis on oil, 37% would like more emphasis on nuclear, and 31% would like more emphasis on coal (Jacobe 2013).

International Comparisons

In the United Kingdom—which has also been debating whether to update its nuclear energy infrastructure—support for nuclear energy has declined in recent years, although the decline may have leveled off. Ipsos MORI found that the percentage of respondents who said they had a “very favourable” or “mainly favourable” “impression…of the nuclear energy industry” was 33% in 2009, 40% in 2010 (just before Fukushima), and 28% in 2011 (just after Fukushima). Similarly, the percentage who said they would “strongly support” or “tend to support” “the building of new nuclear power stations in Britain” went from 42% in 2009 up to 47% in 2010 and then down to 36% in 2011 (Ipsos MORI 2011).

Questions about nuclear energy were also included in the environment module of the ISSP that was fielded in multiple countries in 1993, 2000, and 2010. In 2010, pre-Fukushima, 44% of Americans said that nuclear power stations were very or extremely dangerous; this percentage was relatively low, although it was still similar to a range of countries. There were also many countries where concern was quite high (figure 7-21). In some countries, concern increased between surveys, while in others, concern decreased (appendix table 7-37). As noted in the 2012 NSB report, a Eurobarometer survey from 2010 showed that EU residents were split on whether or not nuclear energy will “improve our way of life” (39%) or “make things worse” (39%). Many also said that nuclear energy would have no effect (10%) or that they held no opinion (13%). Assessments of nuclear energy were more negative when this question was first asked in 1999 (Gaskell et al. 2010).

Genetically Modified Food

U.S. Patterns and Trends

Genetic modification of food has engendered less opposition in the United States than in much of Europe (Jasanoff 2005), but it remains an active issue of public debate around the world as new products continue to enter the market. Scholars often point to the emergence of an anti-GM movement as something that might have been limited if the scientific community had better communicated with the public during the early research and commercialization phases (Einsiedel and Goldenberg 2006). There has also been active discussion on the question of whether the public wants mandatory labeling of food that contains genetically modified ingredients despite arguments by scientists that such labeling would inappropriately suggest risks to buyers (Roe and Teisl 2007). The U.S. Food and Drug Administration was also reviewing an application concerning the first potential use of genetic engineering in an animal species—Atlantic salmon—in 2013.

The 2010 ISSP included a question asking about the perceived danger of “modifying the genes of certain crops.” The survey found that 25% of U.S. respondents said that modification would be very or extremely dangerous to the environment. The 2000 ISSP yielded similar results (figure 7-22; appendix table 7-38).

Most U.S. surveys are focused on safety rather than the environment. A 2010 survey by Thomson Reuters found that about 21% of respondents were willing to say that “genetically engineered foods are safe” (Thomson Reuters 2010). This is consistent with a series of five surveys conducted by the Pew Initiative on Food and Biotechnology between 2001 and 2006, which found that only about one-fourth of U.S. consumers favored “the introduction of genetically modified foods into the U.S. food supply” (Mellman Group 2006).

How genetic modification is used matters to Americans. The Thomson Reuters survey found that 35% of respondents said they would eat GM fish, 38% said they would eat GM meat, and 60% said they would eat GM vegetables, fruit, or grain (Thomson Reuters 2010). Past surveys also generally found that Americans are more wary of genetic modification of animals than they are of genetic modification of plants (Mellman Group 2006).

In total, 69% of respondents said they knew that GM foods are already in U.S. stores, and 93% of respondents said “foods should be labeled to indicate that they have been genetically engineered or contain ingredients that have been genetically engineered” (Thomson Reuters 2010).

International Comparisons

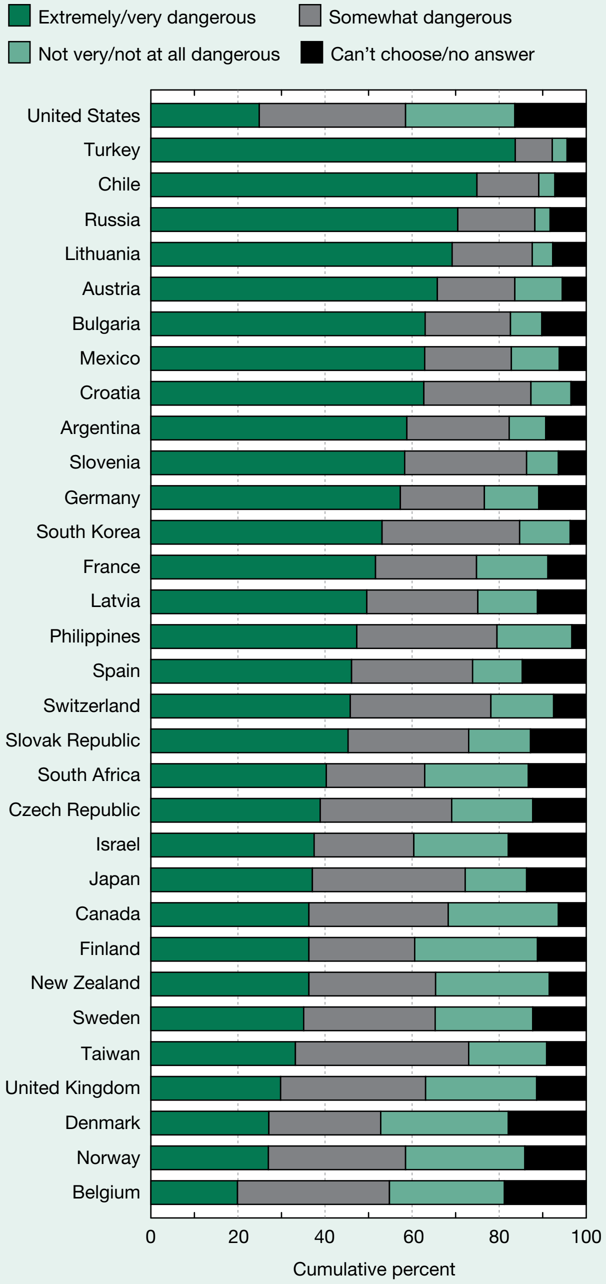
The 2010 GSS/ISSP results show that the United States (25%) is less concerned about genetic modification than most other countries. There were several countries that were similar to the United States but none were more positive, on average. Also, residents of some countries became more concerned between 2000 and 2010 (e.g., Bulgaria and Mexico), while others became less concerned (e.g., Denmark and Japan) (appendix table 7-38).

Nanotechnology

U.S. Patterns and Trends

Nanotechnology involves manipulating matter at unprecedentedly small scales to create new or improved products that can be used in a wide variety of ways. Nanotechnology has been the focus of relatively large public and private investments for more than a decade, and innovations based on nanotechnology are increasingly common. More than 1,000 nanotechnology products—more than 5 times the number available in 2006—were on the market by 2011 (Pew Project on Emerging Technologies 2011). However, relative to other new technologies, the public generally reports relatively low levels of understanding (Ladwig et al. 2012).

Figure 7-22
Public assessment of danger to environment of modifying genes of crops, by country/economy: 2010



NOTES: Responses to *Do you think that modifying the genes of certain crops is extremely dangerous for the environment, very dangerous, somewhat dangerous, not very dangerous, or not dangerous at all for the environment?* Percentages may not add to 100% because of rounding.

SOURCE: International Social Survey Program, Environment Module (2010). See appendix table 7-38.

Science and Engineering Indicators 2014

The 2010 GSS found that 24% of U.S. respondents said they had heard "a lot" or "some" about nanotechnology, up 4 percentage points from both 2006 and 2008. A plurality (44%) of Americans in the 2010 GSS reported having heard "nothing at all" about nanotechnology (NSB 2010). About 37% of 2010 GSS respondents also said the benefits would outweigh the harms, 9% said the benefits and harms would be about equal, and 11% expected the harms to predominate. The remaining 43% held no opinion (NSB 2010). The balance of opinion was similar in 2006 and 2008. As with GM food, attitudes toward nanotechnology vary depending on the context in which it is applied, with energy applications viewed much more positively than those in health and human enhancements (Pidgeon et al. 2009).

International Comparisons

More Europeans than Americans appear to have heard about nanotechnology. About 45% of EU residents said that they had heard of nanotechnology in 2010. Overall, 44% of EU residents agreed that nanotechnology should be encouraged, 35% disagreed, and 22% had no opinion about this issue (Gaskell et al. 2010). One recent study of UK residents found that providing balanced information resulted in more positive views about nanotechnology for those who started out positive about nanotechnology, while those who started out negative became more negative. Such individuals were also less likely to be "ambivalent" after receiving balanced information. Those who started out with a neutral attitude, however, became more ambivalent about nanotechnology after receiving balanced information (Fischer et al. 2012).

Stem Cell Research and Human Cloning

U.S. Patterns and Trends

Stem cell and cloning research focuses on understanding how to use genetic material to produce living cells, tissues, and organisms. Such research creates opportunities for enhanced understanding of life as well as opportunities to develop new health care treatments. The focus on health, human life, and the destruction of human embryos, however, creates a range of ethical issues that have spurred public debate.

Most Americans appear to support the use of stem cells for medical research, and support has stayed within a 5% range in recent years. Annual Gallup Poll data showed that, in 2013, 60% of Americans saw using stem cells from human embryos in medical research as "morally acceptable."

About 32% said it was "morally wrong." The percentage of Americans seeing the use of human embryos as moral climbed from 52% in 2002, when Gallup started polling on the issue, to a high of 64% in 2007. Since then, the percentage of Americans viewing stem cell research as morally acceptable has ranged between 57% and 62% (Newport and Himelfarb 2013).

Support for stem cell research is greater when the question posed asks about research that uses stem cells from sources that do not involve human embryos. About 7 out of 10 respondents (71%) favored this type of research in 2010, down slightly from 75% in 2007 (VCU 2010). Support was also greater when the question was framed as an emotionally compelling personal issue (i.e., "If you or a member of your family had a condition such as Parkinson's Disease, or a spinal cord injury, would you support the use of embryonic stem cells in order to pursue a treatment for that condition?") (VCU 2006).

Gallup has also asked Americans about human cloning. In 2013, Gallup found that only 13% of Americans said human cloning is "morally acceptable" and that 83% said it was "morally wrong." The percentage indicating that cloning is morally acceptable was 7% in 2001 and 2002 and has stayed between 8% and 13% since then (Newport and Himelfarb 2013).

It appears that Americans are particularly opposed to human cloning when there is no mention of a medical purpose. As reported in the 2012 *Indicators*, a 2010 survey showed that 8 in 10 Americans rejected the idea of cloning or genetically altering humans (VCU 2010). Opinions were more mixed when questions mentioned "cloning technology" that is used only to help medical research develop new treatments for disease; opinion about therapeutic cloning has been slowly growing more positive in recent years. Public attitudes toward cloning technology are not grounded in a strong grasp of the difference between reproductive and therapeutic cloning (see "Glossary" for definitions). In 2010, a 54% majority of Americans were "very clear" or "somewhat clear" about the difference between stem cells that come from human embryos, stem cells that come from adults, and stem cells that come from other sources (VCU 2010).

International Comparisons

A 2010 Eurobarometer found that 63% of those surveyed across the EU supported the use of stem cells from human embryos either with no special laws (12%) or "as long as this is regulated by strict laws" (51%). The use of adult stem cells, in contrast, was supported by 69% of Europeans, including 15% who saw no need for special laws and 54% who would approve of "strict laws." The survey did not address human cloning, but it included several questions about animal cloning, and the results also show widespread disapproval. About 17% said that they saw it as "safe for future generations," and 70% of EU residents disagreed that "animal cloning in food production should be encouraged" (European Commission 2010b).

Teaching Evolution in the Schools

In the United States, the topic of whether and how evolution should be taught in the public schools has been a source of controversy for almost a century. Public views about evolution and the role of teaching evolution in the schools have been relatively stable over the course of 30 years.

Public opinion about how evolution should be taught in U.S. public schools consistently shows two key patterns. First, when asked whether intelligent design should be taught alongside or in addition to evolution, a majority of Americans favor this approach to education. Second, when asked whether creation should be taught instead of evolution—thereby replacing it in the science curriculum—a majority oppose this idea, but a sizeable minority favor it. Opposition to replacing evolution ranged between 44% and 54% from 1999 to 2005, whereas support ranged from 37% to 44% over the same period (Plutzer and Berkman 2008; Berkman and Plutzer 2010). A 2007 survey of 926 high school biology teachers also found that 28% might be classified as advocates for evolutionary biology in their classrooms, whereas about 13% of teachers said they tell their students that "creationism or intelligent design" are "valid, scientific" theories about the "origin of the species." Teachers who had taken a college-level course addressing evolution were significantly more likely to advocate for evolutionary biology (Berkman and Plutzer 2011). The difficulty of sampling in such surveys of special populations, however, means that this type of data should be interpreted with caution.

Animal Research

U.S. Patterns and Trends

The medical research community conducts experimental tests on animals for many purposes, including testing the effectiveness of drugs and procedures that may eventually be used to improve human health and advancing scientific understanding of biological processes.

Most Americans support at least some kind of animal research, but support has fallen in recent years. About 56% of Americans said they saw "medical testing on animals" as "morally acceptable" in 2013, similar to the 55% who gave this response in 2011 and 2012 (Newport 2012a). These figures put support at the lowest level registered since Gallup began asking the question in 2001, when 65% said they saw such testing as acceptable (Newport and Himelfarb 2013). A comparison of surveys from 1988 and 2008 found a similar pattern of declining support (NSB 2012).

The 2011 and 2012 Gallup numbers also suggest less support than research by VCU (2007) that showed nearly two-thirds of respondents favoring "using animals in medical research." A comprehensive 2008 Gallup survey also found that a majority of respondents wanted to maintain access to animal testing animal research; 64% opposed "banning all medical research on laboratory animals," and 59% opposed "banning all product testing on laboratory animals"

(Newport 2008). There also appears to be a sizeable gender gap in opinions about animal research, with women less likely than men to support animal testing (Saad 2010), as well as an age gap with younger respondents being less supportive of animal testing (Wilke and Saad 2013).

International Comparisons

A 2010 European-wide survey showed that EU residents have a range of views about animal research but are, on balance, supportive of such practices. Respondents were asked whether "scientists should be allowed to experiment on animals like dogs and monkeys if this can help sort out human health problems." About 44% of EU residents said they "totally" or "tend to" agree that such experiments should be allowed, whereas 37% said they "totally" or "tend to" disagree. The report also indicated that, across the countries surveyed, men (49%) were much more likely to agree that animal testing should be allowed than women (39%). Those who said they were well informed about science (47%) or interested in science (48%) were also more favorable to animal testing than the average. When asked about animal research using mice—instead of dogs and monkeys—66% of EU residents indicated that would be acceptable (European Commission 2010a).

Science, Engineering, and Mathematics Education

Although the news media are important to how adults think about S&T, the formal education system remains most people's primary introduction to S&T. A 2013 Pew Research study found that 11% of Americans named science as the subject that K–12 schools should emphasize more than other subjects. This made science the third most named subject. The most commonly named subject was math (30%), followed by "English/Grammar/Writing/Reading." "Computers/Computer Science" came sixth (4%). When asked, 46% of Americans said the reason "many young people don't pursue degrees in math and science" is because these subjects "are too hard." About equal numbers said these subjects might be "too boring" (20%) or "not useful for their careers" (22%) (Pew Research Center 2013a).

In the 2008 GSS, the majority of Americans in all demographic groups agreed that the quality of science and mathematics education in American schools was inadequate. The level of dissatisfaction increased with education, science knowledge, income, and age. Dissatisfaction has also varied over time: it was 63% in 1985, peaked at 75% in 1992, and declined to 70% in 2008 (NSB 2010). Further, about half of Americans said that their local public schools did not put enough emphasis on teaching science and math, an equal portion (48%) said the emphasis was about right, and just 2% said there was too much emphasis on teaching science and math in the local schools (Rose and Gallup 2007). In addition, the percentage of Americans in the biennial GSS surveys who said they believe the government is spending too little money on improving education has remained greater than 70% since the early 1980s. This is consistently one of the top areas in which the public says government spending is too low.

Conclusion

Assessing public attitudes and understanding about S&T can involve looking at what a technologically advanced society requires to succeed, either currently or in the future. Comparisons over time and between countries can also help identify achievements and areas for concern.

Those who believe that advanced societies require strong S&T performance will likely find many of the available indicators about S&T heartening. Americans remain interested in S&T, and a majority of Americans continue to say that they visit at least one informal science institution, such as a zoo or aquarium, annually. Most Americans are also able to answer basic S&T knowledge questions. In terms of attitudes, a large majority of Americans say that they want funding for scientific research and hold scientists and engineers in high regard. Most Americans also express positive views about various emerging technologies, including nuclear energy, biotechnology, and stem cells. In most cases, indicators for these attitudes have changed little in recent years, and Americans are more positive and have more factual knowledge about S&T than residents of other countries.

However, proponents of S&T may also find some indicators less reassuring. In particular, they may note that indicators of media content show that S&T has represented just a small percentage of the available news content in recent years. Likewise, data showing that many Americans have difficulty answering relatively simple knowledge questions about S&T are not encouraging. Also, while Americans say they are interested in S&T and want to fund S&T, other issues generate greater interest and elicit more support for government funding. Although most of the available indicators have remained stable, stability may represent cause for concern to those who hope to see Americans become more knowledgeable or more supportive of science. Comparisons with other countries are not unambiguously reassuring either. Although Americans generally score better on factual knowledge questions and are more positive about S&T than residents of other countries, multinational surveys have identified several countries where residents have more knowledge or are more supportive of S&T in specific areas.

Although most of the indicators are stable, changes appearing in the most recent data might also cause concern. In 2012, fewer Americans could provide an adequate description of what makes something scientific or were willing to reject astrology as unscientific. Americans were also less supportive of stem cell research than in previous years. People focused on environmental issues might also worry that some indicators show that Americans are becoming less concerned about the environment than in previous years and are less concerned about such issues than residents of many other countries. Climate change is one topic for which substantial evidence suggests that Americans have become less concerned than in the past and where residents of most other countries are closer to sharing the assessment of the evidence that prevails in the scientific community.

One limitation of the available indicators is that much of the data come from Europe, with only limited recent data from the Asia-Pacific region, where there is a high level of S&T activity.

Regardless of the standard used in assessing public attitudes and understanding of S&T, one pattern in the data continues to stands out. Year after year, Americans who are more highly educated—particularly those who are college educated and have completed college courses in science and mathematics—tend to understand more about S&T, tend to see S&T in a more positive light, and tend to engage with S&T more often. Although it is not clear whether this association is causal, the pattern underscores the role of science, technology, engineering, and mathematics education in fostering public understanding of S&T and possibly in developing orientations toward S&T that are similar to those that prevail in the scientific community.

Notes

1. This is an example in which, in 2001, the question was part of a single-purpose telephone survey focused on S&T. In 2008, these data were collected as part of the General Social Survey, a face-to-face, multipurpose survey covering a broad range of behavior and attitudes. It is unclear whether these differences in data collection or a change in public opinion account for the decline in interest observed between 2001 and 2008.

2. The report for the survey did not provide confidence intervals or formal tests to assess the differences in means.

3. The question asked on the Eurobarometer surveys has changed over time, making the data not always strictly comparable with previous Eurobarometer surveys or with U.S. data.

4. The analysis is based on a purposive selection of five media sectors, outlets within each sector, and specific programs or articles for study. The index was designed to capture the main news stories covered each week. Coding of programs and articles was limited to the first 30 minutes of most radio, cable, and network news programs; the front page of newspapers; and the top five stories on websites. Each selected unit of study was coded on 17 variables, according to an established coding protocol. The team of individuals performing the content analysis was directed by a coding manager, a training coordinator, a methodologist, and a senior researcher. For variables that require little or no inference, intercoder agreement was 97% for 2010, the last year in which statistics were reported. For variables requiring more inference, intercoder agreement ranged from 78% to 85% in 2010. Intercoder agreement was similar in earlier years. For more details, see http://www.journalism.org/about_news_index/methodology.

5. The total amount of news consists of the space devoted to news in print and online news sources and the time devoted to news on radio and television sources.

6. "Science, space, and technology" includes stories on manned and unmanned space flight, astronomy, scientific research, computers, the Internet, and telecommunications media technology. It excludes forensic science and telecommunications media content. "Biotechnology and basic medical research" includes stem cell research, genetic research, cloning, and agribusiness bioengineering and excludes clinical research and medical technology. Stories often do not fall neatly into a single category or theme. The Tyndall and PEJ data should not be directly compared because they involve different definitions of content. The coverage of health research in the Tyndall television data represents only a small percentage of the overall health coverage on television.

7. After 11 August 2011, the PEJ used the tracking services Technorati and Icerocket to monitor blogs and Tweetmeme and Twitturly to monitor social media. Prior to August 2011, the data collection was done using Icerocket and Tweetmeme. In all cases, the services used the links embedded on the sites as a proxy for the subject of the blog post or tweet. The sites thus provide a list of the most-linked-to news stories based on the number of blogs, tweets, or other sites that link to each. Typically, the linked-to stories originate from traditional media sources. PEJ staff manually captured the list of most-linked-to stories each weekday, and the coding staff categorized the top five linked-to articles from this list of approximately 50 linked-to articles each week. The coding procedures are similar to those used for the News Coverage Index of traditional media sources. For more, see http://www.journalism.org/node/14356.

8. In general, it is difficult to obtain information about S&T content within entertainment programming, although substantial evidence suggests that the entertainment people view shapes their attitudes about a range of issues, including S&T (Brossard and Dudo 2012).

9. A 2013 report by the PEJ reported that the most popular news sites were those associated with the news divisions of the main television broadcasters and cable networks, with the Yahoo!–ABC News Network leading the way. No clear science source was listed in the summaries of various measures of news site popularity, although several weather-focused sites (e.g., http://www.weather.com) appeared (PEJ 2013).

10. People become involved with S&T through many kinds of nonclassroom activities beyond attendance at informal science institutions. Examples of such activities include participating in government policy processes, going to movies that feature S&T, attending talks or lectures, bird watching, and building computers. *Citizen science* is a term used for activities by citizens with no specific science training who participate in the research process through activities such as observation, measurement, or computation. Nationally representative data on this sort of involvement with S&T are unavailable.

11. In the 2008 GSS, respondents received two different introductions to this set of questions. Response patterns did not vary depending on which introduction was given.

12. S. Feldman, Senior Vice President of External Affairs, Association of Zoos and Aquariums, personal communication to author, 1 May 2013.

13. This question was part of a single-purpose telephone survey focused on science and technology in 2001. In 2008, these data were collected as part of a face-to-face multipurpose survey. It is unclear whether these differences in data collection or a change in visit behavior account for changes seen between 2001, 2008, and 2012.

14. Survey items that test factual knowledge sometimes use easily comprehensible language at the cost of scientific precision. This may prompt some highly knowledgeable respondents to believe that the items blur or neglect important distinctions, and in a few cases may lead respondents to answer questions incorrectly. In addition, the items do not reflect the ways that established scientific knowledge evolves as scientists accumulate new evidence. Although the text of the factual knowledge questions may suggest a fixed body of knowledge, it is more accurate to see scientists as making continual, often subtle modifications in how they understand existing data in light of new evidence. When the answer to a factual knowledge question is categorized as "correct," it means that the answer accords with the current consensus among knowledgeable scientists and that the weight of scientific evidence clearly supports the answer.

15. Although the data clearly show a difference in how respondents answer to different question types, these data do not provide guidance as to what caused the difference. A range of explanations are possible.

16. In its own international comparison of scientific literacy, Japan ranked itself 10th among the 14 countries it evaluated (NISTEP 2002).

17. Twenty questions used a true-or-false format. These included: (1) "Hot air rises" (true; Europe correct: 91%, United States correct: 95%); (2) "The continents have been moving for millions of years and will continue to move in the future" (true; Europe correct: 86%, United States correct: 80%); (3) "The oxygen we breathe comes from plants" (true; Europe correct: 83%, United States correct: 94%); (4) "The gene is the basic unit of heredity of living beings" (true; Europe correct: 82%, United States correct: 82%); (5) "Earth's gravity pulls objects towards it without being touched" (true; Europe correct: 79%, United States correct: 80%); (6) "Energy cannot be created or destroyed, but only changed from one form to another" (true; Europe correct: 66%, United States correct: 80%); (7) "Almost all microorganisms are harmful to human beings" (false; Europe correct: 63%, United States correct: 56%); (8) "Generally speaking, human cells do not divide" (false; Europe correct: 63%, United States correct: 58%); (9) "The earliest humans lived at the same time as the dinosaurs" (false; Europe correct: 61%, United States correct: 43%); (10); "Plants have no DNA" (false; Europe correct: 60%, United States correct: 64%); (11); "The greenhouse effect is caused by the use of nuclear power" (false; Europe correct: 58%, United States correct: 47%); (12) "All radioactivity is a product of human activity" (false; Europe correct: 56%, United States correct: 62%); (13) "Ordinary tomatoes, the ones we normally eat, do not have genes, whereas genetically engineered tomatoes do" (false; Europe correct: 54%, United States correct: 48%); (14) "It is the father's gene that determines a newborn baby's sex, whether it is a boy or a girl" (true; Europe correct: 52%, United States correct: 75%); (15) "Lasers work by sound waves" (false; Europe correct: 48%, United States correct: 54%); (16) "The light that reaches the Earth from the sun is made up of a single color: white" (false; Europe correct: 44%, United States correct: 55%); (17) "Today it is not possible to transfer genes from humans to animals" (false; Europe correct: 41%, United States correct: 43%); (18) "Atoms are smaller than electrons" (false; Europe correct: 38%, United States correct: 50%); (19) "Antibiotics destroy viruses" (false; Europe correct: 36%, United States correct: 47%); (20) "Human stem cells are extracted from human embryos without destroying the embryos" (false; Europe correct: 29%, United States correct: 54%). Two additional questions used a multiple choice format. These asked about (21) whether the sun moves around the Earth, whether the Earth moves around the sun (correct), or neither the sun nor the Earth moves (Europe correct: 80%, United States correct: 82%); and (22) whether light travels faster than sound (correct), sound travels faster than light, or whether they travel at equal speed (Europe correct: 74%, United States correct: 78%).

18. Earlier NSF surveys used for the *Indicators* report used additional questions to measure understanding of probability. Bann and Schwerin (2004) identified a smaller number of questions that could be administered to develop a comparable indicator. Starting in 2004, the NSF surveys used these questions for the trend factual knowledge scale.

19. The evidence for the 2012 decline in understanding of experimental design needs to be regarded with caution. It is important to note that the percentage of Americans who correctly answered the initial, multiple choice question about how to conduct a pharmaceutical trial stayed stable between 2010 and 2012. It was only the follow-up question that asked respondents to use their own words to justify the to use of a control group that saw a decline. For this question, interviewers recorded the response and then trained coders to use a standard set of rules to judge whether the response is correct. Although the instructions and training have remained the same in different years, small changes in survey administration practices can sometimes substantially affect such estimates.

20. The questions were selected from the Trends in Mathematics and Science Studies, National Assessment of Educational Progress, practice General Educational Development exams, and the American Association for the Advancement of Science Project 2061.

21. The pseudoscience section focuses on astrology because of the availability of long-term national trend indicators on this subject. Other examples of pseudoscience include the belief in lucky numbers, the existence of unidentified flying objects (UFOs), extrasensory perception (ESP), or magnetic therapy. One difficulty with this question is that astrology is based on observation of planets and stars and respondents might believe that this makes it "sort of scientific." However, the fact that those with more formal education and higher factual knowledge scores are consistently more likely to reject astrology as a science suggests that this nuance has a limited impact on results.

22. Methodological issues make fine-grained comparisons of data from different survey years particularly difficult for this question. For example, although the question content and interviewer instructions were identical in 2004 and 2006, the percentage of respondents who volunteered "about equal" (an answer not among the choices given) was substantially different. This difference may have been produced by the change from telephone interviews in 2004 to in-person interviews in 2006 (although telephone interviews in 2001 produced results that are similar to those in 2006). More likely, customary interviewing practices in the three different organizations that administered the surveys affected their interviewers' willingness to accept responses other than those that were specifically offered on the interview form, including "don't know" responses.

23. This type of survey question asks respondents about their assessment of government spending in several areas without mentioning the possible negative consequences of spending (e.g., higher taxes, less money available for higher priority expenditures). A question that focused respondents' attention on such consequences might yield response patterns less sympathetic to greater government funding.

24. As noted previously, the 1983 and 2001 surveys were telephone surveys, whereas the 2012 GSS survey was primarily a face-to-face survey. Similarly, there are only three data points for comparison, and these are separated by about a decade each. It is difficult to know the degree to which the change in survey mode may have affected the results, and the widely dispersed data points make determining the presence of a trend difficult. The between-year comparisons are therefore made with caution. Not all of the questions discussed were included each year.

25. There are many different types of specializations within occupations, and prestige may well vary within the same occupation or industry.

26. Given the relationship between education, knowledge, and views about professions, it may be that the ability to assess the degree to which a field or occupation involves the use of S&T concepts or ideas represents a form of science literacy relevant to the question of the role of science in everyday life (NSB 2012; Toumey et al. 2010).

27. The GSS questions on global climate change used the term *global warming*.

28. The 2010 GSS included ratings of nuclear engineers in addition to medical researchers, environmental scientists, and economists. As discussed, the patterns of results were similar whether the group with relevant expertise was engineers or scientists.

29. Similarity comments for ISSP data are based on post hoc statistical tests using mean scores. Also, countries described as being the most or least concerned are those that are statistically similar but in group with the highest or lowest mean score based on mean testing.

30. There is some evidence from a large-scale experimental study that the wording used in such questions ("global warming" or "climate change") can have an effect on reported beliefs about global climate change (Schuldt, Konrath, and Schwarz 2011). Earlier studies, however, suggested that such wording differences had little effect (European Commission 2008; Villar and Krosnick 2010).

31. This question was only asked to those who said they believed there was "solid evidence of increasing global temperatures."

Glossary

Biotechnology: The use of living things to make products.

Climate change: Any distinct change in measures of climate lasting for a long period of time. Climate change means major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer. Climate change may result from natural factors or human activities.

European Union (EU): Eurobarometer survey data for 2008, 2010, and 2011 include data for 27 EU member nations: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Eurobarometer survey data for years prior to 2008 include data for EU member nations as of the survey year (25 countries in 2005 and 15 in 1999).

Genetically modified (GM) food: A food product containing some quantity of any GM organism as an ingredient.

Global warming: An average increase in temperatures near the Earth's surface and in the lowest layer of the atmosphere. Increases in temperatures in the Earth's atmosphere can contribute to changes in global climate patterns. Global warming can be considered part of climate change along with changes in precipitation, sea level, etc.

Nanotechnology: Manipulating matter at unprecedentedly small scales to create new or improved products that can be used in a wide variety of ways.

Reproductive cloning: Technology used to generate genetically identical individuals with the same nuclear DNA as another individual.

Therapeutic cloning: Use of cloning technology in medical research to develop new treatments for diseases; differentiated from human reproductive cloning.

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Chapter 8
State Indicators

Elementary and Secondary Education

Higher Education

Workforce

Financial Research and Development Inputs

Research and Development Outputs

Science and Technology in the Economy

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Introduction

Chapter Overview

To address the interest of the policy and research communities in the role of science and technology (S&T) in state and regional economic development, this chapter presents findings on state trends in S&T education, the employed workforce, finance, and research and development. This chapter includes 59 indicators for individual states, the District of Columbia, and Puerto Rico.

The indicators are designed to present information about various aspects of state S&T infrastructure. The data used to calculate the indicators were gathered from public and private sources. When possible, data covering a 10-year span are presented to assist in identifying trends. However, consistent data were not always available for the 10-year period; in these cases, data are given only for the years in which comparisons are appropriate. Most indicators contain data for 2010–11; some contain data for 2012.

Ready access to accurate and timely information is an important tool for formulating effective S&T policies at the state level. By studying the programs and performance of their peers, state policymakers may be able to better assess and enhance their own programs and performance. Corporations and other organizations considering investments at the state level may also benefit from this information. The tables are intended to provide quantitative data that may be relevant to technology-based economic development. More generally, the chapter aims to foster further consideration of the appropriate uses of state-level indicators.

Types of Indicators

The 59 indicators are divided into six categories.

1. *Elementary and secondary education*
   Indicators in this area cover three topics:
   - Student achievement at elementary and secondary levels
   - Public school expenditures
   - Persons with high school credentials

Student achievement is expressed in terms of performance, which refers to the average state score on a standardized test, and proficiency, which is expressed as the percentage of students who have achieved at least an expected level of competence on the test.

State-level performance data are not available for high school students. Performance and proficiency data in mathematics are available for students in grade 12 at the national level but for students in fewer than one-quarter of the states at the state level. Performance and proficiency data in science are only available at the national level for students in grade 12. Instead, mastery of college-level material through performance on Advanced Placement Exams has been included as a measure of the skills being developed by top-performing high school students.

2. *Higher education*
   Indicators in this area cover three topics:
   - Credentials awarded and sought in S&E
   - Persons with higher education credentials
   - State and student resources supporting higher education

These indicators measure the higher education different states provide, the level of education in their populations, the cost of college attendance at the undergraduate level, and state expenditures to public universities.

3. *Workforce*
   Indicators in this area cover two topics:
   - Higher education credentials of the workforce
   - S&E workers in the labor force

Workforce indicators focus on the level of S&E training and occupations of the employed labor force. These indicators reflect the higher education level of the labor force and the extent of S&E employment.

4. *Financial R&D inputs*
   Indicators in this area cover two topics:
   - Level of R&D activity
   - Public-sector support for R&D activities

Financial indicators present the sources and level of funding for R&D. They show how much R&D is being performed relative to the size of a state's business base. The indicators also present the extent to which R&D is conducted by industrial and academic performers.

5. *Research and development outputs*
   Indicators in this area cover two topics:
   - Human capital outputs
   - Research-based outputs

These indicators show the number of new doctorates conferred, the publication of academic articles, and patent activity from the academic community and from all sources in the state.

6. *S&T in the economy*
   Indicators in this area cover two topics:
   - High-technology business activity
   - Early-stage, high-risk capital investments

These indicators include venture capital activity, Small Business Innovation Research (SBIR) awards, and high-technology business activity.

Unlike other chapters in this volume, this chapter presents indicators individually. Indicators are normalized to enable comparisons among states of different sizes, but indicators are presented discretely rather than in a continuous text that describes the relationships among them. Because these indicators span a broad range of topics across the entire S&E landscape—inputs and outputs, people and dollars, businesses and universities, R&D and education—a validated model synthesizing interrelationships among these specific indicators does not exist. Moreover, states are both heterogeneous, with hubs of intense S&E activity alongside areas without substantial S&E infrastructure, and porous, with limited control over movements of people and funds across their borders. As a result, smaller regions, which form more tightly coupled economic systems, and nations, which create stronger barriers to movement, are often considered to be better units of analysis for studying geographic variation in S&E activity.

Nonetheless, state governments and other state-based actors have significant leverage and can affect S&T-related economic development in their states and regions. The data in this chapter offer ample opportunities for exploratory analysis of variations among states and the interplay of education, R&D, and economic activity. The online state data tool (http://www.nsf.gov/statistics/seind14/c8/interactive/)—which includes the state data in this chapter plus, when available, additional data on state S&T over the past 20 years—enables readers to examine the relationships among the different indicators in the chapter.

Some examples of possible issues that could be explored with the current set of indicators include the following:

- What is the relationship between K–12 student achievement and the S&E workforce within a state?
- How do state commitments of resources for education at different levels relate to R&D performance?
- Do states whose universities provide advanced S&E training to large numbers of students have correspondingly large segments of their workforces in S&E occupations?
- How do indicators of educational attainment within a state's population relate to R&D performance and high-technology business activity?
- What state characteristics are associated with relatively high investments of tax dollars in S&E?
- Are states whose universities produce more articles and patents also involved in more high-technology business activity?

The data in this chapter cannot be expected to provide definitive answers to any of these questions. Additional data, well-defined theoretical models, and more refined geographical comparisons will be required as social scientists grapple with these complex relationships. But exploring relationships in the existing data via the online state data tool can stimulate policymakers and other stakeholders to think more broadly and deeply about the possible implications of strategies used to address state-level S&E policy topics.

The tool offers users the following capabilities:

- Long-term trend data on each indicator are available for download. This provides users with the option to combine data from existing indicators to produce new indicators. Visualizations of the trend data—such as quartile maps, histograms, and charts—are also available.
- Standard error tables for each indicator with sample-based data are available for download.
- Financial information can be translated from current into constant dollars.

Data Sources and Considerations

The tables present estimates for the components that make up each indicator. Each table provides an average value for all states, labeled "United States." For census-based data, the national average is the sum of numerator values for the 50 states and the District of Columbia divided by the sum of the denominator values. For sample-based data, the national totals were estimated directly, and the national average is the ratio of the estimated totals.

The values for most indicators are expressed as ratios or percentages to facilitate comparison between states that differ substantially in size. For example, an indicator of higher education achievement is not defined as the absolute number of degrees conferred in a state because less populous states are unlikely to have or need as extensive a higher education system as states with larger populations. Instead, the indicator is defined as the number of degrees per number of residents in the college-age cohort, which measures the intensity of educational services relative to the size of the resident population.

Although data for Puerto Rico are reported whenever available, they frequently were collected by a different source, making it unclear whether the methodology used for data collection and analysis is comparable with that used for the states. For this reason, Puerto Rico was not listed with the states, not assigned a quartile value, and not displayed on the maps. Data for United States territories and protectorates—such as American Samoa, Guam, Northern Mariana Islands, and Virgin Islands—were available only on a sporadic basis and thus are not included.

Readers must exercise caution when evaluating the indicator values for the District of Columbia. Frequently, the indicator value for the District of Columbia is appreciably different from the indicator values for any of the states. The District of Columbia is unique because it is an urban region with a large federal presence and many universities. In addition, it has a large student population and provides employment for many individuals who live in neighboring states. Indicator values can be quite different depending on whether data attributed to the District of Columbia are based on where people live or where they work.

Key Elements for Indicators

Six key elements are provided for each indicator. The first element is a map color coded to show in which quartile each state placed on that indicator for the latest year that data were available. This helps the reader quickly grasp geographic patterns. On the indicator maps, the darkest color indicates states that rank in the first or highest quartile, and white indicates states that rank in the fourth or lowest quartile. Cross-hatching indicates states for which no data are available.

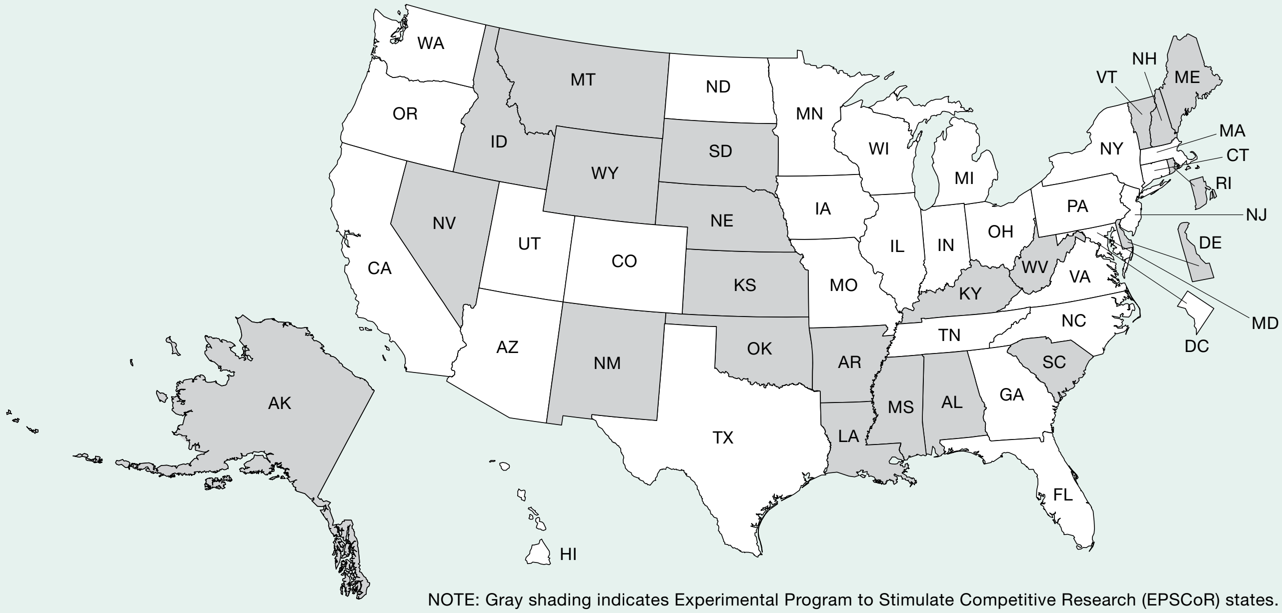
The sample map (figure 8-A) shows the outline of each state. Each state is identified by its U.S. Postal Service abbreviation. In 1978, Congress initiated the Experimental Program to Stimulate Competitive Research (EPSCoR) at the National Science Foundation to build R&D capacity in states that have historically been less competitive in receiving federal R&D funding. Subsequently, several federal agencies established similar programs, the largest of which is the Institutional Development Award program at the National Institutes of Health. Four other agencies with programs used for the EPSCoR-like programs are the National Science Foundation, the Department of Energy, the National Aeronautics and Space Administration, and the U.S. Department of Agriculture. States shown with a gray background in figure 8-A were eligible for EPSCoR-like programs at four of the five federal agencies or departments in 2012. The 22 states in the EPSCoR group are Alabama, Alaska, Arkansas, Delaware, Idaho, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, Oklahoma, Rhode Island, South Carolina, South Dakota, Vermont, West Virginia, and Wyoming. The remaining 28 states are considered states in the non-EPSCoR group. Puerto Rico (an EPSCoR jurisdiction), and the District of Columbia (a non-EPSCoR jurisdiction) are not included in EPSCoR tabulations in the tables. The EPSCoR Program is discussed in greater depth in chapter 5, "Academic Research and Development," in the sidebar "Experimental Program to Stimulate Competitive Research."

The second element is a state distribution chart below the map, illustrating state values for the latest data year for that indicator (figure 8-B). States are listed alphabetically by U.S. Postal Service abbreviation and are centered over the midpoint of the range for their indicator values. Indicator values are presented along the x-axis of the chart. States stacked together have indicator values that are in the same range but are not necessarily identical. The reader is referred to the table for values of the indicators. All of the indicators are broad measures, and several rely on sample estimates that have a margin of error. Small differences in state values generally carry little useful information.

The third element, at the bottom of the map box, is a short citation for the data source. The full citation appears under the table on the facing page.

The fourth element, in a shaded box on the lower left side of the page, is a summary of findings that includes the national average and comments on national and state trends and patterns for the particular indicator. Only statistically significant findings are presented; adjustments in the testing to account for multiple comparisons have been made, when appropriate. Although most of the findings are directly related to the data, some represent interpretations that are meant to stimulate further investigation and discussion.

Figure 8-A
U.S. map and list of abbreviations



NOTE: Gray shading indicates Experimental Program to Stimulate Competitive Research (EPSCoR) states.

AK	Alaska
AL	Alabama
AR	Arkansas
AZ	Arizona
CA	California
CO	Colorado
CT	Connecticut
DC	District of Columbia
DE	Delaware
FL	Florida
GA	Georgia
HI	Hawaii
IA	Iowa
ID	Idaho
IL	Illinois
IN	Indiana
KS	Kansas
KY	Kentucky
LA	Louisiana
MA	Massachusetts
MD	Maryland
ME	Maine
MI	Michigan
MN	Minnesota
MO	Missouri
MS	Mississippi
MT	Montana
NC	North Carolina
ND	North Dakota
NE	Nebraska
NH	New Hampshire
NJ	New Jersey
NM	New Mexico
NV	Nevada
NY	New York
OH	Ohio
OK	Oklahoma
OR	Oregon
PA	Pennsylvania
RI	Rhode Island
SC	South Carolina
SD	South Dakota
TN	Tennessee
TX	Texas
UT	Utah
VA	Virginia
VT	Vermont
WA	Washington
WI	Wisconsin
WV	West Virginia
WY	Wyoming

The fifth element, on the lower right side of the page, is a description of the indicator and includes information pertaining to the underlying data.

The final element is the data table, which appears on the facing page. Up to 3 years of data and the calculated values of the indicator are presented for each state, the District of Columbia, and Puerto Rico. Puerto Rico is included in the data table only when data are available.

For selected indicators, the data table has been expanded to include the average data and indicator value for the 50 states and the District of Columbia, and the averages for the EPSCoR and non-EPSCoR states. These averages have been calculated in two ways. The first two lines, “EPSCoR states” and “Non-EPSCoR states,” treat each group as a single geographical unit, ignoring the division of that unit into separate states. The ratio for the group is calculated by totaling the numerator value of each of the states in the group and the denominator value of each of the states in the group and dividing to compute an average. For example, the EPSCoR states’ average of R&D by gross domestic product by state, shown in table 8-40, is calculated by summing the R&D of all the EPSCoR states, summing the gross domestic product of these states, and dividing to compute an average. States with more R&D and a larger gross domestic product affect this average more than smaller ones do, just as data on California affect U.S. totals more than data on Wyoming do.

The third and fourth lines, “Average EPSCoR state value” and “Average non-EPSCoR state value,” represent the average of the individual state ratios for an indicator. The average EPSCoR state value for R&D by gross domestic product by state is calculated by summing the ratios for the 22 EPSCoR states and dividing by 22. All state ratios count equally in this computation. Examples of this calculation are shown in tables 8-5 and 8-18.

Technical Note: High-Technology Industries

To define high-technology industries, this chapter uses a modification of the approach employed by the Bureau of Labor Statistics (BLS) (Hecker 2005). BLS’s approach is based on the intensity of high-technology employment within an industry.

High-technology occupations include scientific, engineering, and technician occupations. These occupations employ workers who possess an in-depth knowledge of the theories and principles of science, engineering, and mathematics, which is generally acquired through postsecondary education in some field of technology. An industry is considered a high-technology industry if employment in technology-oriented occupations accounts for a proportion of that industry’s total employment that is at least twice the 4.9% average for all industries (i.e., 9.8% or higher).

In this chapter, the category “high-technology industries” refers only to private-sector businesses. In contrast, BLS includes the “Federal Government, excluding Postal Service” in its listing of high-technology industries.

Each industry is defined by a four-digit code that is based on the listings in the North American Industry Classification System (NAICS). The NAICS codes change over time, thereby affecting the trend data presented in the tables. For data years up through 2008, the 2002 NAICS codes were used to define business establishments. Subsequent data years reflect the use of the 2007 NAICS codes. The list of high-technology industries used in this chapter includes the four-digit codes from the 2002 and 2007 NAICS listings shown in table 8-A.

Appendix Tables

Additional data tables pertaining to the indicators in this chapter have been included in the appendix. These tables provide supplemental information to assist the reader in evaluating the data used in an indicator. The appendix tables contain state-level data on the performance of students in different racial/ethnic and gender groups on the National Assessment of Educational Progress evaluations.

Reference

Hecker D. 2005. High-technology employment: A NAICS-based update. *Monthly Labor Review* 128(7):57–72.

Figure 8-B
Example state distribution chart

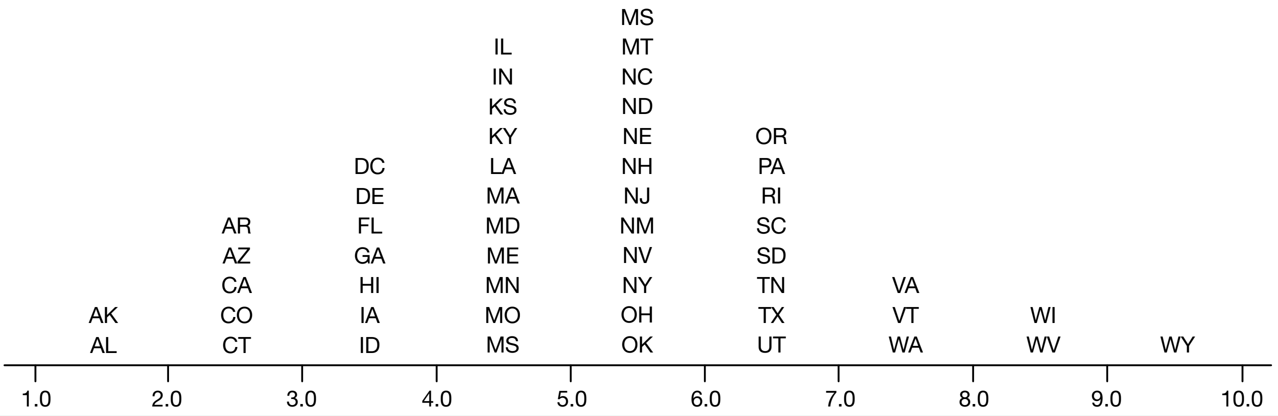


Table 8-A

NAICS codes that constitute high-technology industries

2002 NAICS code	2007 NAICS code	Industry
1131	1131	Timber track operations
1132	1132	Forest nurseries and gathering of forest products
2111	2111	Oil and gas extraction
2211	2211	Electric power generation, transmission, and distribution
3241	3241	Petroleum and coal products manufacturing
3251	3251	Basic chemical manufacturing
3252	3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing
3253	3253	Pesticide, fertilizer, and other agricultural chemical manufacturing
3254	3254	Pharmaceutical and medicine manufacturing
3255	3255	Paint, coating, and adhesive manufacturing
3259	3259	Other chemical product and preparation manufacturing
3332	3332	Industrial machinery manufacturing
3333	3333	Commercial and service industry machinery manufacturing
3336	3336	Engine, turbine, and power transmission equipment manufacturing
3339	3339	Other general purpose machinery manufacturing
3341	3341	Computer and peripheral equipment manufacturing
3342	3342	Communications equipment manufacturing
3343	3343	Audio and video equipment manufacturing
3344	3344	Semiconductor and other electronic component manufacturing
3345	3345	Navigational, measuring, electromedical, and control instruments manufacturing
3346	3346	Manufacturing and reproducing magnetic and optical media
3353	3353	Electrical equipment manufacturing
3364	3364	Aerospace product and parts manufacturing
3369	3369	Other transportation equipment manufacturing
4234	4234	Professional and commercial equipment and supplies, merchant wholesalers
4861	4861	Pipeline transportation of crude oil
4862	4862	Pipeline transportation of natural gas
4869	4869	Other pipeline transportation
5112	5112	Software publishers
5161	na	Internet publishing and broadcasting
na	519130	Internet publishing and broadcasting and Web search portals
5171	5171	Wired telecommunications carriers
5172	5172	Wireless telecommunications carriers (except satellite)
5173	na	Telecommunications resellers
5174	5174	Satellite telecommunications
5179	5179	Other telecommunications
5181	na	Internet service providers and Web search portals
5182	5182	Data processing, hosting, and related services
5211	5211	Monetary authorities, central bank
5232	5232	Securities and commodity exchanges
5413	5413	Architectural, engineering, and related services
5415	5415	Computer systems design and related services
5416	5416	Management, scientific, and technical consulting services
5417	5417	Scientific research and development services
5511	5511	Management of companies and enterprises
5612	5612	Facilities support services
na	561312	Executive search services
8112	8112	Electronic and precision equipment repair and maintenance

na = not applicable.

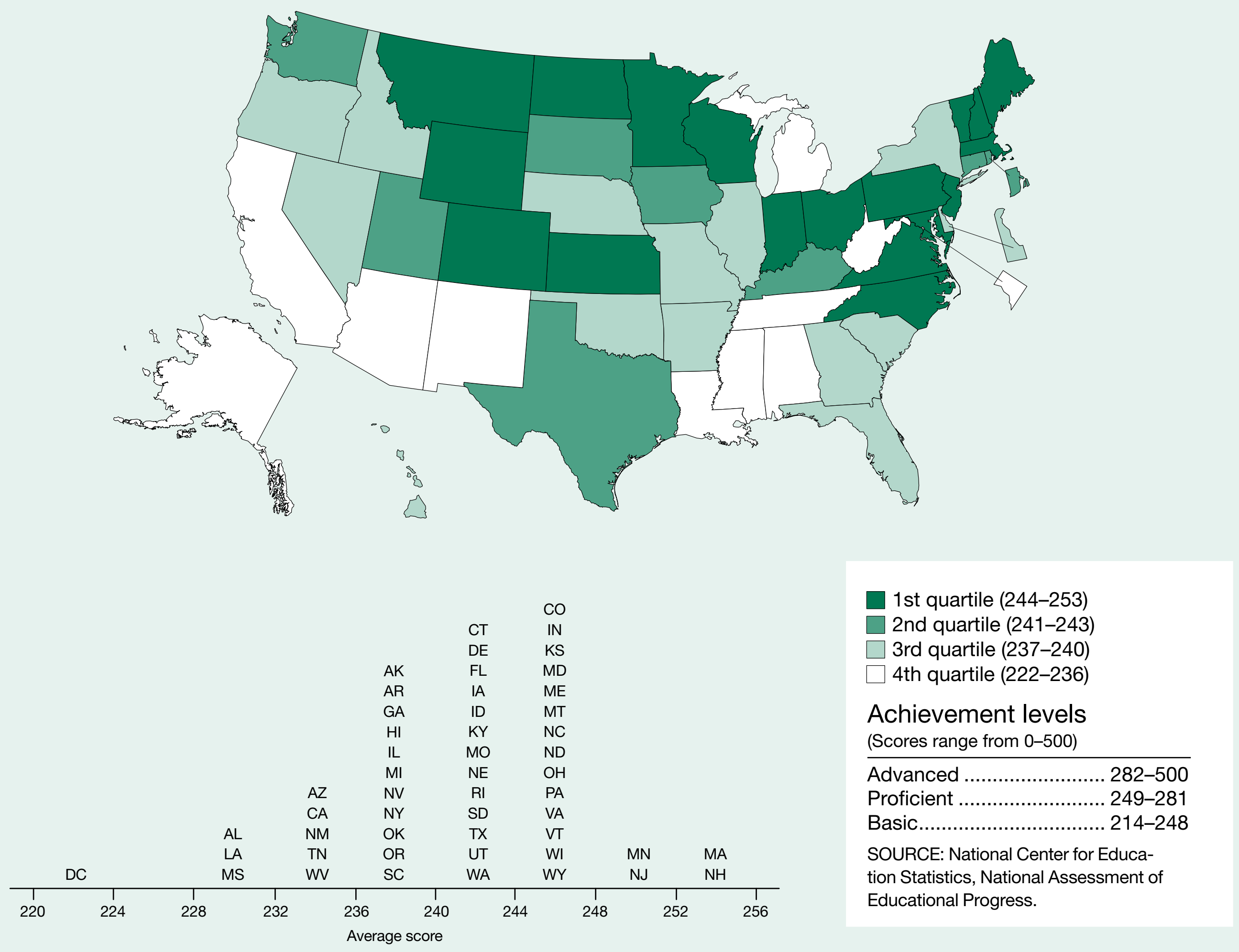
NAICS = North American Industry Classification System.

NOTES: Data on high-tech industries for 2008 and earlier years were compiled using the 2002 NAICS codes. Data for 2009 and 2010 were compiled using the 2007 NAICS codes.

Science and Engineering Indicators 2014

Fourth Grade Mathematics Performance

Figure 8-1
Average fourth grade mathematics performance: 2011



Achievement levels
(Scores range from 0–500)

Advanced	282–500
Proficient	249–281
Basic	214–248

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2011, the nationwide average mathematics score of fourth grade public school students was 240, an increase from 234 in 2003. Fourth graders scored higher in mathematics in 2011 than in any previous assessment year.
- The states with the highest average fourth grade performance scores are concentrated in the northern United States.
- Nationally, the 2011 average mathematics score for white public school fourth grade students was 249 compared to 224 for black students, a gap of 25 points, and 229 for Hispanic students, a gap of 20 points, based upon racial classifications provided by the schools. In 2003, these score gaps were 27 and 22 points, respectively, indicating that these demographic gaps are not shrinking.

This indicator represents each state's average score on the National Assessment of Educational Progress (NAEP) in mathematics for its fourth grade students in public schools. The NAEP mathematics assessment, conducted by the National Center for Education Statistics, is part of a legally mandated federal effort to measure student performance. It measures students' knowledge and skills in mathematics and their ability to apply that knowledge in the content areas of number properties and operations; measurement; geometry; data analysis, statistics, and probability; and algebra. Student performance is presented in terms of average scores on a scale from 0 to 500.

All 50 states and the District of Columbia participated in the 2011 NAEP mathematics assessment. Students with disabilities or limited English-language proficiency are allowed to use certain accommodations (e.g., extra testing time or individual rather than group administration). All data presented here represent scores from tests taken with accommodations offered. For additional details on NAEP scores by gender and race/ethnicity, see appendix tables 8-1 to 8-12.

Table 8-1

Average fourth grade mathematics performance, by state: 2003, 2007, and 2011

(Score out of 500)

State	2003	2007	2011
United States	234	239	240
Alabama	223	229	231
Alaska	233	237	236
Arizona	229	232	235
Arkansas	229	238	238
California	227	230	234
Colorado	235	240	244
Connecticut	241	243	242
Delaware	236	242	240
District of Columbia	205	214	222
Florida	234	242	240
Georgia	230	235	238
Hawaii	227	234	239
Idaho	235	241	240
Illinois	233	237	239
Indiana	238	245	244
Iowa	238	243	243
Kansas	242	248	246
Kentucky	229	235	241
Louisiana	226	230	231
Maine	238	242	244
Maryland	233	240	247
Massachusetts	242	252	253
Michigan	236	238	236
Minnesota	242	247	249
Mississippi	223	228	230
Missouri	235	239	240
Montana	236	244	244
Nebraska	236	238	240
Nevada	228	232	237
New Hampshire	243	249	252
New Jersey	239	249	248
New Mexico	223	228	233
New York	236	243	238
North Carolina	242	242	245
North Dakota	238	245	245
Ohio	238	245	244
Oklahoma	229	237	237
Oregon	236	236	237
Pennsylvania	236	244	246
Rhode Island	230	236	242
South Carolina	236	237	237
South Dakota	237	241	241
Tennessee	228	233	233
Texas	237	242	241
Utah	235	239	243
Vermont	242	246	247
Virginia	239	244	245
Washington	238	243	243
West Virginia	231	236	235
Wisconsin	237	244	245
Wyoming	241	244	244
Puerto Rico	NA	NA	NA

NA = not available.

NOTES: National Assessment of Educational Progress (NAEP) grade 4 mathematics scores are for public schools only. For additional details on NAEP scores by sex and race or ethnicity, see appendix tables 8-1–8-12.

SOURCE: National Center for Education Statistics, NAEP (various years).

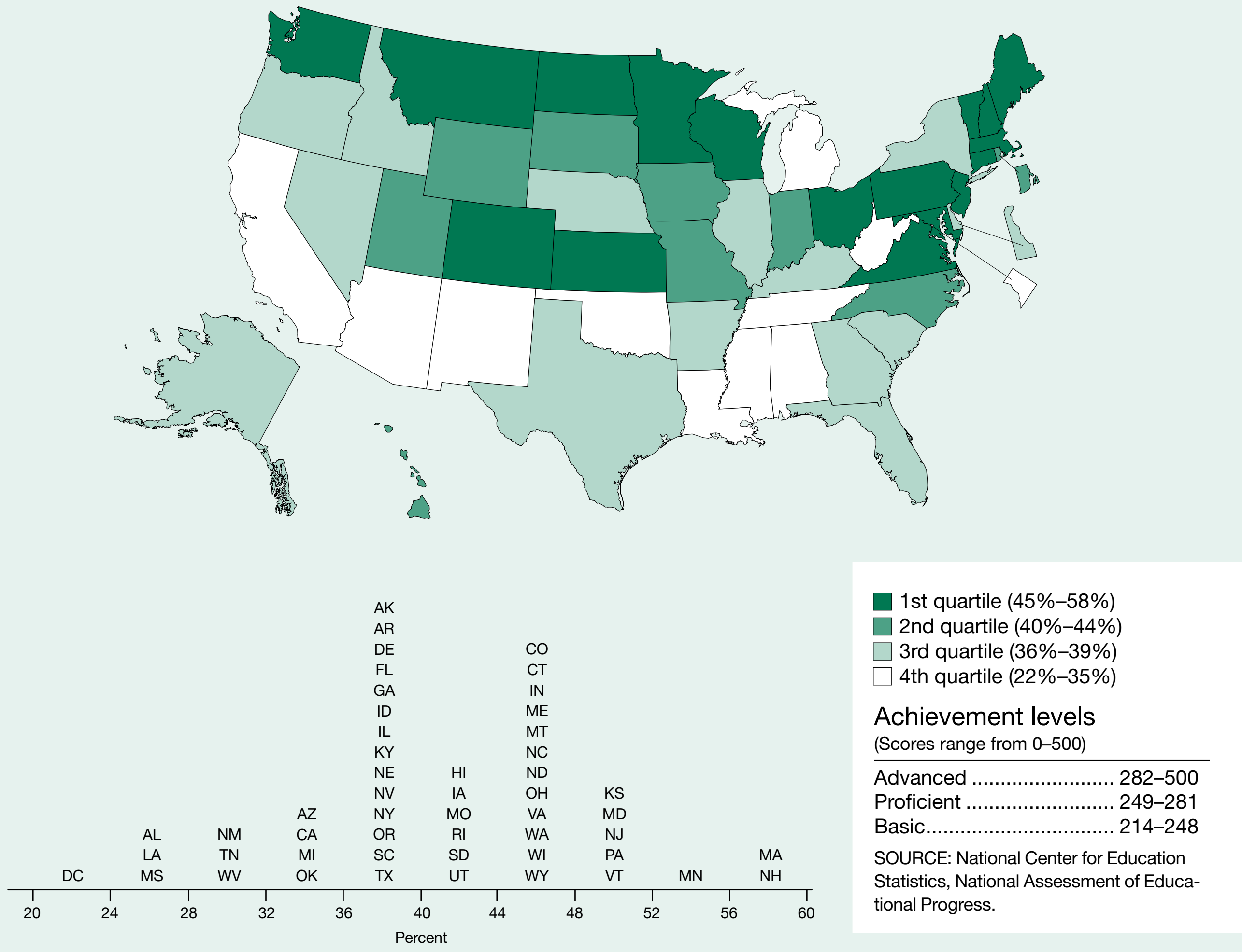
Science and Engineering Indicators 2014

Fourth Grade Mathematics Proficiency

Figure 8-2

Students reaching proficiency in fourth grade mathematics: 2011

(Percentage of students scoring 249 or above)



- 🟩 1st quartile (45%–58%)
- 🟩 2nd quartile (40%–44%)
- ▨ 3rd quartile (36%–39%)
- ☐ 4th quartile (22%–35%)

Achievement levels

(Scores range from 0–500)

Advanced	282–500
Proficient	249–281
Basic	214–248

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2011, 40% of fourth grade public school students nationwide performed at or above the proficient level in mathematics, an increase from 31% in 2003.
- Of the 51 jurisdictions that participated in both the 2003 and 2011 fourth grade mathematics assessments, 50 showed increases in mathematics proficiency among public school fourth graders over the period.
- Nationally, the percentage of fourth grade white public school students demonstrating proficient performance in mathematics was 52% in 2011 compared to 17% for black students, a gap of 35 percentage points, and 24% for Hispanic students, a gap of 28 percentage points, based upon racial classifications provided by the schools. In 2003, these gaps were 32 and 27 points, respectively, indicating that these demographic gaps are not shrinking.

This indicator represents the proportion of a state's fourth grade students in public schools that has met or exceeded the proficiency standard in mathematics. The National Assessment Governing Board sets performance standards that provide a context for interpreting National Assessment of Educational Progress (NAEP) results. The standards define "proficiency" as well as "advanced" and "basic" accomplishment. For the fourth grade, the proficient level (scores 249–281) represents solid academic performance and demonstrates competency over challenging subject-matter knowledge. The advanced level (282–500) signifies superior performance. The basic level (214–248) denotes partial mastery of knowledge and skills that are prerequisite for proficient work. The National Center for Education Statistics has determined that achievement levels should be used on a trial basis and interpreted with caution.

Approximately 210,000 fourth grade students in 8,500 schools participated in the 2011 NAEP mathematics assessment. Students with disabilities or limited English-language proficiency are allowed to use certain accommodations (e.g., extra testing time or individual rather than group administration). All data presented here represent scores from tests taken with accommodations offered. For additional details on NAEP scores by gender and race/ethnicity, see appendix tables 8-1 to 8-12.

Table 8-2

Students reaching proficiency in fourth grade mathematics, by state: 2003, 2007, and 2011

(Percent)

State	2003	2007	2011
United States	31	39	40
Alabama	19	26	27
Alaska	30	38	37
Arizona	25	31	34
Arkansas	26	37	37
California	25	30	34
Colorado	34	41	47
Connecticut	41	45	45
Delaware	31	40	39
District of Columbia	7	14	22
Florida	31	40	37
Georgia	27	32	37
Hawaii	23	33	40
Idaho	31	40	39
Illinois	32	36	38
Indiana	35	46	44
Iowa	36	43	43
Kansas	41	51	48
Kentucky	22	31	39
Louisiana	21	24	26
Maine	34	42	45
Maryland	31	40	48
Massachusetts	41	58	58
Michigan	34	37	35
Minnesota	42	51	53
Mississippi	17	21	25
Missouri	30	38	41
Montana	31	44	45
Nebraska	34	38	39
Nevada	23	30	36
New Hampshire	43	52	57
New Jersey	39	52	51
New Mexico	17	24	30
New York	33	43	36
North Carolina	41	41	44
North Dakota	34	46	46
Ohio	36	46	45
Oklahoma	23	33	33
Oregon	33	35	37
Pennsylvania	36	47	48
Rhode Island	28	34	43
South Carolina	32	36	36
South Dakota	34	41	40
Tennessee	24	29	30
Texas	33	40	39
Utah	31	39	43
Vermont	42	49	49
Virginia	36	42	46
Washington	36	44	45
West Virginia	24	33	31
Wisconsin	35	47	47
Wyoming	39	44	44
Puerto Rico	NA	NA	NA

NA = not available.

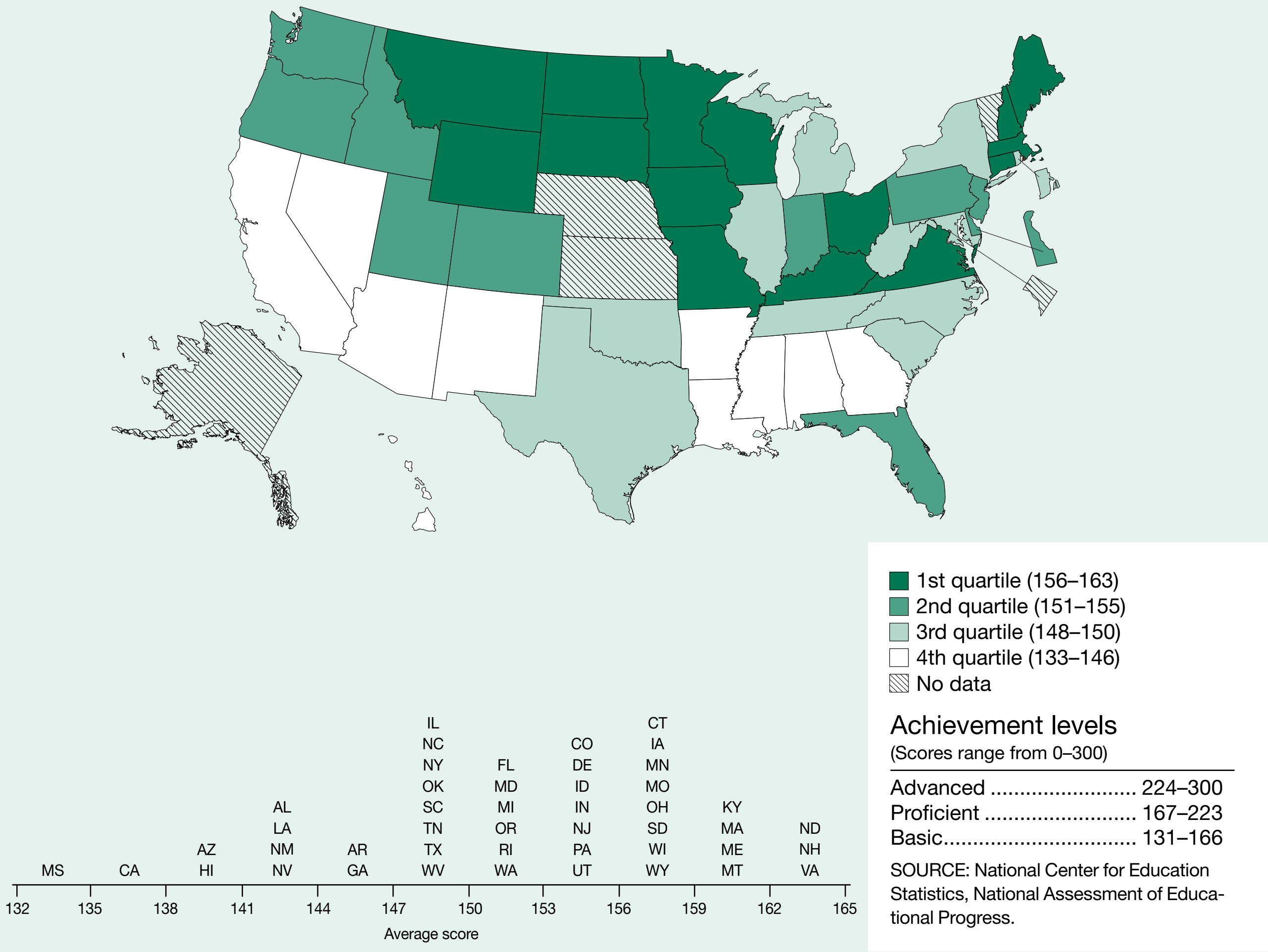
NOTES: National Assessment of Educational Progress (NAEP) grade 4 mathematics scores are for public schools only. For additional details on NAEP scores by sex and race or ethnicity, see appendix tables 8-1–8-12.

SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2014

Fourth Grade Science Performance

Figure 8-3
Average fourth grade science performance: 2009



🟩 1st quartile (156–163)
🟩 2nd quartile (151–155)
🟩 3rd quartile (148–150)
☐ 4th quartile (133–146)
▨ No data

Achievement levels
(Scores range from 0–300)

Advanced	224–300
Proficient	167–223
Basic	131–166

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, the nationwide average science score of fourth grade public school students was 149. Average scores for individual states ranged between 133 and 163.
- Of the 46 jurisdictions that participated in the 2009 fourth grade science assessment, 24 had scores that were higher than the national average, 12 were not significantly different, and 10 were lower.
- Nationally, the 2009 average science score for white public school fourth grade students was 162 compared to 127 for black students, a gap of 35 points, and 130 for Hispanic students, a gap of 32 points, based upon racial classifications provided by the schools.
- Male fourth grade public school students scored 1 point higher in science than female fourth grade public school students although females scored higher in the life science subsection than did males.

This indicator represents each state's average score on the National Assessment of Educational Progress (NAEP) in science for its fourth grade students in public schools. The NAEP science assessment, conducted by the National Center for Education Statistics, is part of a legally mandated federal effort to measure student performance. It measures students' knowledge and skill in science and their ability to apply that knowledge in the content areas of physical, life, and earth and space science. The NAEP assessment in science was updated in 2009 to keep pace with recent developments in science and science education. Because it is based on a new framework, 2009 results cannot be compared to those from previous science assessments. Student performance is presented in terms of average scores on a scale from 0 to 300.

An average score designated as "NA" (not available) indicates that the state either did not participate in the assessment or did not meet the minimum guidelines for reporting. Students with disabilities or limited English-language proficiency are allowed to use certain accommodations (e.g., extra testing time or individual rather than group administration). All data presented here represent scores from tests taken with accommodations offered. For additional details on NAEP scores by gender and race/ethnicity, see appendix tables 8-1 to 8-12.

Table 8-3

Average fourth grade science performance, by state: 2009

(Score out of 300)

State	2009
United States	149
Alabama	143
Alaska	NA
Arizona	138
Arkansas	146
California	136
Colorado	155
Connecticut	156
Delaware	153
District of Columbia	NA
Florida	151
Georgia	144
Hawaii	140
Idaho	154
Illinois	148
Indiana	153
Iowa	157
Kansas	NA
Kentucky	161
Louisiana	141
Maine	160
Maryland	150
Massachusetts	160
Michigan	150
Minnesota	158
Mississippi	133
Missouri	156
Montana	160
Nebraska	NA
Nevada	141
New Hampshire	163
New Jersey	155
New Mexico	142
New York	148
North Carolina	148
North Dakota	162
Ohio	157
Oklahoma	148
Oregon	151
Pennsylvania	154
Rhode Island	150
South Carolina	149
South Dakota	157
Tennessee	148
Texas	148
Utah	154
Vermont	NA
Virginia	162
Washington	151
West Virginia	148
Wisconsin	157
Wyoming	156
Puerto Rico	NA

NA = not available.

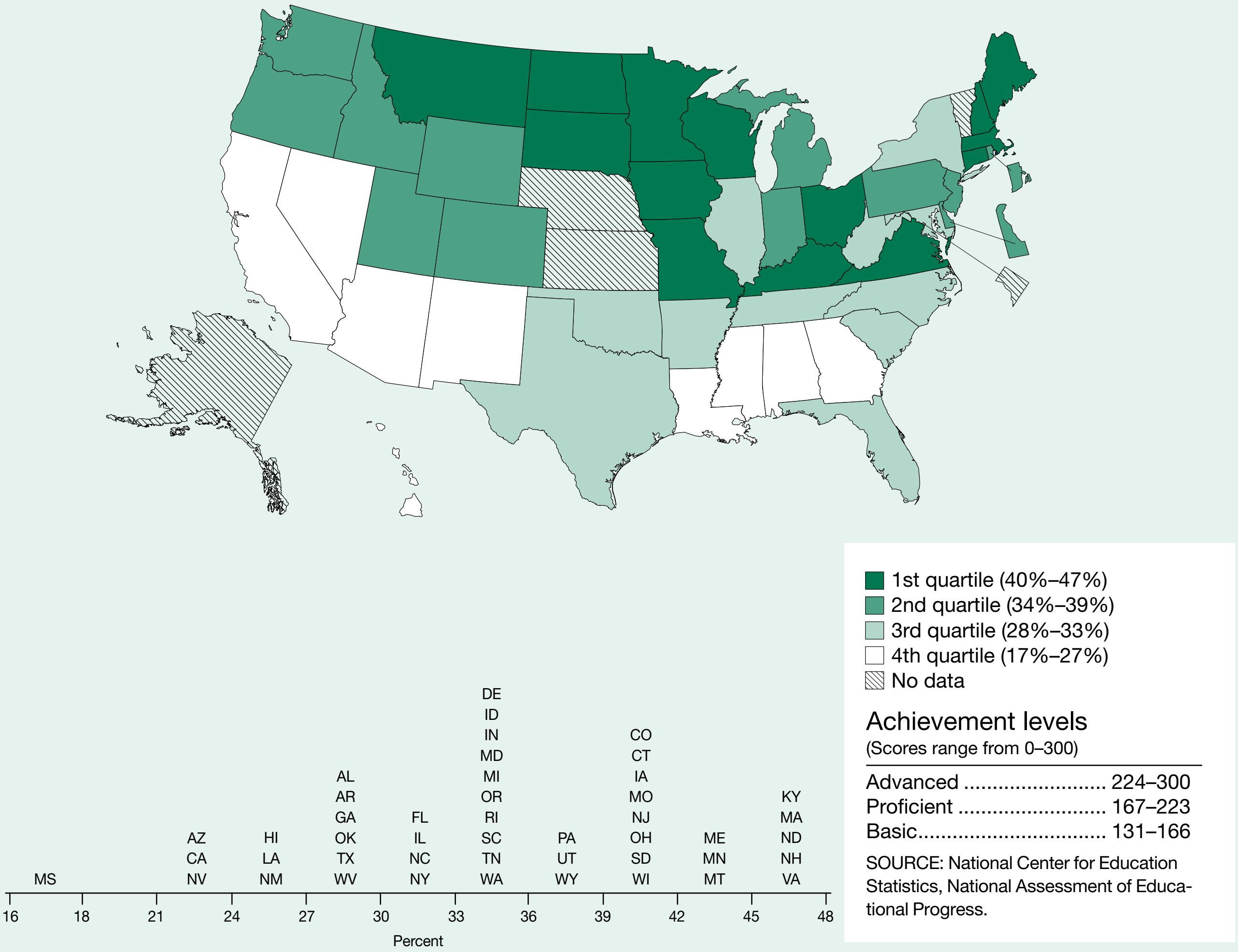
NOTES: National Assessment of Educational Progress (NAEP) grade 4 science scores are for public schools only. For additional details on NAEP scores by sex and race or ethnicity, see appendix tables 8-1–8-12.

SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2014

Fourth Grade Science Proficiency

Figure 8-4
Students reaching proficiency in fourth grade science: 2009
(Percentage of students scoring 167 or above)



Achievement levels
(Scores range from 0–300)

Advanced 224–300
Proficient 167–223
Basic................................ 131–166

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, 32% of fourth grade public school students nationwide performed at or above the proficient level in science. Among the states, there were substantial differences in the percentage of fourth grade public school students who demonstrated proficiency in science. State values for this indicator ranged from 17% to 47%.
- Nationally, the percentage of fourth grade white public school students demonstrating proficient performance in science was 46% in 2009 compared to 10% for black students, a gap of 36 percentage points, and 13% for Hispanic students, a gap of 33 percentage points, based upon racial classifications provided by the schools.

This indicator represents the proportion of a state's fourth grade students in public schools that has met or exceeded the proficiency standard in science. The National Assessment Governing Board sets performance standards that provide a context for interpreting National Assessment of Educational Progress (NAEP) results. The standards define "proficiency" as well as "advanced" and "basic" accomplishment. For the fourth grade, the proficient level (scores 167–223) represents solid academic performance and demonstrates competency over challenging subject-matter knowledge. The advanced level (224–300) signifies superior performance. The basic level (131–166) denotes partial mastery of knowledge and skills that are prerequisite for proficient work. The National Center for Education Statistics has determined that achievement levels should be used on a trial basis and interpreted with caution.

Approximately 156,500 fourth grade students in 9,330 schools participated in the 2009 NAEP science assessment. A designation of "NA" (not available) indicates that the state either did not participate in the assessment or did not meet minimum guidelines for reporting. Students with disabilities or limited English-language proficiency are allowed to use certain accommodations (e.g., extra testing time or individual rather than group administration). All data presented here represent scores from tests taken with accommodations offered. For additional details on NAEP scores by gender and race/ethnicity, see appendix tables 8-1 to 8-12.

Table 8-4
Students reaching proficiency in fourth grade science, by state: 2009
(Percent)

State	2009
United States	32
Alabama	27
Alaska	NA
Arizona	22
Arkansas	29
California	22
Colorado	39
Connecticut	40
Delaware	34
District of Columbia	NA
Florida	32
Georgia	27
Hawaii	25
Idaho	35
Illinois	32
Indiana	35
Iowa	41
Kansas	NA
Kentucky	45
Louisiana	25
Maine	42
Maryland	33
Massachusetts	45
Michigan	34
Minnesota	43
Mississippi	17
Missouri	40
Montana	43
Nebraska	NA
Nevada	23
New Hampshire	47
New Jersey	39
New Mexico	24
New York	30
North Carolina	30
North Dakota	45
Ohio	41
Oklahoma	28
Oregon	34
Pennsylvania	38
Rhode Island	34
South Carolina	33
South Dakota	40
Tennessee	33
Texas	29
Utah	38
Vermont	NA
Virginia	46
Washington	35
West Virginia	28
Wisconsin	41
Wyoming	37
Puerto Rico	NA

NA = not available.

NOTES: National Assessment of Educational Progress (NAEP) grade 4 science scores are for public schools only. For additional details on NAEP scores by sex and race or ethnicity, see appendix tables 8-1–8-12.

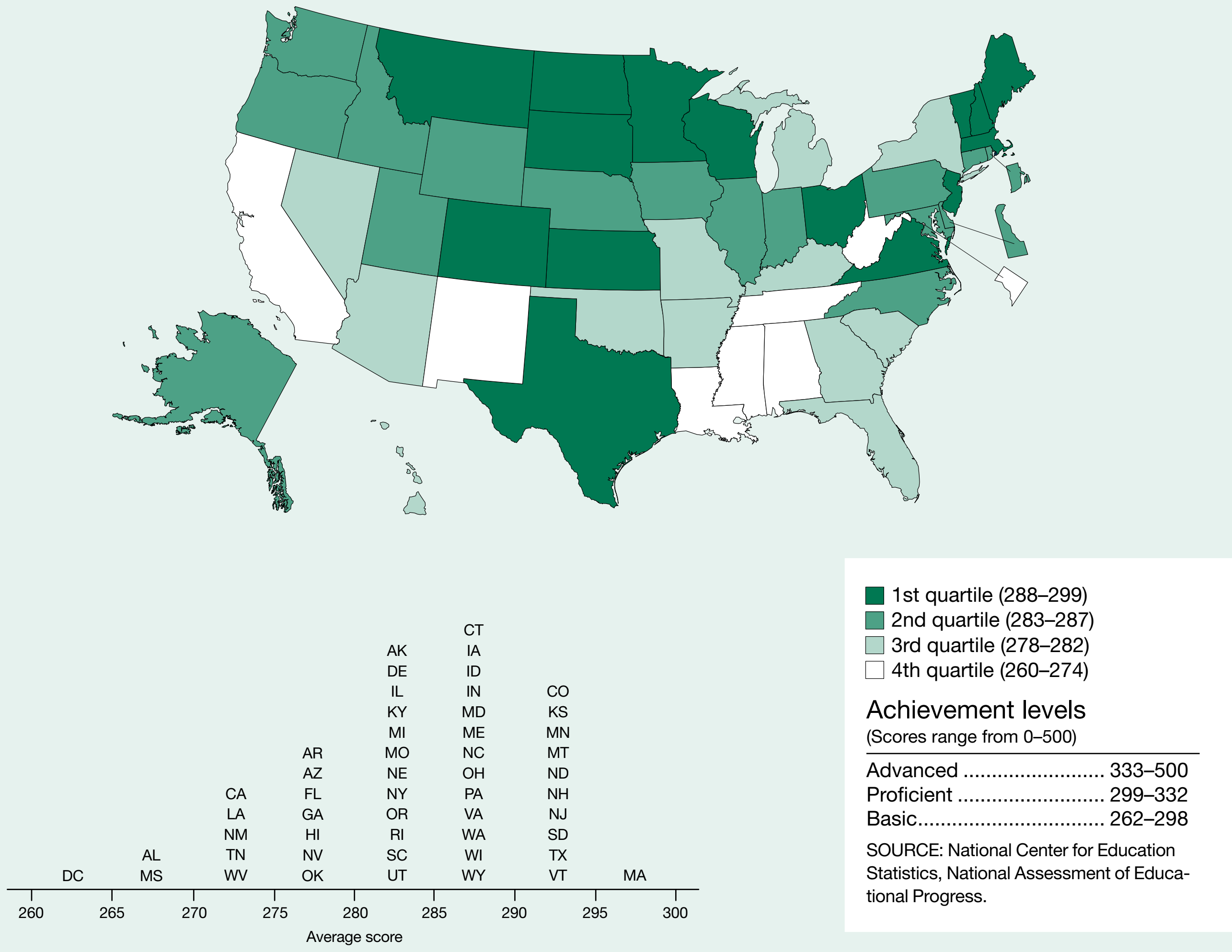
SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2014

Eighth Grade Mathematics Performance

Figure 8-5

Average eighth grade mathematics performance: 2011



- 🟩 1st quartile (288–299)
- 🟩 2nd quartile (283–287)
- 🟩 3rd quartile (278–282)
- ☐ 4th quartile (260–274)

Achievement levels

(Scores range from 0–500)

Advanced	333–500
Proficient	299–332
Basic	262–298

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2011, the nationwide average mathematics score of eighth grade public school students was 283, an increase from 276 in 2003. Eighth graders scored higher in mathematics in 2011 than in any previous assessment year.
- Of the 51 jurisdictions that participated in both the 2003 and 2011 mathematics assessments, 46 showed increases in mathematics scores among public school eighth graders over the period. Since 2007, eighth grade mathematics scores showed an increase for public school students in 28 states.
- Nationally, the 2011 average mathematics score for white public school eighth grade students was 293 compared to 262 for black students, a gap of 31 points, and 269 for Hispanic students, a gap of 24 points, based upon racial classifications provided by the schools. In 2003, these score gaps were 35 and 29 points, respectively.

This indicator represents each state's average score on the National Assessment of Educational Progress (NAEP) in mathematics for its eighth grade students in public schools. The NAEP mathematics assessment, conducted by the National Center for Education Statistics, is part of a legally mandated federal effort to measure student performance. It measures students' knowledge and skills in mathematics and their ability to apply that knowledge in the content areas of number properties and operations; measurement; geometry; data analysis, statistics, and probability; and algebra. Student performance is presented in terms of average scores on a scale from 0 to 500.

All 50 states and the District of Columbia participated in the 2011 NAEP mathematics assessment. Students with disabilities or limited English-language proficiency are allowed to use certain accommodations (e.g., extra testing time or individual rather than group administration). All data presented here represent scores from tests taken with accommodations offered. For additional details on NAEP scores by gender and race/ethnicity, see appendix tables 8-1 to 8-12.

Table 8-5

Average eighth grade mathematics performance, by state: 2003, 2007, and 2011

(Score out of 500)

State	2003	2007	2011
Average EPSCoR state value	276	279	282
Average non-EPSCoR state value	279	283	285
United States	276	280	283
Alabama	262	266	269
Alaska	279	283	283
Arizona	271	276	279
Arkansas	266	274	279
California	267	270	273
Colorado	283	286	292
Connecticut	284	282	287
Delaware	277	283	283
District of Columbia	243	248	260
Florida	271	277	278
Georgia	270	275	278
Hawaii	266	269	278
Idaho	280	284	287
Illinois	277	280	283
Indiana	281	285	285
Iowa	284	285	285
Kansas	284	290	290
Kentucky	274	279	282
Louisiana	266	272	273
Maine	282	286	289
Maryland	278	286	288
Massachusetts	287	298	299
Michigan	276	277	280
Minnesota	291	292	295
Mississippi	261	265	269
Missouri	279	281	282
Montana	286	287	293
Nebraska	282	284	283
Nevada	268	271	278
New Hampshire	286	288	292
New Jersey	281	289	294
New Mexico	263	268	274
New York	280	280	280
North Carolina	281	284	286
North Dakota	287	292	292
Ohio	282	285	289
Oklahoma	272	275	279
Oregon	281	284	283
Pennsylvania	279	286	286
Rhode Island	272	275	283
South Carolina	277	282	281
South Dakota	285	288	291
Tennessee	268	274	274
Texas	277	286	290
Utah	281	281	283
Vermont	286	291	294
Virginia	282	288	289
Washington	281	285	288
West Virginia	271	270	273
Wisconsin	284	286	289
Wyoming	284	287	288
Puerto Rico	NA	NA	NA

NA = not available.

EPSCoR = Experimental Program to Stimulate Competitive Research.

NOTES: National Assessment of Educational Progress (NAEP) grade 8 mathematics scores are for public schools only. For additional details on NAEP scores by sex and race or ethnicity, see appendix tables 8-1–8-12. For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

SOURCE: National Center for Education Statistics, NAEP (various years).

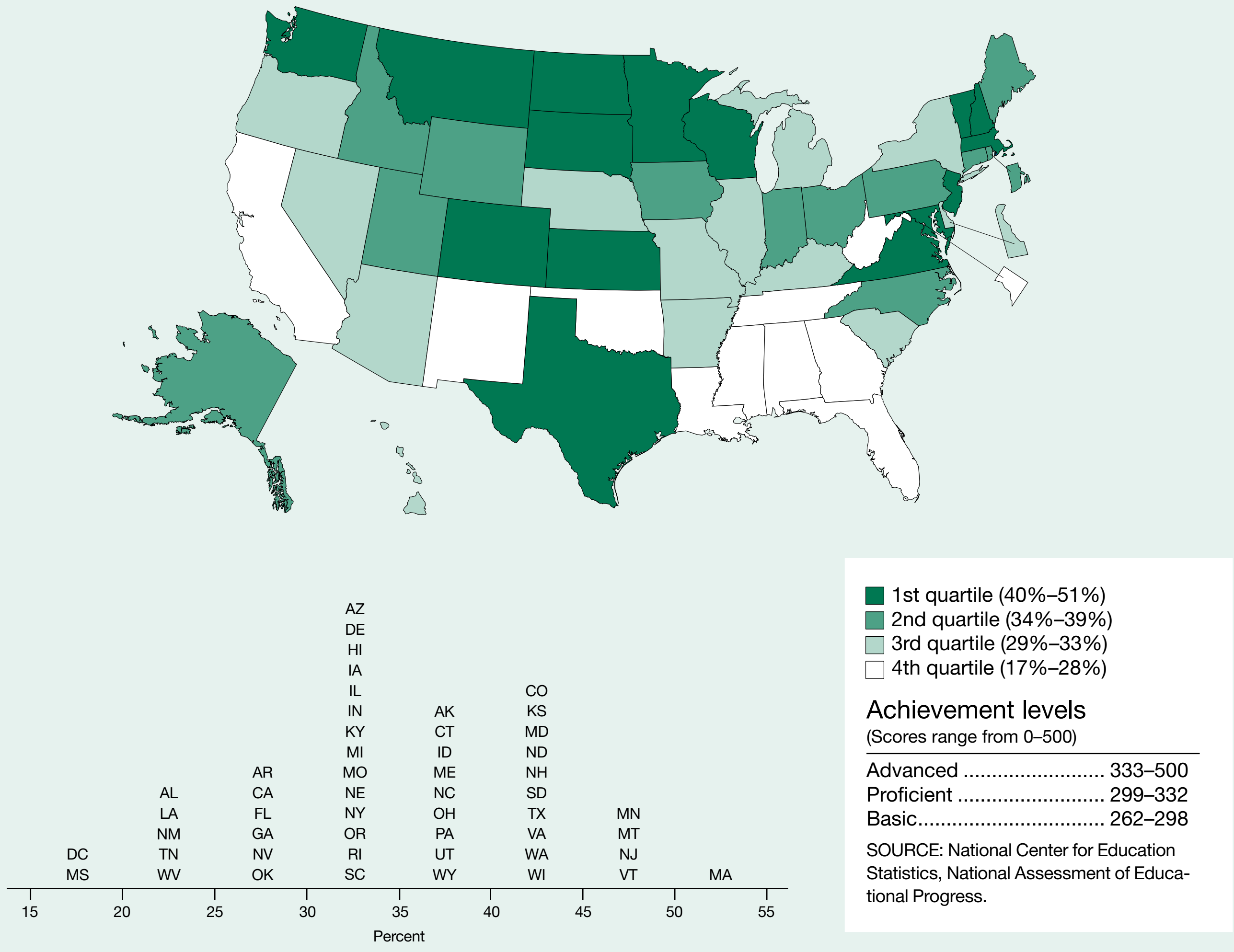
Science and Engineering Indicators 2014

Eighth Grade Mathematics Proficiency

Figure 8-6

Students reaching proficiency in eighth grade mathematics: 2011

(Percentage of students scoring 299 or above)



Achievement levels

(Scores range from 0–500)

Advanced	333–500
Proficient	299–332
Basic	262–298

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2011, 34% of eighth grade public school students nationwide performed at or above the proficient level in mathematics, a sizable increase from 27% in 2003.
- Of the 51 jurisdictions that participated in both the 2003 and 2011 eighth grade mathematics assessments, 43 showed increases in mathematics proficiency among public school eighth graders during the period. Only 25 showed a significant increase from 2007 to 2011.
- Nationally, the percentage of eighth grade white public school students demonstrating proficient performance in mathematics was 43% in 2011 compared to 13% for black students, a gap of 30 percentage points, and 20% for Hispanic students, a gap of 23 percentage points, based upon racial classifications provided by the schools. In 2003, these gaps were 29 and 25 percentage points, respectively.
- The percentage of eighth grade students proficient in mathematics increased for both sexes between 2003 and 2011, and the size of the gender gap decreased from 3% to 1% during this period.

This indicator represents the proportion of a state's eighth grade students in public schools that has met or exceeded the proficiency standard in mathematics. The National Assessment Governing Board sets performance standards that provide a context for interpreting National Assessment of Educational Progress (NAEP) results. The standards define "proficiency" as well as "advanced" and "basic" accomplishment. For the eighth grade, the proficient level (scores 299–332) represents solid academic performance and demonstrates competency over challenging subject-matter knowledge. The advanced level (333–500) signifies superior performance. The basic level (262–298) denotes partial mastery of knowledge and skills that are prerequisite for proficient work. The National Center for Education Statistics has determined that achievement levels should be used on a trial basis and interpreted with caution.

Approximately 175,200 eighth grade students in 7,610 schools participated in the 2011 NAEP mathematics assessment. Students with disabilities or limited English-language proficiency are allowed to use certain accommodations (e.g., extra testing time or individual rather than group administration). All data presented here represent scores from tests taken with accommodations offered. For additional details on NAEP scores by gender and race/ethnicity, see appendix tables 8-1 to 8-12.

Table 8-6

Students reaching proficiency in eighth grade mathematics, by state: 2003, 2007, and 2011

(Percent)

State	2003	2007	2011
United States	27	31	34
Alabama	16	18	20
Alaska	30	32	35
Arizona	21	26	31
Arkansas	19	24	29
California	22	24	25
Colorado	34	37	43
Connecticut	35	35	38
Delaware	26	31	32
District of Columbia	6	8	17
Florida	23	27	28
Georgia	22	25	28
Hawaii	17	21	30
Idaho	28	34	37
Illinois	29	31	33
Indiana	31	35	34
Iowa	33	35	34
Kansas	34	40	41
Kentucky	24	27	31
Louisiana	17	19	22
Maine	29	34	39
Maryland	30	37	40
Massachusetts	38	51	51
Michigan	28	29	31
Minnesota	44	43	48
Mississippi	12	14	19
Missouri	28	30	32
Montana	35	38	46
Nebraska	32	35	33
Nevada	20	23	29
New Hampshire	35	38	44
New Jersey	33	40	47
New Mexico	15	17	24
New York	32	30	30
North Carolina	32	34	37
North Dakota	36	41	43
Ohio	30	35	39
Oklahoma	20	21	27
Oregon	32	35	33
Pennsylvania	30	38	39
Rhode Island	24	28	34
South Carolina	26	32	32
South Dakota	35	39	42
Tennessee	21	23	24
Texas	25	35	40
Utah	31	32	35
Vermont	35	41	46
Virginia	31	37	40
Washington	32	36	40
West Virginia	20	19	21
Wisconsin	35	37	41
Wyoming	32	36	37
Puerto Rico	NA	NA	NA

NA = not available.

NOTES: National Assessment of Educational Progress (NAEP) grade 8 mathematics scores are for public schools only. For additional details on NAEP scores by sex and race or ethnicity, see appendix tables 8-1–8-12.

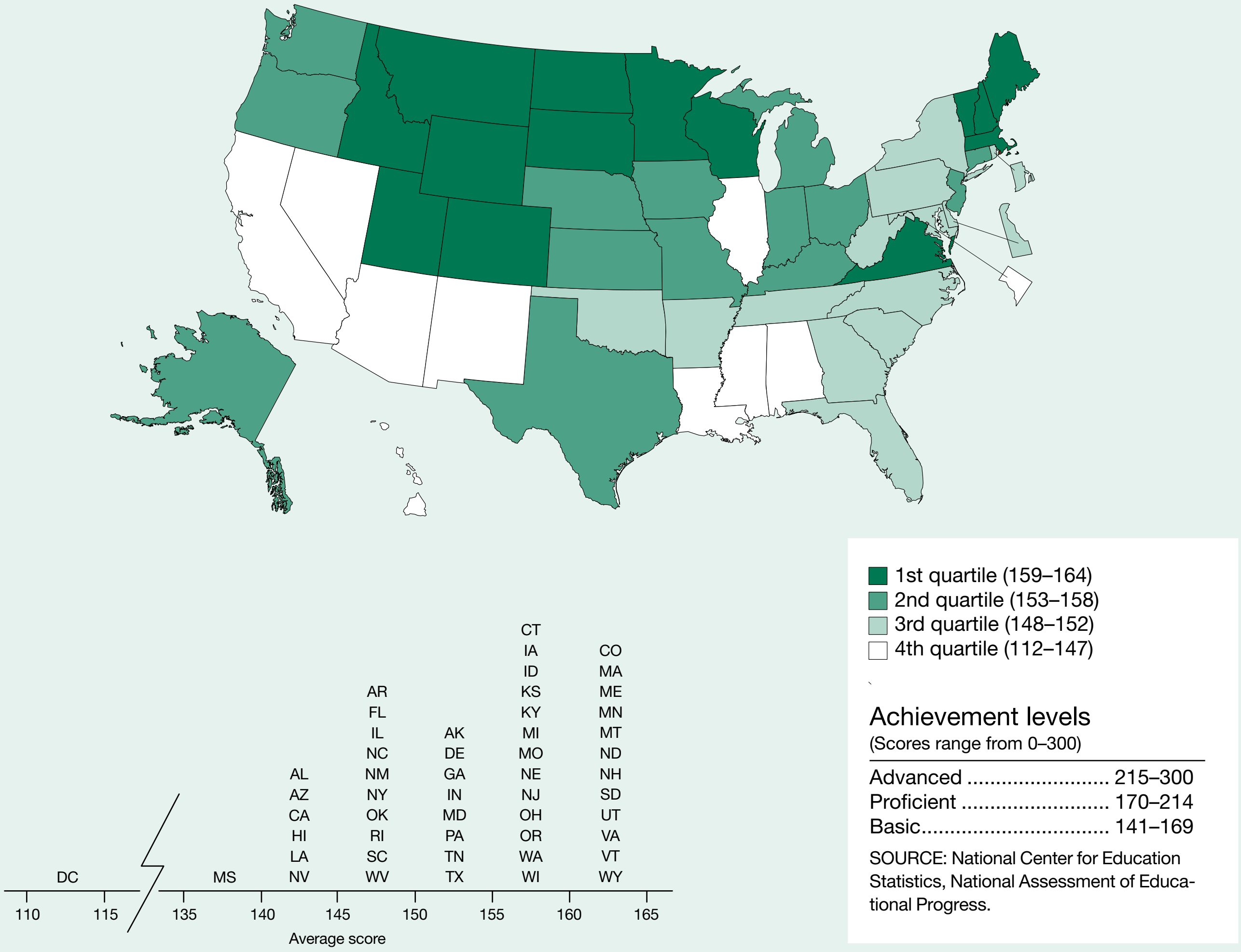
SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2014

Eighth Grade Science Performance

Figure 8-7

Average eighth grade science performance: 2011



Achievement levels

(Scores range from 0–300)

Advanced 215–300
Proficient 170–214
Basic................................ 141–169

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2011, the nationwide average science score of eighth grade public school students was 151, an increase from 149 in 2009. Average scores in 2011 for individual states ranged from a high of 164 to a low of 137.
- Of the 46 jurisdictions that participated in both the 2009 and 2011 eighth grade science assessments, 22 showed increases in science scores among public school eighth graders over the period.
- Nationally, the 2011 average science score for white public school eighth grade students was 163 compared to 128 for black students, a gap of 35 points, and 136 for Hispanic students, a gap of 27 points, based upon racial classifications provided by the schools. In 2009, these gaps were 36 and 30 points, respectively.

This indicator represents each state's average score on the National Assessment of Educational Progress (NAEP) in science for its eighth grade students in public schools. The NAEP science assessment, conducted by the National Center for Education Statistics, is part of a legally mandated federal effort to measure student performance. It measures students' knowledge and skill in science and their ability to apply that knowledge in the content areas of physical, life, and earth and space science. The NAEP assessment in science was updated in 2009 to keep pace with recent developments in science and science education. Because it is based on a new framework, 2009 results cannot be compared to those from previous science assessments. Student performance is presented in terms of average scores on a scale from 0 to 300.

An average score designated as "NA" (not available) indicates that the state either did not participate in the assessment or did not meet the minimum guidelines for reporting. NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extra testing time or individual rather than group administration). All data presented here represent scores from tests taken with accommodations offered. For additional details on NAEP scores by gender and race/ethnicity, see appendix tables 8-1 to 8-12.

Table 8-7
Average eighth grade science performance, by state: 2009 and 2011
(Score out of 300)

State	2009	2011
United States	149	151
Alabama	139	140
Alaska	NA	153
Arizona	141	144
Arkansas	144	148
California	137	140
Colorado	156	161
Connecticut	155	155
Delaware	148	150
District of Columbia	NA	112
Florida	146	148
Georgia	147	151
Hawaii	139	142
Idaho	158	159
Illinois	148	147
Indiana	152	153
Iowa	156	157
Kansas	NA	156
Kentucky	156	157
Louisiana	139	143
Maine	158	160
Maryland	148	152
Massachusetts	160	161
Michigan	153	157
Minnesota	159	161
Mississippi	132	137
Missouri	156	156
Montana	162	163
Nebraska	NA	157
Nevada	141	144
New Hampshire	160	162
New Jersey	155	155
New Mexico	143	145
New York	149	149
North Carolina	144	148
North Dakota	162	164
Ohio	158	158
Oklahoma	146	148
Oregon	154	155
Pennsylvania	154	151
Rhode Island	146	149
South Carolina	143	149
South Dakota	161	162
Tennessee	148	150
Texas	150	153
Utah	158	161
Vermont	NA	163
Virginia	156	160
Washington	155	156
West Virginia	145	149
Wisconsin	157	159
Wyoming	158	160
Puerto Rico	NA	NA

NA = not available.

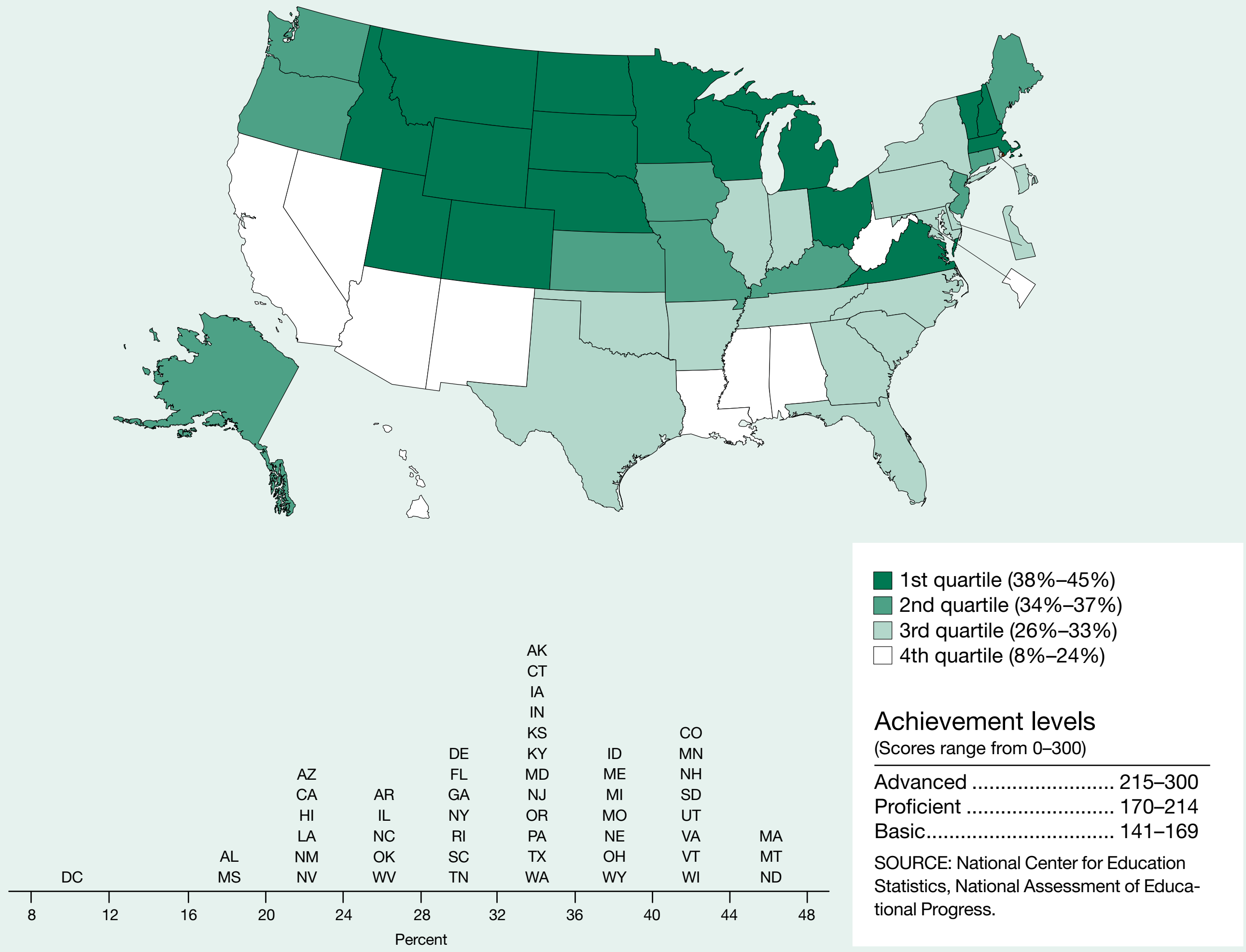
NOTES: National Assessment of Educational Progress (NAEP) grade 8 science scores are for public schools only. For additional details on NAEP scores by sex and race or ethnicity, see appendix tables 8-1–8-12.

SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2014

Eighth Grade Science Proficiency

Figure 8-8
Students reaching proficiency in eighth grade science: 2011
(Percentage of students scoring 170 or above)



Achievement levels
(Scores range from 0–300)

Advanced	215–300
Proficient	170–214
Basic	141–169

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2011, 31% of eighth grade public school students nationwide performed at or above the proficient level in science. State values for this indicator ranged from 19% to 45%.
- Nationally, the percentage of eighth grade white students demonstrating proficient performance in science was 43% in 2011 compared to 9% for black students, a gap of 34 percentage points, and 16% for Hispanic students, a gap of 27 percentage points, based upon the racial classifications provided by the schools. In 2009, these gaps were 33 and 29 percentage points, respectively.

This indicator represents the proportion of a state's eighth grade students in public schools that has met or exceeded the proficiency standard in science. The National Assessment Governing Board sets performance standards that provide a context for interpreting National Assessment of Educational Progress (NAEP) results. The standards define "proficiency" as well as "advanced" and "basic" accomplishment. For the eighth grade, the proficient level (scores 170–214) represents solid academic performance and demonstrates competency over challenging subject-matter knowledge. The advanced level (215–300) signifies superior performance. The basic level (141–169) denotes partial mastery of knowledge and skills that are prerequisite for proficient work. The National Center for Education Statistics has determined that achievement levels should be used on a trial basis and interpreted with caution.

Approximately 122,000 eighth grade students in 7,290 schools participated in the 2011 NAEP science assessment. A designation of "NA" (not available) indicates that the state either did not participate in the assessment or did not meet minimum guidelines for reporting. NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extra testing time or individual rather than group administration). All data presented here represent scores from tests taken with accommodations offered. For additional details on NAEP scores by gender and race/ethnicity, see appendix tables 8-1 to 8-12.

Table 8-8

Students reaching proficiency in eighth grade science, by state: 2009 and 2011

(Percent)

State	2009	2011
United States	29	31
Alabama	19	19
Alaska	NA	34
Arizona	22	23
Arkansas	24	26
California	20	22
Colorado	36	42
Connecticut	35	35
Delaware	25	28
District of Columbia	NA	8
Florida	25	28
Georgia	27	30
Hawaii	17	22
Idaho	37	38
Illinois	28	26
Indiana	32	33
Iowa	35	35
Kansas	NA	35
Kentucky	34	34
Louisiana	20	22
Maine	35	37
Maryland	28	32
Massachusetts	41	44
Michigan	35	38
Minnesota	40	42
Mississippi	15	19
Missouri	36	36
Montana	43	44
Nebraska	NA	38
Nevada	20	23
New Hampshire	39	42
New Jersey	34	34
New Mexico	21	22
New York	31	29
North Carolina	24	26
North Dakota	42	45
Ohio	37	38
Oklahoma	25	26
Oregon	35	35
Pennsylvania	35	33
Rhode Island	26	31
South Carolina	23	28
South Dakota	40	42
Tennessee	28	31
Texas	29	32
Utah	39	43
Vermont	NA	43
Virginia	36	40
Washington	34	35
West Virginia	22	24
Wisconsin	38	40
Wyoming	36	38
Puerto Rico	NA	NA

NA = not available.

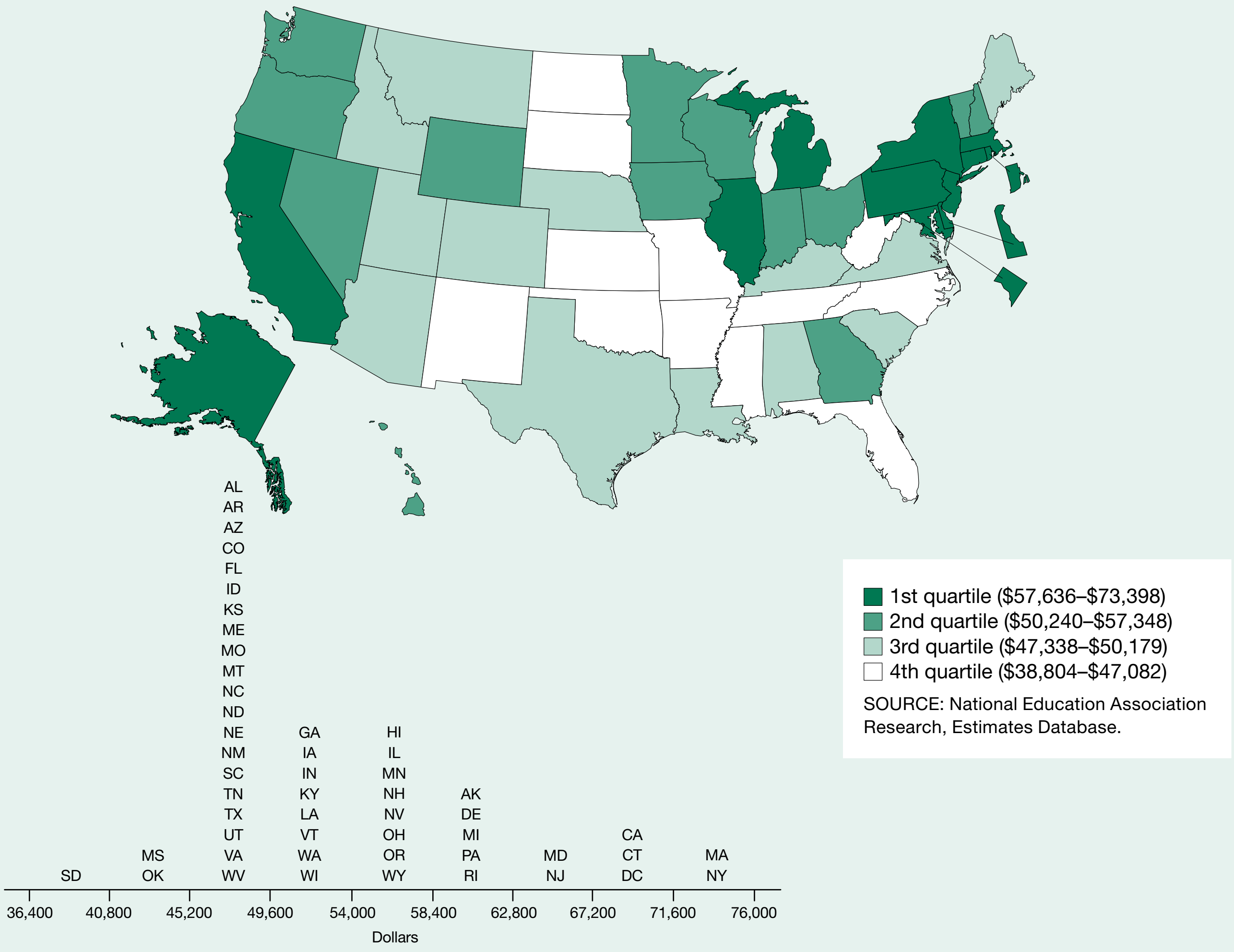
NOTES: National Assessment of Educational Progress (NAEP) grade 8 science scores are for public schools only. For additional details on NAEP scores by sex and race or ethnicity, see appendix tables 8-1–8-12.

SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2014

Public School Teacher Salaries

Figure 8-9
Public school teacher salaries: 2012



SOURCE: National Education Association Research, Estimates Database.

Findings

- In 2012, salaries for public school teachers nationwide averaged $55,418, ranging from a state low of $38,804 to a high of $73,398.
- Fifteen states and the District of Columbia had average public school teacher salaries higher than the national average in 2012, an increase from 13 states and the District of Columbia that were higher than the national average in 2002.
- Between 2002 and 2012, average teacher salaries across the nation rose by 24% in unadjusted dollars. Average teacher salaries declined by 1% after adjusting for inflation.
- Average state salaries for public school teachers and state achievement scores on the NAEP mathematics and science tests are not correlated: some states rank high on one measure and low on the other.

This indicator represents the average salary of all full-time public school teachers. The year is the end date of the academic year. For example, 2012 data represent salaries for the 2011–12 academic year. The figures include salaries for teachers with varying amounts of teaching experience and various types and levels of formal education.

Salary estimates for public elementary and secondary teachers are provided by the National Education Association's *Estimates of School Statistics, 1969–70 through 2011–12*.

Public school teacher salaries may reflect a range of factors, including the value that the state places on primary and secondary education, the state's cost of living, the teachers' experience and education level, and the local supply and demand in the job market. Relatively low teacher salaries may hinder recruitment into the teaching profession.

Table 8-9

Public school teacher salaries, by state: 2002, 2007, and 2012

(Dollars)

State	2002	2007	2012
United States	44,683	50,816	55,418
Alabama	37,194	43,389	48,003
Alaska	49,418	54,658	62,425
Arizona	39,973	45,941	48,691
Arkansas	36,962	44,245	46,314
California	54,348	63,640	68,531
Colorado	40,659	45,833	49,049
Connecticut	53,551	60,822	69,465
Delaware	48,363	54,680	58,800
District of Columbia	47,049	59,000	68,720
Florida	39,275	45,308	46,479
Georgia	44,073	49,905	52,938
Hawaii	42,615	51,922	54,070
Idaho	39,591	42,798	48,551
Illinois	49,435	58,246	57,636
Indiana	44,195	47,831	50,516
Iowa	38,230	43,130	50,240
Kansas	37,093	43,334	46,718
Kentucky	37,951	43,646	49,730
Louisiana	36,328	42,816	50,179
Maine	37,300	41,596	47,338
Maryland	48,251	56,927	63,634
Massachusetts	50,293	58,624	71,721
Michigan	52,676	54,895	61,560
Minnesota	42,194	49,634	54,959
Mississippi	33,295	40,182	41,646
Missouri	37,996	41,839	46,406
Montana	34,379	41,225	48,546
Nebraska	36,236	42,044	48,154
Nevada	40,764	45,342	54,559
New Hampshire	39,915	46,527	54,177
New Jersey	53,192	59,920	67,078
New Mexico	36,440	42,780	45,622
New York	52,000	58,537	73,398
North Carolina	42,680	46,410	45,947
North Dakota	32,253	38,822	46,058
Ohio	44,029	51,937	56,715
Oklahoma	34,744	42,379	44,391
Oregon	46,081	50,911	57,348
Pennsylvania	50,599	54,970	61,934
Rhode Island	49,758	55,956	62,186
South Carolina	39,923	44,133	47,428
South Dakota	31,295	35,378	38,804
Tennessee	38,515	43,816	47,082
Texas	39,232	44,897	48,373
Utah	37,414	40,566	48,159
Vermont	39,240	48,370	51,306
Virginia	41,731	44,727	48,703
Washington	43,464	47,882	52,232
West Virginia	36,751	40,531	45,320
Wisconsin	42,232	47,901	53,792
Wyoming	37,837	50,692	57,222
Puerto Rico	NA	NA	NA

NA = not available.

NOTES: The 2002 and 2007 national averages for the United States are the reported values from the *Digest of Education Statistics*; the 2012 national average for the United States is the reported value from the National Education Association.

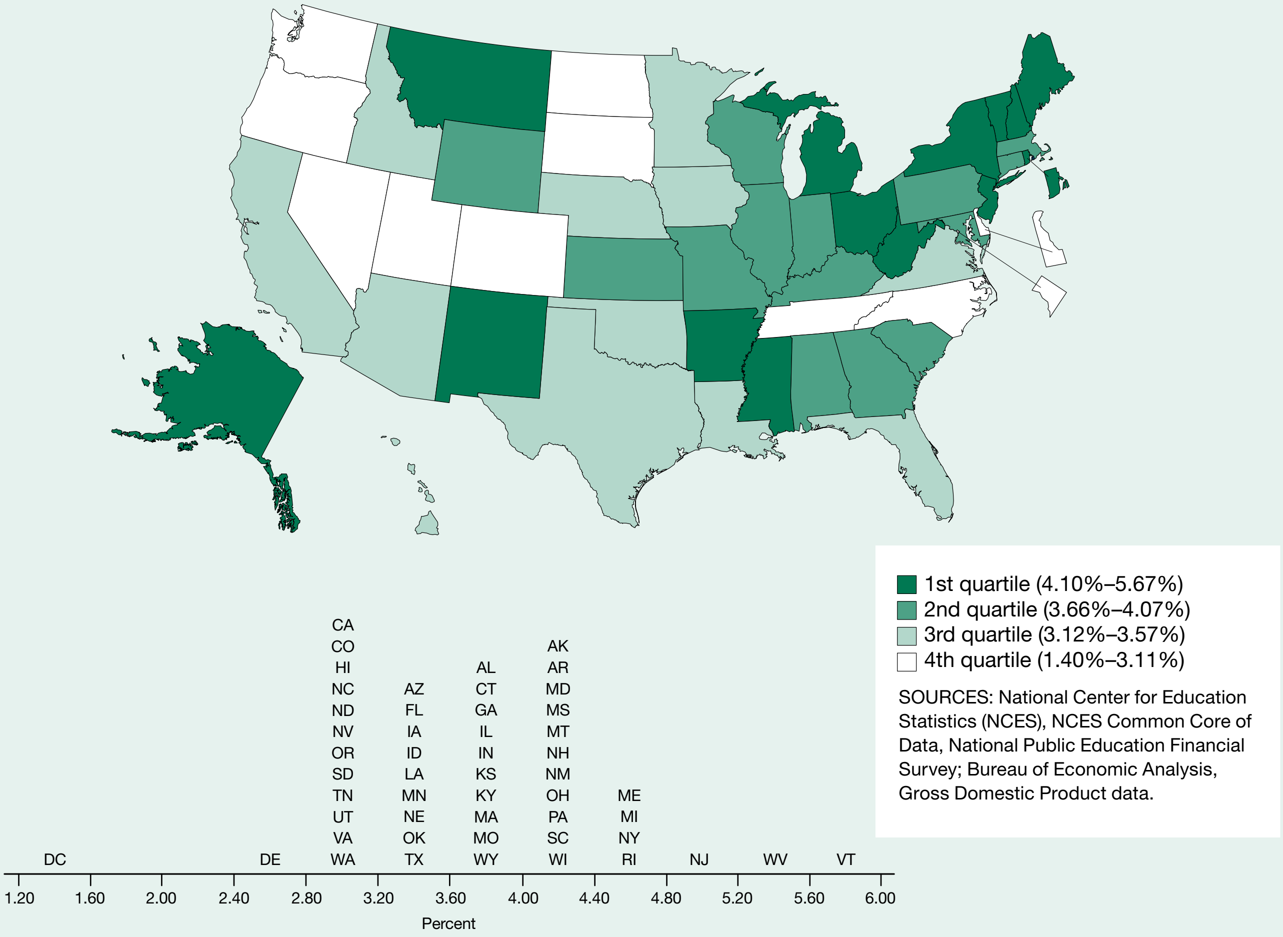
SOURCE: National Center for Education Statistics, *Digest of Education Statistics* (various years). National Education Association Research, Estimates Database (2012).

Science and Engineering Indicators 2014

Elementary and Secondary Public School Expenditures as a Percentage of Gross Domestic Product

Figure 8-10

Elementary and secondary public school expenditures as a percentage of gross domestic product: 2010



SOURCES: National Center for Education Statistics (NCES), NCES Common Core of Data, National Public Education Financial Survey; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The 2010 national average for spending on elementary and secondary education was 3.65% of the gross domestic product (GDP), an increase from 3.28% in 2000. Among individual states, the value for this indicator ranged from 2.47% to 5.67% of the state's GDP in 2010, indicating that some states were directing a much higher percentage of their resources toward elementary and secondary education.
- Spending for elementary and secondary public education as a percentage of the state's GDP decreased in 10 states during the 2000–10 period.
- Several states spending the highest percentage of their GDP on elementary and secondary education had relatively small student populations (100,000–300,000 students), suggesting that some level of expenditure for educational infrastructure (e.g., assessments of curriculum development) may be largely independent of the size of the student population.

This indicator represents the relative amount of resources that state governments expend to support public education in prekindergarten through grade 12. It is calculated by dividing a state's expenditures for elementary and secondary public schools by the state's GDP. Expenditures include instruction and instruction-related costs, student support services, administration, and operations and exclude funds for school construction and other capital outlays, debt service, and programs outside of public elementary and secondary education. State and local support represent the largest sources of funding for elementary and secondary education.

Expenditure data on public elementary and secondary education are reported by the National Center for Education Statistics, Department of Education. They are part of the National Public Education Financial Survey and are included in the Common Core of Data, a comprehensive annual national statistical database that covers approximately 100,000 public elementary and secondary schools and 18,000 regular school districts in the 50 states, the District of Columbia, and outlying areas, as well as Department of Defense Schools. Most of the data are obtained from administrative records maintained by state education agencies.

Expenditures are expressed in actual dollars and their data year is the end date of the academic year. For example, expenditure data for 2010 represent expenditures for the 2009–10 academic year. GDP data refer to the 2010 calendar year.

Table 8-10

Elementary and secondary public school expenditures as a percentage of gross domestic product, by state: 2000, 2005, and 2010

	Public school expenditures ($thousands)			State GDP ($millions)			School expenditures/ GDP (%)		
State	2000	2005	2010	2000	2005	2010	2000	2005	2010
United States	323,808,910	424,562,096	525,497,899	9,884,170	12,539,116	14,388,814	3.28	3.39	3.65
Alabama	4,176,082	5,164,406	6,670,517	116,009	150,968	172,842	3.60	3.42	3.86
Alaska	1,183,499	1,442,269	2,084,019	25,911	37,774	47,910	4.57	3.82	4.35
Arizona	4,262,182	6,451,870	8,587,889*	161,792	222,569	247,329	2.63	2.90	3.47
Arkansas	2,380,331	3,546,999	4,459,910*	68,335	88,501	103,170	3.48	4.01	4.32
California	38,129,479	50,918,654	58,248,662*	1,319,472	1,688,949	1,845,249	2.89	3.01	3.16
Colorado	4,400,888	5,994,440	7,429,302	172,037	217,329	254,551	2.56	2.76	2.92
Connecticut	5,402,868	7,080,396	8,853,337*	163,455	196,307	221,767	3.31	3.61	3.99
Delaware	937,630	1,299,349	1,549,812	40,614	54,422	62,832	2.31	2.39	2.47
District of Columbia	780,192	1,023,952	1,451,870	58,267	82,488	103,745	1.34	1.24	1.40
Florida	13,885,988	19,042,877	23,349,314*	481,239	681,225	727,972	2.89	2.80	3.21
Georgia	9,158,624	12,528,856	15,730,409*	293,966	363,177	402,006	3.12	3.45	3.91
Hawaii	1,213,695	1,648,086	2,110,864	41,450	56,901	67,274	2.93	2.90	3.14
Idaho	1,302,817	1,618,215	1,961,857*	36,147	48,683	55,639	3.60	3.32	3.53
Illinois	14,462,773	18,658,428	24,695,773*	474,520	568,114	642,769	3.05	3.28	3.84
Indiana	7,110,930	9,108,931	9,921,243*	198,238	239,321	270,739	3.59	3.81	3.66
Iowa	3,264,336	3,808,200	4,794,308	93,312	119,998	138,378	3.50	3.17	3.46
Kansas	2,971,814	3,718,153	4,731,676	85,722	104,869	126,640	3.47	3.55	3.74
Kentucky	3,837,794	4,812,591	6,091,814	113,233	138,772	161,064	3.39	3.47	3.78
Louisiana	4,391,214	5,554,766	7,393,452*	131,289	196,917	227,373	3.34	2.82	3.25
Maine	1,604,438	2,056,266	2,356,312*	36,438	45,520	51,343	4.40	4.52	4.59
Maryland	6,545,135	8,682,586	11,883,677*	182,923	247,241	295,981	3.58	3.51	4.02
Massachusetts	8,511,065	11,357,857	14,067,276*	273,006	323,314	376,908	3.12	3.51	3.73
Michigan	13,994,294	16,353,921	17,227,515	337,459	375,753	367,107	4.15	4.35	4.69
Minnesota	6,140,442	7,310,284	8,927,288*	188,818	237,813	268,578	3.25	3.07	3.32
Mississippi	2,510,376	3,243,888	3,990,876*	65,625	81,360	95,763	3.83	3.99	4.17
Missouri	5,655,531	7,115,207	8,923,448*	180,967	216,336	243,876	3.13	3.29	3.66
Montana	994,770	1,193,182	1,498,252	21,633	30,054	36,521	4.60	3.97	4.10
Nebraska	1,926,500	2,512,914	3,247,970	57,333	72,505	90,910	3.36	3.47	3.57
Nevada	1,875,467	2,722,264	3,592,994	75,895	114,478	124,838	2.47	2.38	2.88
New Hampshire	1,418,503	2,021,144	2,576,956	44,161	53,693	61,147	3.21	3.76	4.21
New Jersey	13,327,645	19,669,576	24,261,392	350,110	430,246	483,007	3.81	4.57	5.02
New Mexico	1,890,274	2,554,638	3,217,328	50,294	67,763	77,686	3.76	3.77	4.14
New York	28,433,240	38,866,853	50,251,461*	769,291	959,867	1,136,417	3.70	4.05	4.42
North Carolina	7,713,293	9,567,000	12,200,362	281,542	354,664	426,875	2.74	2.70	2.86
North Dakota	638,946	786,870	1,000,095	18,266	24,670	35,357	3.50	3.19	2.83
Ohio	12,974,575	17,167,866	19,801,670	380,895	444,083	465,679	3.41	3.87	4.25
Oklahoma	3,382,581	4,161,024	5,192,124	91,273	120,529	147,649	3.71	3.45	3.52
Oregon	3,896,287	4,458,028	5,401,667	113,180	143,429	181,523	3.44	3.11	2.98
Pennsylvania	14,120,112	18,711,100	22,733,518	395,602	482,200	558,818	3.57	3.88	4.07
Rhode Island	1,393,143	1,825,900	2,136,582*	33,584	44,189	48,572	4.15	4.13	4.40
South Carolina	4,087,355	5,312,739	6,566,165	115,443	141,877	162,292	3.54	3.74	4.05
South Dakota	737,998	916,563	1,115,861	24,038	31,549	38,297	3.07	2.91	2.91
Tennessee	4,931,734	6,446,691	7,894,661	177,540	224,288	253,602	2.78	2.87	3.11
Texas	25,098,703	31,919,107	42,621,886	731,064	968,553	1,226,714	3.43	3.30	3.47
Utah	2,102,655	2,627,022	3,635,085	69,489	90,616	118,225	3.03	2.90	3.07
Vermont	870,198	1,177,478	1,463,792	18,039	22,743	25,809	4.82	5.18	5.67
Virginia	7,757,598	10,705,162	13,193,633	261,759	356,370	422,763	2.96	3.00	3.12
Washington	6,399,883	7,870,979	9,832,913	227,704	279,333	342,702	2.81	2.82	2.87
West Virginia	2,086,937	2,527,767	3,315,648	41,386	51,857	62,732	5.04	4.87	5.29
Wisconsin	6,852,178	8,435,359	9,918,809	177,355	218,689	245,415	3.86	3.86	4.04
Wyoming	683,918	863,423	1,334,655	17,050	26,250	36,459	4.01	3.29	3.66
Puerto Rico	2,086,414	2,865,945	3,464,044*	69,208	86,158	NA	3.00	3.30	NA

* = value is affected by the redistribution of reported values to correct for missing data items and/or to distribute state direct-support expenditures; NA = not available.

GDP = gross domestic product.

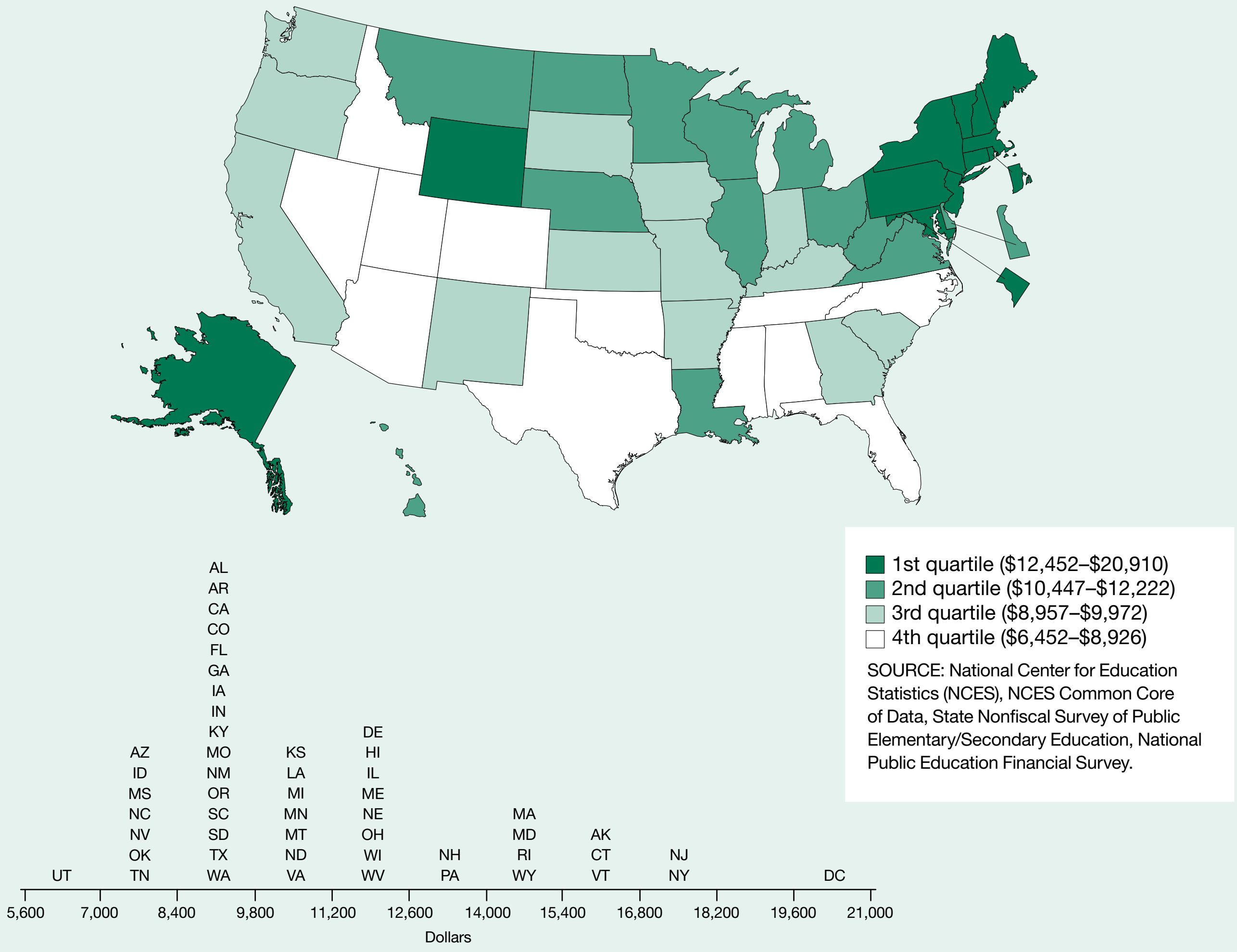
SOURCES: National Center for Education Statistics (NCES), NCES Common Core of Data, National Public Education Financial Survey (various years); Bureau of Economic Analysis, Gross Domestic Product data (June 2013); Government of Puerto Rico, Office of the Governor (various years); United Nations Statistics Division.

Science and Engineering Indicators 2014

Expenditures per Pupil for Elementary and Secondary Public Schools

Figure 8-11

Expenditures per pupil for elementary and secondary public schools: 2010



SOURCE: National Center for Education Statistics (NCES), NCES Common Core of Data, State Nonfiscal Survey of Public Elementary/Secondary Education, National Public Education Financial Survey.

Findings

- Per-pupil spending on day-to-day operations grew nationwide from $6,911 in 2000 to $10,652 in 2010, an increase of 54% in unadjusted dollars. This was equivalent to an increase of approximately 23% after adjusting for inflation.
- In 2010, all states showed substantial increases in per-pupil spending relative to 2000, and only one state did not exceed the 2000 national average.
- Per-pupil spending in individual states varied widely, ranging from a low of $6,452 to a high of $18,167 in 2010. The District of Columbia had the highest per-pupil spending of any jurisdiction at $20,910.
- Several states that ranked in the lower two quartiles of this indicator ranked in the upper quartiles of the National Assessment of Educational Progress indicators.

This indicator represents the amount that local, state, and federal governments spend on elementary and secondary education in a state, adjusted for the size of the student body. It is calculated by dividing the expenditures over the entire academic year for prekindergarten through grade 12 by the number of students in those grades in public schools. Expenditures include expenditures for instruction and instruction-related costs, student support services, administration, and operations and exclude funds for school construction and other capital outlays, debt service, and programs outside of public elementary and secondary education. The number of pupils enrolled in prekindergarten through grade 12 is determined during the fall of the academic year. Expenditures represent actual spending in current dollars and have not been adjusted for inflation or for the cost of living in a state, which affects the amount of goods and services that can be purchased.

During the 2009–10 school year, 66.1% of expenses were used for instructional costs, 17.7% for operational costs, 10.7% for administrative costs, and 5.6% for student support services.

The year is the end date of the academic year. For example, data for 2010 represent costs for the 2009–10 academic year.

Table 8-11
Expenditures per pupil for elementary and secondary public schools, by state: 2000, 2005, and 2010

State	Public school expenditures ($thousands)			Student enrollment			Per-pupil expenditures ($)		
	2000	2005	2010	2000	2005	2010	2000	2005	2010
United States	323,808,910	424,562,096	525,497,899	46,857,149	48,794,911	49,333,543	6,911	8,701	10,652
Alabama	4,176,082	5,164,406	6,670,517	740,732	730,140	748,889	5,638	7,073	8,907
Alaska	1,183,499	1,442,269	2,084,019	134,391	132,970	131,661	8,806	10,847	15,829
Arizona	4,262,182	6,451,870	8,587,889*	852,612	1,043,298	1,077,831	4,999	6,184	7,968
Arkansas	2,380,331	3,546,999	4,459,910*	451,034	463,115	480,559	5,277	7,659	9,281
California	38,129,479	50,918,654	58,248,662*	6,038,590	6,441,557	6,263,438	6,314	7,905	9,300
Colorado	4,400,888	5,994,440	7,429,302	708,109	765,976	832,368	6,215	7,826	8,926
Connecticut	5,402,868	7,080,396	8,853,337*	553,993	577,390	563,968	9,753	12,263	15,698
Delaware	937,630	1,299,349	1,549,812	112,836	119,091	126,801	8,310	10,911	12,222
District of Columbia	780,192	1,023,952	1,451,870	77,194	76,714	69,433	10,107	13,348	20,910
Florida	13,885,988	19,042,877	23,349,314*	2,381,396	2,639,336	2,634,522	5,831	7,215	8,863
Georgia	9,158,624	12,528,856	15,730,409*	1,422,762	1,553,437	1,667,685	6,437	8,065	9,432
Hawaii	1,213,695	1,648,086	2,110,864	185,860	183,185	180,196	6,530	8,997	11,714
Idaho	1,302,817	1,618,215	1,961,857*	245,136	256,084	276,299	5,315	6,319	7,100
Illinois	14,462,773	18,658,428	24,695,773*	2,027,600	2,097,503	2,103,813	7,133	8,896	11,739
Indiana	7,110,930	9,108,931	9,921,243*	988,702	1,021,348	1,046,661	7,192	8,919	9,479
Iowa	3,264,336	3,808,200	4,794,308	497,301	478,319	491,842	6,564	7,962	9,748
Kansas	2,971,814	3,718,153	4,731,676	472,188	469,136	474,489	6,294	7,926	9,972
Kentucky	3,837,794	4,812,591	6,091,814	648,180	674,796	680,089	5,921	7,132	8,957
Louisiana	4,391,214	5,554,766	7,393,452*	756,579	724,281	690,915	5,804	7,669	10,701
Maine	1,604,438	2,056,266	2,356,312*	209,253	198,820	189,225	7,667	10,342	12,452
Maryland	6,545,135	8,682,586	11,883,677*	846,582	865,561	848,412	7,731	10,031	14,007
Massachusetts	8,511,065	11,357,857	14,067,276*	971,425	975,574	957,053	8,761	11,642	14,699
Michigan	13,994,294	16,353,921	17,227,515	1,725,639	1,750,919	1,649,082	8,110	9,340	10,447
Minnesota	6,140,442	7,310,284	8,927,288*	854,034	838,503	837,053	7,190	8,718	10,665
Mississippi	2,510,376	3,243,888	3,990,876*	500,716	495,376	492,481	5,014	6,548	8,104
Missouri	5,655,531	7,115,207	8,923,448*	914,110	905,449	917,982	6,187	7,858	9,721
Montana	994,770	1,193,182	1,498,252	157,556	146,705	141,807	6,314	8,133	10,565
Nebraska	1,926,500	2,512,914	3,247,970	288,261	285,761	283,414	6,683	8,794	11,460
Nevada	1,875,467	2,722,264	3,592,994	325,610	400,083	428,947	5,760	6,804	8,376
New Hampshire	1,418,503	2,021,144	2,576,956	206,783	206,852	197,140	6,860	9,771	13,072
New Jersey	13,327,645	19,669,576	24,261,392	1,289,256	1,393,347	1,396,029	10,337	14,117	17,379
New Mexico	1,890,274	2,554,638	3,217,328	324,495	326,102	334,419	5,825	7,834	9,621
New York	28,433,240	38,866,853	50,251,461*	2,887,776	2,836,337	2,766,052	9,846	13,703	18,167
North Carolina	7,713,293	9,567,000	12,200,362	1,275,925	1,385,754	1,483,397	6,045	6,904	8,225
North Dakota	638,946	786,870	1,000,095	112,751	100,513	95,073	5,667	7,829	10,519
Ohio	12,974,575	17,167,866	19,801,670	1,836,554	1,840,032	1,764,297	7,065	9,330	11,224
Oklahoma	3,382,581	4,161,024	5,192,124	627,032	629,476	654,802	5,395	6,610	7,929
Oregon	3,896,287	4,458,028	5,401,667	545,033	552,322	582,839	7,149	8,071	9,268
Pennsylvania	14,120,112	18,711,100	22,733,518	1,816,716	1,828,089	1,785,993	7,772	10,235	12,729
Rhode Island	1,393,143	1,825,900	2,136,582*	156,454	156,498	145,118	8,904	11,667	14,723
South Carolina	4,087,355	5,312,739	6,566,165	666,780	703,736	723,143	6,130	7,549	9,080
South Dakota	737,998	916,563	1,115,861	131,037	122,798	123,713	5,632	7,464	9,020
Tennessee	4,931,734	6,446,691	7,894,661	916,202	941,091	972,549	5,383	6,850	8,117
Texas	25,098,703	31,919,107	42,621,886	3,991,783	4,405,215	4,850,210	6,288	7,246	8,788
Utah	2,102,655	2,627,022	3,635,085	480,255	503,607	563,361	4,378	5,216	6,452
Vermont	870,198	1,177,478	1,463,792	104,559	98,352	91,451	8,323	11,972	16,006
Virginia	7,757,598	10,705,162	13,193,633	1,133,994	1,204,739	1,245,340	6,841	8,886	10,594
Washington	6,399,883	7,870,979	9,832,913	1,003,714	1,020,005	1,035,347	6,376	7,717	9,497
West Virginia	2,086,937	2,527,767	3,315,648	291,811	280,129	282,662	7,152	9,024	11,730
Wisconsin	6,852,178	8,435,359	9,918,809	877,753	864,757	866,072	7,806	9,755	11,453
Wyoming	683,918	863,423	1,334,655	92,105	84,733	87,621	7,425	10,190	15,232
Puerto Rico	2,086,414	2,865,945	3,464,044*	613,019	575,648	493,393	3,404	4,979	7,021

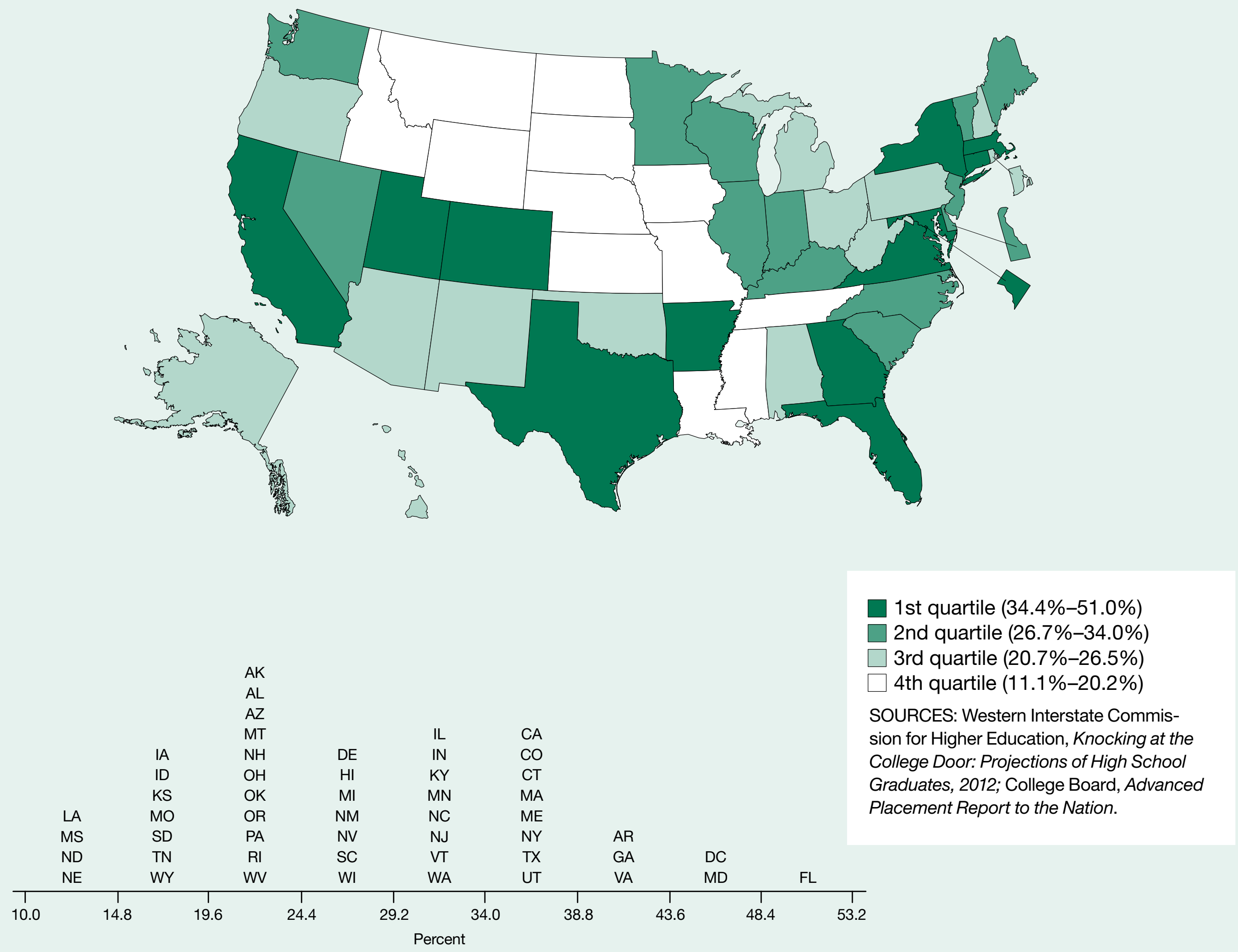
* = value is affected by the redistribution of reported values to correct for missing data items and/or to distribute state direct-support expenditures.

SOURCES: National Center for Education Statistics (NCES), NCES Common Core of Data, State Nonfiscal Survey of Public Elementary/Secondary Education (various years); National Public Education Financial Survey (various years).

Science and Engineering Indicators 2014

Public High School Students Taking Advanced Placement Exams

Figure 8-12
Public high school students taking Advanced Placement Exams: 2012



SOURCES: Western Interstate Commission for Higher Education, *Knocking at the College Door: Projections of High School Graduates, 2012;* College Board, *Advanced Placement Report to the Nation.*

Findings

- Nationwide, the percentage of public school students who took an AP Exam rose from 18.0% of the class of 2002 to 31.2% of the class of 2012.
- The percentage of public school students taking an AP Exam varied greatly among states and ranged from 11.1% to 51.0% of the class of 2012. Forty-one states and the District of Columbia exceeded the 2002 national average in 2012, compared with 16 states and the District of Columbia that exceeded the national average in 2002.
- AP participation levels were higher for all jurisdictions in 2012 than in 2002. Arkansas showed the largest increase, with the class of 2012 exceeding the participation of the class of 2002 by 34 percentage points.

Participation in the Advanced Placement (AP) program provides a measure of the extent to which a rigorous curriculum is available to and used by high school students. This indicator represents the percentage of students in the graduating class who have taken one or more AP Exams.

Throughout the United States, more than 954,000 public school students from the class of 2012 took nearly 2.9 million AP Exams during their high school careers. Generally, students who take AP Exams have completed a rigorous course of study in a specific subject area in high school with the expectation of obtaining college credit or advanced placement. AP Exams were taken most frequently in U.S. history, English literature and composition, English language and composition, calculus AB, and U.S. government and politics.

Students from the class of 2012 attended 13,383 U.S. public high schools that participated in the AP program. These schools make many different AP courses available to their students.

Table 8-12

Public high school students taking Advanced Placement Exams, by state: 2002, 2007, and 2012

State	Public high school graduates who took an Advanced Placement Exam			High school graduates			High school graduates who took an Advanced Placement Exam (%)		
	2002	2007	2012	2002	2007	2012	2002	2007	2012
United States	471,404	694,705	954,070	2,621,534	2,893,045	3,053,230	18.0	24.0	31.2
Alabama	3,103	4,181	9,852	35,887	38,912	44,317	8.6	10.7	22.2
Alaska	1,085	1,497	1,621	6,945	7,666	7,813	15.6	19.5	20.7
Arizona	5,100	9,087	14,407	47,175	55,954	61,958	10.8	16.2	23.3
Arkansas	2,630	8,781	12,175	26,984	27,166	27,990	9.7	32.3	43.5
California	78,638	110,253	144,801	325,895	356,641	384,080	24.1	30.9	37.7
Colorado	8,585	13,753	18,358	40,760	45,628	50,176	21.1	30.1	36.6
Connecticut	6,790	9,819	13,332	32,327	37,541	36,836	21.0	26.2	36.2
Delaware	1,017	1,843	2,417	6,482	7,205	8,395	15.7	25.6	28.8
District of Columbia	584	1,017	1,512	3,090	2,944	3,194	18.9	34.5	47.3
Florida	28,170	49,234	76,128	119,537	142,284	149,219	23.6	34.6	51.0
Georgia	13,518	21,730	33,647	65,983	77,829	84,813	20.5	27.9	39.7
Hawaii	1,239	1,702	2,905	10,452	11,063	10,990	11.9	15.4	26.4
Idaho	1,795	2,507	3,150	15,874	16,242	17,043	11.3	15.4	18.5
Illinois	18,833	27,798	40,653	116,657	130,220	135,636	16.1	21.3	30.0
Indiana	7,575	11,306	21,260	56,722	59,887	63,354	13.4	18.9	33.6
Iowa	2,667	3,989	5,542	33,789	34,127	32,833	7.9	11.7	16.9
Kansas	2,458	3,519	5,167	29,541	30,139	30,428	8.3	11.7	17.0
Kentucky	4,537	7,036	12,218	36,337	39,099	41,038	12.5	18.0	29.8
Louisiana	1,399	1,957	3,931	37,905	34,274	35,501	3.7	5.7	11.1
Maine	2,572	3,680	4,576	12,593	13,151	13,468	20.4	28.0	34.0
Maryland	12,019	20,232	26,640	50,881	57,564	58,009	23.6	35.1	45.9
Massachusetts	12,084	17,036	22,808	55,272	63,903	63,701	21.9	26.7	35.8
Michigan	14,706	20,129	26,822	95,001	111,838	107,956	15.5	18.0	24.8
Minnesota	8,926	12,527	16,780	57,440	59,497	57,486	15.5	21.1	29.2
Mississippi	1,659	2,605	3,615	23,740	24,186	25,756	7.0	10.8	14.0
Missouri	3,895	5,846	9,235	54,487	60,275	61,471	7.1	9.7	15.0
Montana	1,367	1,543	1,913	10,554	10,122	9,466	13.0	15.2	20.2
Nebraska	1,199	1,882	2,886	19,910	19,873	19,656	6.0	9.5	14.7
Nevada	2,239	4,371	6,890	16,270	17,149	25,710	13.8	25.5	26.8
New Hampshire	1,919	2,850	3,238	12,452	14,452	13,917	15.4	19.7	23.3
New Jersey	15,350	21,944	27,433	77,664	93,013	93,211	19.8	23.6	29.4
New Mexico	2,496	3,434	4,815	18,094	16,131	18,141	13.8	21.3	26.5
New York	42,000	54,201	64,946	140,139	168,333	181,454	30.0	32.2	35.8
North Carolina	15,008	22,315	26,633	65,955	76,031	88,421	22.8	29.3	30.1
North Dakota	562	768	882	8,114	7,159	6,785	6.9	10.7	13.0
Ohio	14,057	19,929	25,170	110,608	117,658	119,318	12.7	16.9	21.1
Oklahoma	5,032	7,018	8,140	36,852	37,100	37,792	13.7	18.9	21.5
Oregon	3,643	6,107	8,059	31,153	33,446	34,662	11.7	18.3	23.3
Pennsylvania	15,890	21,887	28,750	114,943	128,603	127,773	13.8	17.0	22.5
Rhode Island	1,118	1,438	2,176	9,006	10,384	9,809	12.4	13.8	22.2
South Carolina	6,444	8,142	10,564	31,302	35,108	39,496	20.6	23.2	26.7
South Dakota	1,003	1,268	1,545	8,796	8,346	8,345	11.4	15.2	18.5
Tennessee	5,193	7,954	10,743	40,894	54,502	60,444	12.7	14.6	17.8
Texas	43,308	65,788	96,166	225,167	241,193	279,291	19.2	27.3	34.4
Utah	7,744	8,737	10,439	30,183	28,276	30,229	25.7	30.9	34.5
Vermont	1,280	1,913	2,151	7,083	7,317	6,827	18.1	26.1	31.5
Virginia	17,825	25,627	33,626	66,519	73,997	80,354	26.8	34.6	41.8
Washington	8,513	14,741	20,581	58,311	62,801	64,002	14.6	23.5	32.2
West Virginia	1,806	2,505	3,722	17,128	17,407	17,017	10.5	14.4	21.9
Wisconsin	10,205	14,454	18,076	60,575	63,968	62,111	16.8	22.6	29.1
Wyoming	619	825	974	6,106	5,441	5,538	10.1	15.2	17.6
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available.

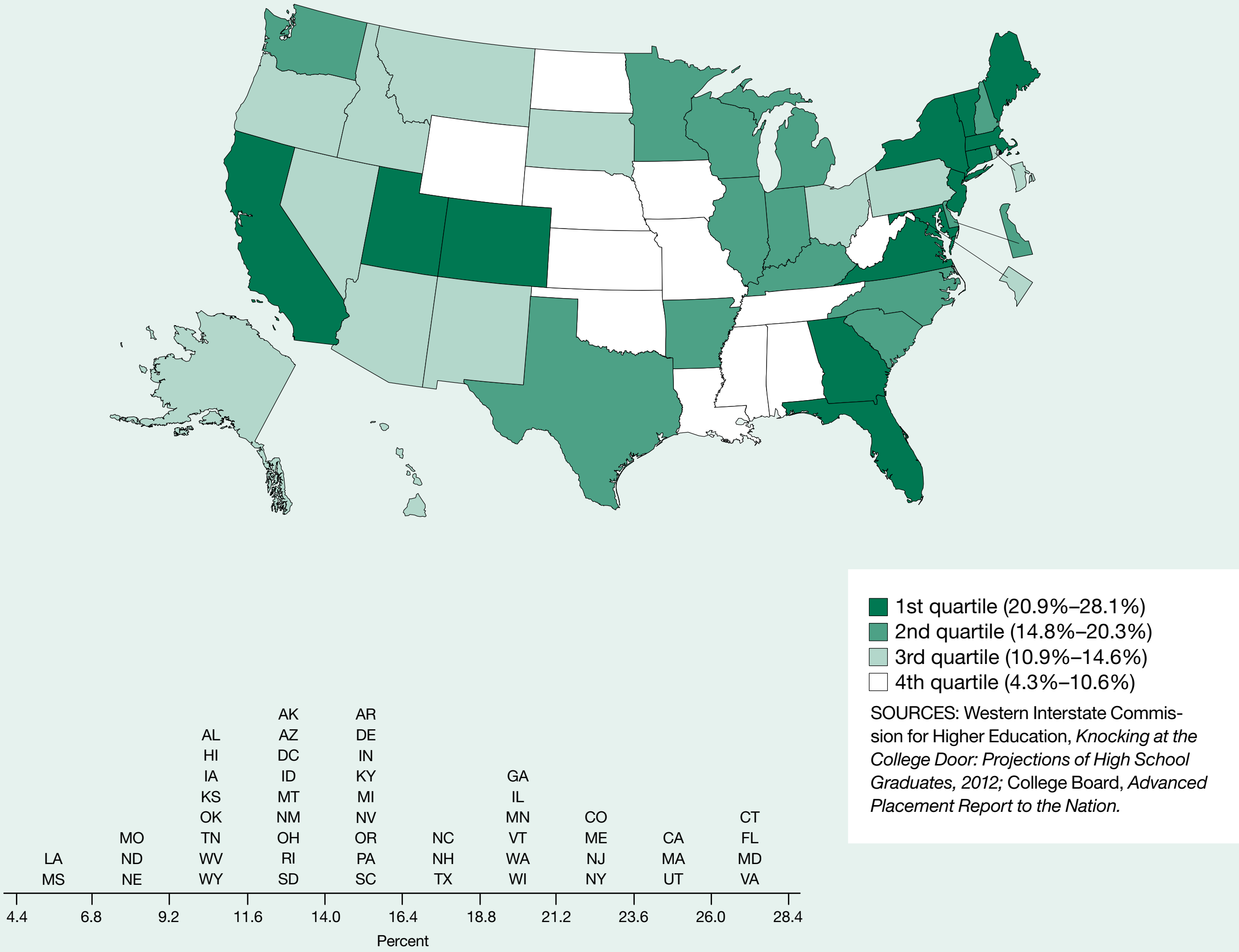
NOTE: The national average for the United States is the reported value in the *Advanced Placement Report to the Nation*.

SOURCES: Western Interstate Commission for Higher Education, *Knocking at the College Door: Projections of High School Graduates, 2012*. College Board, *Advanced Placement Report to the Nation* (various years).

Science and Engineering Indicators 2014

Public High School Students Scoring 3 or Higher on at Least One Advanced Placement Exam

Figure 8-13
Public high school students scoring 3 or higher on at least one Advanced Placement Exam: 2012



SOURCES: Western Interstate Commission for Higher Education, *Knocking at the College Door: Projections of High School Graduates, 2012;* College Board, *Advanced Placement Report to the Nation.*

Findings

- Nationally, 18.8% of public high school students in the class of 2012 demonstrated the ability to do college-level work by obtaining a score of 3 or higher on at least one AP Exam, a substantial increase from the 11.6% of the class of 2002 who obtained that score.
- Students from all states and the District of Columbia demonstrated greater success on AP Exams in 2012 than in 2002, but this success was not evenly distributed. In 2012, 13 states had percentages below the 2002 national average of 11.6% compared with 34 jurisdictions in 2002.
- The percentage of students who scored 3 or higher on an AP Exam varied widely among states. For the class of 2012, this percentage ranged from a low of 4.3% to a high of 28.1%.

This indicator represents the extent to which high school students are successfully demonstrating mastery of college-level material in specific disciplines. State scores on this indicator reflect students' access to rigorous coursework as well as their success in comprehending and using it. The indicator value is defined as the percentage of U.S. public high school graduates who have scored 3 or higher on at least one Advanced Placement (AP) Exam. Many colleges and universities grant college credit or advanced placement for AP Exam scores of 3 or higher. Students who score a 3 or higher typically experience greater academic success in college and higher graduation rates.

More than 30 different AP Exams are offered each spring by the College Board. The exams include a multiple choice section and a free response section. To prepare for the AP Exam in a subject area, most students enroll in an AP class that employs a curriculum of high academic intensity. Performance on AP Exams has been shown in research to be one of the best predictors of success in college.

Table 8-13
Public high school students scoring 3 or higher on at least one Advanced Placement Exam, by state: 2002, 2007, and 2012

State	Public high school graduates who scored 3+ on an Advanced Placement Exam			High school graduates			High school graduates who scored 3+ on an Advanced Placement Exam (%)		
	2002	2007	2012	2002	2007	2012	2002	2007	2012
United States	305,098	424,004	573,472	2,621,534	2,893,045	3,053,230	11.6	14.7	18.8
Alabama	1,710	2,398	4,258	35,887	38,912	44,317	4.8	6.2	9.6
Alaska	762	957	1,062	6,945	7,666	7,813	11.0	12.5	13.6
Arizona	3,285	5,428	8,307	47,175	55,954	61,958	7.0	9.7	13.4
Arkansas	1,333	2,620	4,227	26,984	27,166	27,990	4.9	9.6	15.1
California	53,816	72,097	95,695	325,895	356,641	384,080	16.5	20.2	24.9
Colorado	5,582	8,569	11,442	40,760	45,628	50,176	13.7	18.8	22.8
Connecticut	5,006	7,089	9,685	32,327	37,541	36,836	15.5	18.9	26.3
Delaware	617	979	1,257	6,482	7,205	8,395	9.5	13.6	15.0
District of Columbia	234	211	389	3,090	2,944	3,194	7.6	7.2	12.2
Florida	17,256	26,360	39,306	119,537	142,284	149,219	14.4	18.5	26.3
Georgia	7,686	11,592	17,767	65,983	77,829	84,813	11.6	14.9	20.9
Hawaii	682	867	1,200	10,452	11,063	10,990	6.5	7.8	10.9
Idaho	1,156	1,605	2,115	15,874	16,242	17,043	7.3	9.9	12.4
Illinois	13,666	18,857	26,461	116,657	130,220	135,636	11.7	14.5	19.5
Indiana	4,134	5,786	9,634	56,722	59,887	63,354	7.3	9.7	15.2
Iowa	1,828	2,640	3,481	33,789	34,127	32,833	5.4	7.7	10.6
Kansas	1,631	2,208	3,117	29,541	30,139	30,428	5.5	7.3	10.2
Kentucky	2,396	3,518	6,067	36,337	39,099	41,038	6.6	9.0	14.8
Louisiana	775	920	1,531	37,905	34,274	35,501	2.0	2.7	4.3
Maine	1,701	2,275	2,933	12,593	13,151	13,468	13.5	17.3	21.8
Maryland	8,414	12,882	16,327	50,881	57,564	58,009	16.5	22.4	28.1
Massachusetts	8,773	12,307	16,251	55,272	63,903	63,701	15.9	19.3	25.5
Michigan	9,594	13,062	17,262	95,001	111,838	107,956	10.1	11.7	16.0
Minnesota	5,631	7,815	11,067	57,440	59,497	57,486	9.8	13.1	19.3
Mississippi	696	845	1,145	23,740	24,186	25,756	2.9	3.5	4.4
Missouri	2,566	3,686	5,554	54,487	60,275	61,471	4.7	6.1	9.0
Montana	929	1,033	1,205	10,554	10,122	9,466	8.8	10.2	12.7
Nebraska	733	1,105	1,724	19,910	19,873	19,656	3.7	5.6	8.8
Nevada	1,375	2,430	3,607	16,270	17,149	25,710	8.5	14.2	14.0
New Hampshire	1,341	2,052	2,430	12,452	14,452	13,917	10.8	14.2	17.5
New Jersey	11,230	15,772	20,283	77,664	93,013	93,211	14.5	17.0	21.8
New Mexico	1,215	1,642	2,108	18,094	16,131	18,141	6.7	10.2	11.6
New York	28,196	35,707	42,627	140,139	168,333	181,454	20.1	21.2	23.5
North Carolina	9,016	12,858	16,558	65,955	76,031	88,421	13.7	16.9	18.7
North Dakota	402	542	553	8,114	7,159	6,785	5.0	7.6	8.2
Ohio	8,896	12,301	16,201	110,608	117,658	119,318	8.0	10.5	13.6
Oklahoma	2,620	3,268	4,023	36,852	37,100	37,792	7.1	8.8	10.6
Oregon	2,477	3,812	5,025	31,153	33,446	34,662	8.0	11.4	14.5
Pennsylvania	10,918	14,442	18,665	114,943	128,603	127,773	9.5	11.2	14.6
Rhode Island	666	900	1,302	9,006	10,384	9,809	7.4	8.7	13.3
South Carolina	3,944	4,765	6,231	31,302	35,108	39,496	12.6	13.6	15.8
South Dakota	610	793	1,005	8,796	8,346	8,345	6.9	9.5	12.0
Tennessee	3,153	4,344	5,790	40,894	54,502	60,444	7.7	8.0	9.6
Texas	24,801	34,869	49,062	225,167	241,193	279,291	11.0	14.5	17.6
Utah	5,586	5,896	7,298	30,183	28,276	30,229	18.5	20.9	24.1
Vermont	910	1,311	1,425	7,083	7,317	6,827	12.8	17.9	20.9
Virginia	11,198	16,007	21,524	66,519	73,997	80,354	16.8	21.6	26.8
Washington	5,619	8,938	12,542	58,311	62,801	64,002	9.6	14.2	19.6
West Virginia	886	1,148	1,631	17,128	17,407	17,017	5.2	6.6	9.6
Wisconsin	7,100	10,053	12,590	60,575	63,968	62,111	11.7	15.7	20.3
Wyoming	347	443	523	6,106	5,441	5,538	5.7	8.1	9.4
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available.

NOTE: The national average for the United States is the reported value in the *Advanced Placement Report to the Nation*.

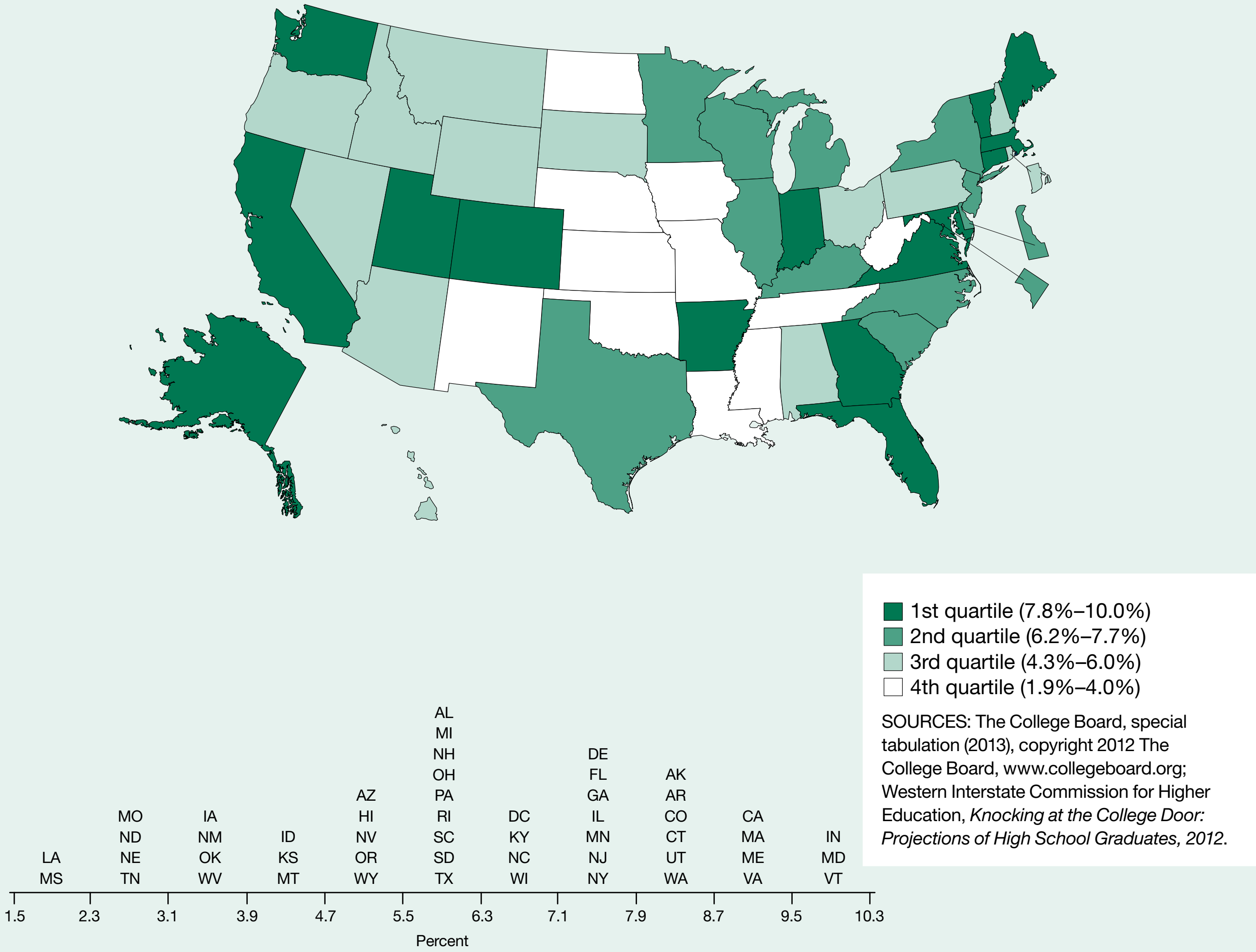
SOURCE: Western Interstate Commission for Higher Education, *Knocking at the College Door: Projections of High School Graduates, 2012*. College Board, *Advanced Placement Report to the Nation* (various years).

Science and Engineering Indicators 2014

Public High School Students Scoring 3 or Higher on Advanced Placement Calculus AB Exam

Figure 8-14

Public high school students scoring 3 or higher on Advanced Placement Calculus AB Exam: 2012



SOURCES: The College Board, special tabulation (2013), copyright 2012 The College Board, www.collegeboard.org; Western Interstate Commission for Higher Education, *Knocking at the College Door: Projections of High School Graduates, 2012*.

Findings

- Nationally, the share of the graduating class that demonstrated a mastery of Calculus AB by scoring a 3 or higher on the AP Exam increased from 4.7% in 2002 to 6.9% in 2012.
- Values for individual states ranged from a low of 1.9% to a high of 10.0% for the class of 2012.
- Between 2002 and 2012, all but 2 states increased the percentage of high school graduates that successfully completed the Calculus AB exam. For the class of 2012, improvements of 4 percentage points or higher as compared with the class of 2002 were reported in Maryland, Indiana, and Vermont.
- Because the percentages are small, year-to-year comparisons should be made with caution. Variability in students' course selection and level of performance can affect the numbers.

The Advanced Placement (AP) Calculus AB exam seeks to assess how well a student has mastered the concepts and techniques of differential and integral calculus. The indicator value is defined as the percentage of U.S. public high school graduates who have scored 3 or higher on the AP Calculus AB exam during their high school careers. Many colleges and universities grant college credit or advanced placement for AP exam scores of 3 or higher.

AP courses in calculus consist of a full high school academic year of work and are comparable to calculus courses taught at colleges and universities. Prior to taking an AP Calculus course, students are expected to have completed 4 years of secondary mathematics intended for college-bound students consisting of courses in algebra, geometry, trigonometry, analytic geometry, and elementary functions. Even though a Calculus AB course may cover elementary functions, most of its topics will address differential and integral calculus. The use of a graphing calculator in AP Calculus is considered an integral part of the course, and graphing calculators are required on portions of the AP Exam.

Successful performance on the Calculus AB exam indicates that the student has a solid mathematical background and is prepared to undertake advanced training in mathematics, science, or engineering at the college or university level.

Table 8-14
Public high school students scoring 3 or higher on Advanced Placement Calculus AB Exam, by state: 2002, 2007, and 2012

	Public high school graduates who scored 3+ on Advanced Placement Calculus AB Exam			High school graduates			High school graduates who scored 3+ on Advanced Placement Calculus AB Exam (%)		
State	2002	2007	2012	2002	2007	2012	2002	2007	2012
United States	123,388	166,239	211,570	2,621,534	2,893,045	3,053,230	4.7	5.7	6.9
Alabama	696	1,022	2,441	35,887	38,912	44,317	1.9	2.6	5.5
Alaska	338	431	616	6,945	7,666	7,813	4.9	5.6	7.9
Arizona	1,344	2,118	2,971	47,175	55,954	61,958	2.8	3.8	4.8
Arkansas	622	1,709	2,419	26,984	27,166	27,990	2.3	6.3	8.6
California	19,653	27,410	36,107	325,895	356,641	384,080	6.0	7.7	9.4
Colorado	1,705	3,020	4,108	40,760	45,628	50,176	4.2	6.6	8.2
Connecticut	1,691	2,235	3,032	32,327	37,541	36,836	5.2	6.0	8.2
Delaware	385	449	608	6,482	7,205	8,395	5.9	6.2	7.2
District of Columbia	141	158	205	3,090	2,944	3,194	4.6	5.4	6.4
Florida	5,987	9,113	11,670	119,537	142,284	149,219	5.0	6.4	7.8
Georgia	3,798	4,715	6,619	65,983	77,829	84,813	5.8	6.1	7.8
Hawaii	375	443	566	10,452	11,063	10,990	3.6	4.0	5.2
Idaho	433	628	727	15,874	16,242	17,043	2.7	3.9	4.3
Illinois	5,069	6,950	9,807	116,657	130,220	135,636	4.3	5.3	7.2
Indiana	3,415	4,696	6,348	56,722	59,887	63,354	6.0	7.8	10.0
Iowa	764	914	1,178	33,789	34,127	32,833	2.3	2.7	3.6
Kansas	565	968	1,224	29,541	30,139	30,428	1.9	3.2	4.0
Kentucky	1,334	1,934	2,800	36,337	39,099	41,038	3.7	4.9	6.8
Louisiana	288	423	695	37,905	34,274	35,501	0.8	1.2	2.0
Maine	737	907	1,208	12,593	13,151	13,468	5.9	6.9	9.0
Maryland	2,614	3,935	5,801	50,881	57,564	58,009	5.1	6.8	10.0
Massachusetts	3,285	4,588	6,006	55,272	63,903	63,701	5.9	7.2	9.4
Michigan	4,062	5,765	6,736	95,001	111,838	107,956	4.3	5.2	6.2
Minnesota	3,030	3,639	4,309	57,440	59,497	57,486	5.3	6.1	7.5
Mississippi	304	428	495	23,740	24,186	25,756	1.3	1.8	1.9
Missouri	969	1,168	1,583	54,487	60,275	61,471	1.8	1.9	2.6
Montana	288	348	411	10,554	10,122	9,466	2.7	3.4	4.3
Nebraska	258	322	585	19,910	19,873	19,656	1.3	1.6	3.0
Nevada	519	968	1,227	16,270	17,149	25,710	3.2	5.6	4.8
New Hampshire	625	810	830	12,452	14,452	13,917	5.0	5.6	6.0
New Jersey	4,363	5,323	6,783	77,664	93,013	93,211	5.6	5.7	7.3
New Mexico	596	665	695	18,094	16,131	18,141	3.3	4.1	3.8
New York	11,776	12,620	13,992	140,139	168,333	181,454	8.4	7.5	7.7
North Carolina	4,120	5,398	5,850	65,955	76,031	88,421	6.2	7.1	6.6
North Dakota	157	224	185	8,114	7,159	6,785	1.9	3.1	2.7
Ohio	4,567	5,986	6,864	110,608	117,658	119,318	4.1	5.1	5.8
Oklahoma	999	1,100	1,374	36,852	37,100	37,792	2.7	3.0	3.6
Oregon	868	1,325	1,744	31,153	33,446	34,662	2.8	4.0	5.0
Pennsylvania	4,203	5,708	6,985	114,943	128,603	127,773	3.7	4.4	5.5
Rhode Island	301	425	554	9,006	10,384	9,809	3.3	4.1	5.6
South Carolina	2,119	2,384	2,460	31,302	35,108	39,496	6.8	6.8	6.2
South Dakota	372	445	491	8,796	8,346	8,345	4.2	5.3	5.9
Tennessee	1,086	1,554	1,781	40,894	54,502	60,444	2.7	2.9	2.9
Texas	9,724	14,278	17,397	225,167	241,193	279,291	4.3	5.9	6.2
Utah	1,905	2,049	2,518	30,183	28,276	30,229	6.3	7.2	8.3
Vermont	396	576	654	7,083	7,317	6,827	5.6	7.9	9.6
Virginia	4,228	5,450	7,297	66,519	73,997	80,354	6.4	7.4	9.1
Washington	2,797	4,212	5,369	58,311	62,801	64,002	4.8	6.7	8.4
West Virginia	402	519	655	17,128	17,407	17,017	2.3	3.0	3.8
Wisconsin	2,894	3,526	4,315	60,575	63,968	62,111	4.8	5.5	6.9
Wyoming	221	258	275	6,106	5,441	5,538	3.6	4.7	5.0
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

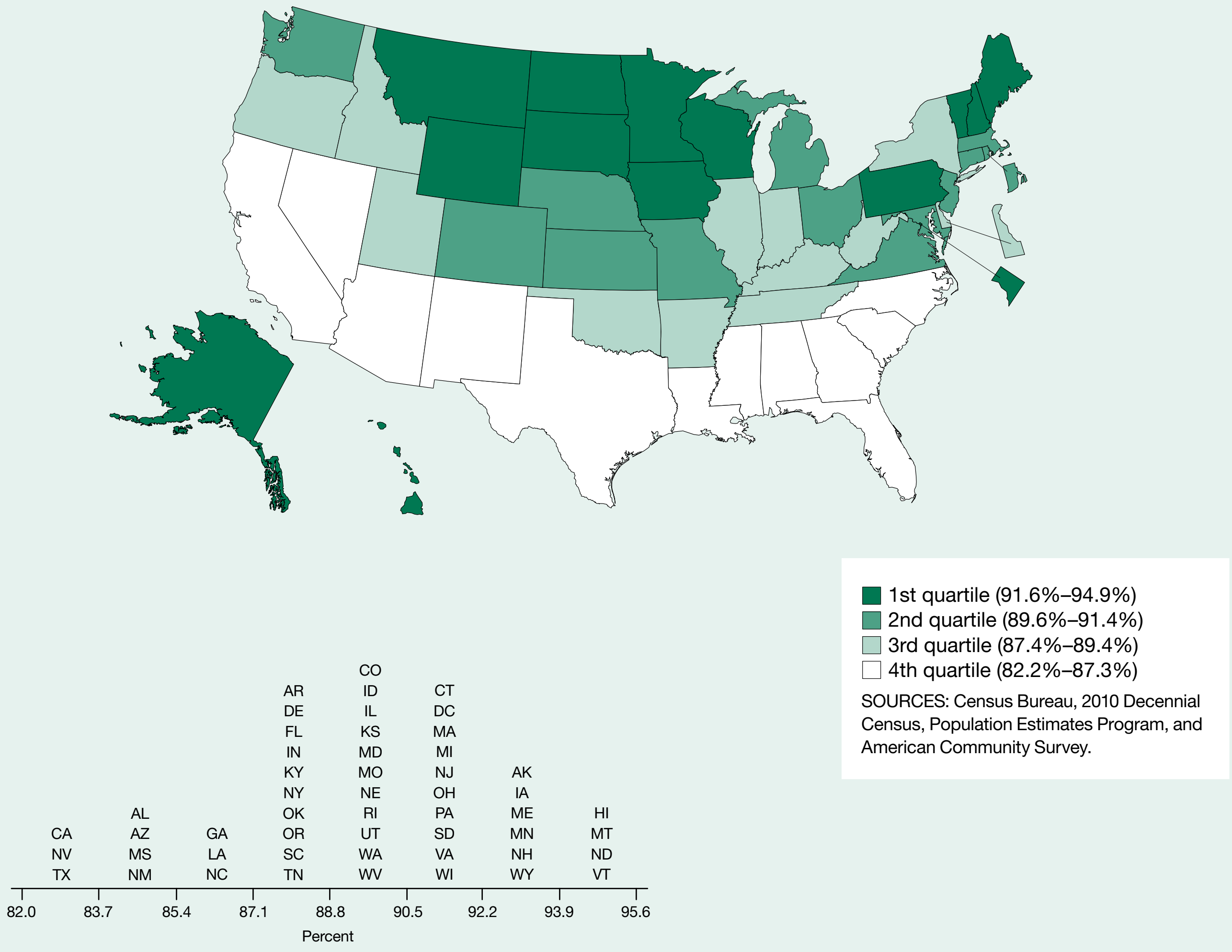
NA = not available.

SOURCES: Derived from data provided by the College Board, special tabulations (2013), copyright 2001–12 The College Board, www.collegeboard.org; Western Interstate Commission for Higher Education, *Knocking at the College Door: Projections of High School Graduates, 2012*.

Science and Engineering Indicators 2014

High School Graduates or Higher among Individuals 25–44 Years Old

Figure 8-15
High school graduates or higher among individuals 25–44 years old: 2011



SOURCES: Census Bureau, 2010 Decennial Census, Population Estimates Program, and American Community Survey.

Findings

- Nationwide, 87.5% of the early- to midcareer population had at least a high school credential in 2011, an increase from the 84.0% who held such a credential in 2001.
- Between 2001 and 2011, 23 states and the District of Columbia showed a significant increase in the percentage of their early- to midcareer population with at least a high school credential. Two states had 2011 values below the 2001 national average of 84.0% compared with 8 in 2001.
- In 2011, the early- to midcareer population with at least a high school credential varied greatly among states, ranging from 82.2% to 94.9%. States at or near the southern border of the United States tended to rank lowest on this indicator.

This indicator represents the percentage of a state's early- to midcareer population that has earned at least a high school credential. The indicator displays results based on where high school graduates live rather than where they were educated. High values indicate a resident population and potential workforce with widespread basic education credentials.

Estimates of educational attainment have been developed by the U.S. Census Bureau. Data from 2005 and later are derived from the American Community Survey (ACS), the largest household survey in the United States, with a sample size of about 3 million addresses. The ACS collects information on an annual basis. Data prior to 2005 were derived from the Decennial Census.

Estimates of the population aged 25–44 are provided by the Census Bureau based on the 2000 and 2010 Decennial Censuses. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-15
High school graduates or higher among individuals 25–44 years old, by state: 2001, 2006, and 2011

	Graduates 25–44 years old			Population 25–44 years old			Graduates/ population 25–44 years old (%)		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	71,031,901	72,494,658	72,168,571	84,523,274	82,638,980	82,432,298	84.0	87.7	87.5
Alabama	1,060,262	1,041,196	1,038,840	1,266,952	1,233,767	1,223,076	83.7	84.4	84.9
Alaska	176,545	177,011	186,627	198,158	188,470	198,914	89.1	93.9	93.8
Arizona	1,167,520	1,461,333	1,436,551	1,526,458	1,664,223	1,688,279	76.5	87.8	85.1
Arkansas	608,424	644,782	651,633	743,315	747,504	745,421	81.9	86.3	87.4
California	8,038,587	8,641,477	8,684,128	10,750,718	10,578,738	10,565,342	74.8	81.7	82.2
Colorado	1,211,816	1,253,856	1,304,869	1,412,620	1,380,451	1,448,033	85.8	90.8	90.1
Connecticut	908,023	876,847	815,391	1,017,477	944,217	898,232	89.2	92.9	90.8
Delaware	207,147	208,667	200,262	233,890	232,516	227,578	88.6	89.7	88.0
District of Columbia	156,642	168,221	198,756	190,251	187,870	216,233	82.3	89.5	91.9
Florida	3,808,005	4,201,616	4,153,736	4,591,807	4,804,621	4,758,046	82.9	87.4	87.3
Georgia	2,205,133	2,389,315	2,356,862	2,668,017	2,727,666	2,741,412	82.7	87.6	86.0
Hawaii	318,552	336,004	348,052	357,271	358,311	366,855	89.2	93.8	94.9
Idaho	307,283	344,342	359,687	362,154	383,267	402,781	84.8	89.8	89.3
Illinois	3,239,703	3,204,663	3,119,362	3,756,180	3,572,420	3,491,104	86.2	89.7	89.4
Indiana	1,532,633	1,519,940	1,471,266	1,769,492	1,705,535	1,665,758	86.6	89.1	88.3
Iowa	723,260	691,725	693,855	793,288	747,836	749,530	91.2	92.5	92.6
Kansas	700,664	650,567	653,237	755,887	713,707	727,160	92.7	91.2	89.8
Kentucky	983,313	1,022,178	997,294	1,194,291	1,162,541	1,138,883	82.3	87.9	87.6
Louisiana	1,007,477	956,118	1,027,440	1,268,704	1,152,042	1,203,069	79.4	83.0	85.4
Maine	332,327	321,680	292,585	364,111	337,692	312,002	91.3	95.3	93.8
Maryland	1,456,139	1,442,853	1,410,513	1,652,198	1,598,650	1,565,884	88.1	90.3	90.1
Massachusetts	1,801,547	1,660,827	1,588,629	1,967,815	1,795,786	1,738,118	91.6	92.5	91.4
Michigan	2,623,986	2,467,686	2,192,907	2,905,689	2,658,755	2,414,603	90.3	92.8	90.8
Minnesota	1,403,384	1,332,478	1,298,651	1,486,814	1,412,852	1,400,438	94.4	94.3	92.7
Mississippi	620,634	641,562	639,787	794,888	767,066	760,122	78.1	83.6	84.2
Missouri	1,387,967	1,392,466	1,371,220	1,606,777	1,547,126	1,523,458	86.4	90.0	90.0
Montana	207,722	213,879	223,374	238,899	228,548	237,269	86.9	93.6	94.1
Nebraska	434,381	421,144	423,823	478,968	458,133	469,737	90.7	91.9	90.2
Nevada	517,456	625,412	634,590	648,880	747,896	766,544	79.7	83.6	82.8
New Hampshire	348,880	337,033	298,047	378,536	348,846	319,411	92.2	96.6	93.3
New Jersey	2,372,904	2,220,609	2,118,729	2,603,347	2,446,589	2,338,637	91.1	90.8	90.6
New Mexico	421,618	431,947	436,332	506,151	507,378	519,946	83.3	85.1	83.9
New York	4,931,556	4,751,228	4,630,437	5,775,563	5,417,603	5,280,570	85.4	87.7	87.7
North Carolina	2,014,720	2,155,551	2,219,453	2,504,293	2,518,651	2,577,307	80.5	85.6	86.1
North Dakota	162,511	147,532	159,980	168,631	156,114	170,010	96.4	94.5	94.1
Ohio	2,947,087	2,765,830	2,612,564	3,259,384	3,037,836	2,873,075	90.4	91.0	90.9
Oklahoma	774,640	820,764	856,716	960,435	938,630	975,445	80.7	87.4	87.8
Oregon	853,696	893,508	913,086	992,783	994,743	1,031,267	86.0	89.8	88.5
Pennsylvania	3,046,733	2,921,526	2,860,909	3,435,158	3,224,924	3,123,097	88.7	90.6	91.6
Rhode Island	259,555	252,937	233,864	306,912	284,670	261,020	84.6	88.9	89.6
South Carolina	1,003,899	1,006,117	1,040,906	1,175,787	1,179,555	1,193,581	85.4	85.3	87.2
South Dakota	187,100	180,183	185,252	202,454	193,284	201,235	92.4	93.2	92.1
Tennessee	1,414,180	1,473,533	1,484,697	1,699,828	1,690,961	1,678,144	83.2	87.1	88.5
Texas	4,978,683	5,507,182	5,937,001	6,529,822	6,742,164	7,180,834	76.2	81.7	82.7
Utah	565,686	643,346	708,544	633,099	701,224	793,074	89.4	91.7	89.3
Vermont	159,184	150,033	138,202	172,405	155,997	146,497	92.3	96.2	94.3
Virginia	1,907,914	1,977,743	2,014,374	2,227,441	2,190,642	2,215,775	85.7	90.3	90.9
Washington	1,602,454	1,634,206	1,683,779	1,805,606	1,791,998	1,868,055	88.7	91.2	90.1
West Virginia	401,838	414,635	404,537	487,860	468,119	455,269	82.4	88.6	88.9
Wisconsin	1,410,448	1,378,346	1,322,584	1,561,327	1,479,447	1,440,314	90.3	93.2	91.8
Wyoming	120,083	121,024	134,651	134,483	131,399	145,854	89.3	92.1	92.3
Puerto Rico	NA	878,376	798,311	1,055,380	1,080,801	955,369	NA	81.3	83.6

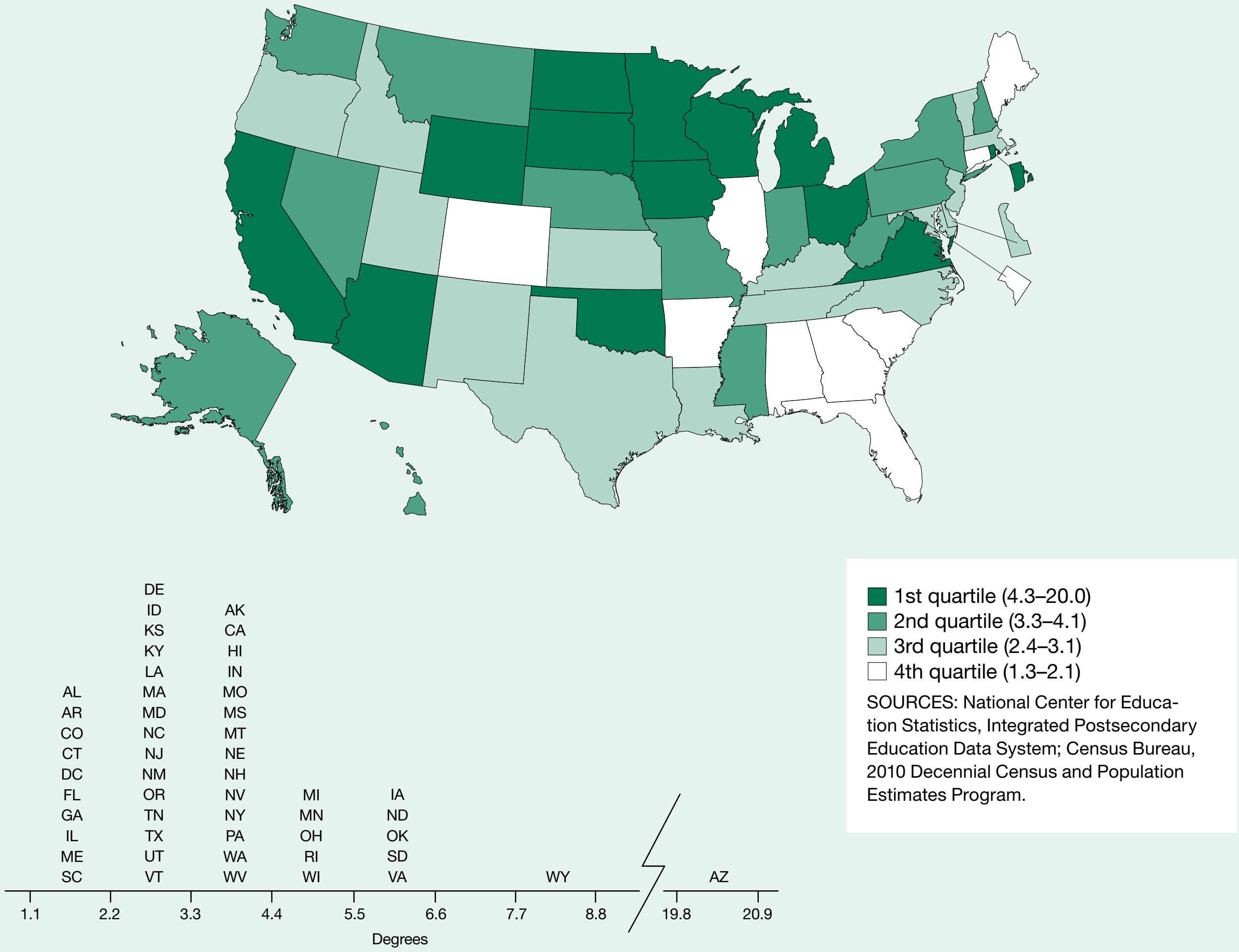
SOURCES: Census Bureau, 2000 and 2010 Decennial Censuses, Population Estimates Program (various years), and American Community Survey (various years).

Science and Engineering Indicators 2014

Associate's Degrees in Science, Engineering, and Technology Conferred per 1,000 Individuals 18–24 Years Old

Figure 8-16

Associate's degrees in science, engineering, and technology conferred per 1,000 individuals 18–24 years old: 2011



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Census Bureau, 2010 Decennial Census and Population Estimates Program.

Findings

- In 2011, nearly 116,000 associate's degrees in SET were conferred nationally, which is up from 85,000 in 2001 and represents an increase of 37%. Between 2001 and 2011, the number of associate's degrees in SET fields conferred per 1,000 individuals 18–24 years old in the population increased by 23% nationwide.
- In 2011, state values on this indicator varied greatly. They ranged from 1.3 to 20.0 associate's degrees in SET fields conferred per 1,000 individuals 18–24 years old.
- California has consistently awarded the largest number of SET associate's degrees, at between 12% and 15% of the national total.

Educational attainment in a science, engineering, or technology (SET) field gives people greater opportunities to work in higher-paying technical jobs than are generally available to those in other fields of study. Earning an associate's degree in a SET field also prepares an individual for more advanced technical education.

This indicator represents the extent to which a state provides associate's level training in SET fields, controlling for the size of its college-age population. The cohort 18–24 years old was chosen to approximate the age range of most students who are pursuing an associate's degree.

The National Center for Education Statistics counts the number of associate's degrees awarded in SET fields; these data include degrees in science and engineering technology fields, which are not included in measures of S&E degrees. Associate's degrees are awarded at both 2-year and 4-year institutions in the United States; states and regions vary in the kinds of institutions that are accredited to award degrees in different fields. Estimates of the population aged 18–24 years old are provided by the U.S. Census Bureau. Small differences in the indicator value between states or across time generally are not meaningful.

Because students may move across state lines after receiving their associate's degrees, this indicator does not necessarily predict the qualifications of a state's future technical workforce.

Table 8-16

Associate's degrees in science, engineering, and technology conferred per 1,000 individuals 18–24 years old, by state: 2001, 2006, and 2011

	SET associate's degrees			Population 18–24 years old			Degrees/1,000 individuals 18–24 years old		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
EPSCoR states	14,248	12,088	15,610	4,617,353	4,785,938	4,930,966	3.1	2.5	3.2
Non-EPSCoR states	69,513	67,171	99,175	23,105,302	24,522,581	25,834,531	3.0	2.7	3.8
Average EPSCoR state value	na	na	na	na	na	na	3.5	2.9	3.5
Average non-EPSCoR state value	na	na	na	na	na	na	2.8	2.7	4.0
United States	84,856	80,346	115,838	27,992,652	29,602,839	31,067,478	3.0	2.7	3.7
Alabama	1,011	679	1,026	447,963	459,114	482,405	2.3	1.5	2.1
Alaska	125	145	262	61,774	74,369	77,271	2.0	1.9	3.4
Arizona	2,009	2,291	12,854	536,018	591,986	643,726	3.7	3.9	20.0
Arkansas	378	400	545	268,131	273,882	287,131	1.4	1.5	1.9
California	11,291	9,961	17,166	3,488,933	3,700,882	3,975,377	3.2	2.7	4.3
Colorado	1,148	761	922	453,712	477,387	498,956	2.5	1.6	1.8
Connecticut	432	409	427	278,499	310,891	333,524	1.6	1.3	1.3
Delaware	230	258	280	78,530	84,759	92,520	2.9	3.0	3.0
District of Columbia	226	217	106	72,568	76,839	84,786	3.1	2.8	1.3
Florida	3,850	3,759	3,682	1,401,785	1,652,892	1,773,048	2.7	2.3	2.1
Georgia	500	1,210	1,631	866,190	915,634	996,088	0.6	1.3	1.6
Hawaii	524	490	440	120,970	131,489	133,388	4.3	3.7	3.3
Idaho	776	337	466	144,212	153,844	155,895	5.4	2.2	3.0
Illinois	1,936	2,317	2,295	1,230,513	1,238,706	1,246,926	1.6	1.9	1.8
Indiana	2,121	2,428	2,424	628,372	638,724	656,136	3.4	3.8	3.7
Iowa	796	1,132	1,759	303,271	312,319	310,985	2.6	3.6	5.7
Kansas	1,101	652	800	282,851	296,431	291,056	3.9	2.2	2.7
Kentucky	1,031	1,024	1,272	411,270	405,029	418,168	2.5	2.5	3.0
Louisiana	1,359	819	1,225	485,975	459,662	474,817	2.8	1.8	2.6
Maine	217	295	236	107,177	117,346	116,333	2.0	2.5	2.0
Maryland	510	735	1,380	470,318	525,903	567,560	1.1	1.4	2.4
Massachusetts	1,636	1,473	1,655	594,747	637,145	685,891	2.8	2.3	2.4
Michigan	2,967	3,152	4,546	955,459	975,541	986,710	3.1	3.2	4.6
Minnesota	1,576	1,578	2,433	486,444	517,679	505,955	3.2	3.0	4.8
Mississippi	688	670	1,037	316,243	306,076	308,468	2.2	2.2	3.4
Missouri	1,813	1,450	2,095	552,622	583,691	591,301	3.3	2.5	3.5
Montana	265	243	343	89,343	99,357	96,660	3.0	2.4	3.5
Nebraska	925	762	651	178,947	188,966	183,949	5.2	4.0	3.5
Nevada	337	399	868	190,232	229,614	250,650	1.8	1.7	3.5
New Hampshire	463	379	450	107,717	121,400	125,008	4.3	3.1	3.6
New Jersey	1,545	1,628	1,932	690,374	729,181	779,067	2.2	2.2	2.5
New Mexico	813	573	644	184,493	202,027	206,918	4.4	2.8	3.1
New York	8,257	5,673	6,724	1,802,422	1,869,014	1,996,795	4.6	3.0	3.4
North Carolina	1,610	2,056	2,810	824,717	876,910	953,966	2.0	2.3	2.9
North Dakota	345	380	507	76,459	85,992	83,807	4.5	4.4	6.0
Ohio	3,766	4,266	5,231	1,079,689	1,083,220	1,106,053	3.5	3.9	4.7
Oklahoma	1,349	1,748	2,189	369,614	381,715	385,762	3.6	4.6	5.7
Oregon	840	699	1,007	337,357	350,178	362,400	2.5	2.0	2.8
Pennsylvania	4,810	4,518	5,078	1,121,223	1,200,427	1,269,203	4.3	3.8	4.0
Rhode Island	704	616	593	109,990	116,788	120,607	6.4	5.3	4.9
South Carolina	909	788	972	418,111	440,769	481,483	2.2	1.8	2.0
South Dakota	324	314	479	79,716	84,428	82,667	4.1	3.7	5.8
Tennessee	1,274	1,319	1,685	563,268	572,909	613,516	2.3	2.3	2.7
Texas	7,256	6,165	7,950	2,283,119	2,463,849	2,628,169	3.2	2.5	3.0
Utah	1,010	859	937	328,513	322,408	321,208	3.1	2.7	2.9
Vermont	252	215	184	58,845	65,566	65,966	4.3	3.3	2.8
Virginia	2,644	3,490	5,044	706,828	781,520	815,225	3.7	4.5	6.2
Washington	2,037	1,840	2,727	586,456	628,998	665,328	3.5	2.9	4.1
West Virginia	651	402	642	174,409	168,204	170,502	3.7	2.4	3.8
Wisconsin	1,879	2,002	2,781	534,453	564,587	551,418	3.5	3.5	5.0
Wyoming	340	370	446	51,810	56,592	56,730	6.6	6.5	7.9
Puerto Rico	1,348	952	1,130	429,366	400,529	376,652	3.1	2.4	3.0

na = not applicable.

EPSCoR = Experimental Program to Stimulate Competitive Research; SET = science, engineering, and technology.

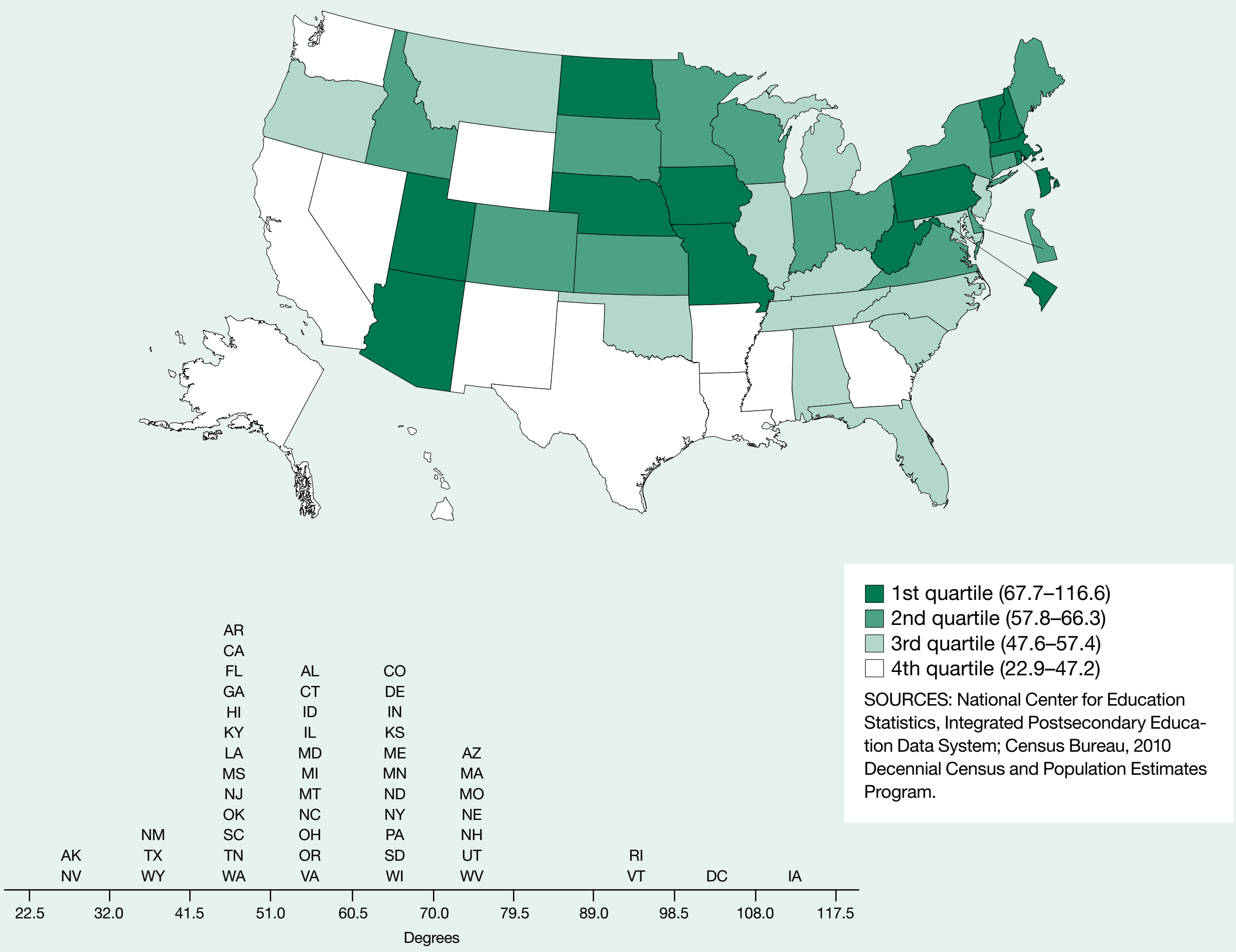
NOTES: SET associate's degrees include engineering, physical sciences, computer and mathematical sciences, agricultural and biological sciences, social sciences, science technologies, and engineering technologies.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Census Bureau, 2000 and 2010 Decennial Censuses and Population Estimates Program (various years).

Science and Engineering Indicators 2014

Bachelor’s Degrees Conferred per 1,000 Individuals 18–24 Years Old

Figure 8-17
Bachelor’s degrees conferred per 1,000 individuals 18–24 years old: 2011



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Census Bureau, 2010 Decennial Census and Population Estimates Program.

Findings

- In 2011, more than 1.7 million bachelor’s degrees were conferred nationally in all fields, which is up from 1.2 million in 2001 and represents an increase of 38%.
- Between 2001 and 2011, the number of bachelor’s degrees conferred per 1,000 individuals 18–24 years old in the population has increased by more than 24% nationwide.
- In 2011, state values on this indicator varied greatly. They ranged from 22.9 to 116.6 bachelor’s degrees conferred per 1,000 individuals 18–24 years old.
- Except in the District of Columbia and Montana, the number of bachelor’s degrees conferred per 1,000 individuals 18–24 years old increased in all jurisdictions between 2001 and 2011.

Educational attainment gives people greater opportunities to work in higher-paying jobs than are generally available to those with less education. Earning a bachelor’s degree also prepares them for advanced education.

Educational attainment varies by several demographic characteristics including age. The cohort 18–24 years old was chosen to approximate the age range of most students who are pursuing an undergraduate degree. This indicator represents the extent to which the 18–24-year-old population has earned a bachelor’s degree.

The number of bachelor’s degrees awarded is based on an actual count provided by the National Center for Education Statistics. Estimates of the population aged 18–24 years are provided by the U.S. Census Bureau. Small differences in the indicator value between states or across time generally are not meaningful.

A high value for this indicator may suggest the successful provision of educational opportunity at this level. Student mobility after graduation is not accounted for, which may make this indicator less meaningful in predicting the qualifications of a state’s future workforce. A state’s value for this indicator may also be high when its higher education system draws a large percentage of out-of-state students—a situation characteristic of the District of Columbia and of some states with small resident populations.

Table 8-17

Bachelor's degrees conferred per 1,000 individuals 18–24 years old, by state: 2001, 2006, and 2011

	Bachelor's degrees			Population 18–24 years old			Degrees/ 1,000 individuals 18–24 years old		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	1,244,171	1,485,242	1,715,913	27,992,652	29,602,839	31,067,478	44.4	50.2	55.2
Alabama	20,823	21,995	27,248	447,963	459,114	482,405	46.5	47.9	56.5
Alaska	1,338	1,573	1,770	61,774	74,369	77,271	21.7	21.2	22.9
Arizona	20,856	32,708	50,928	536,018	591,986	643,726	38.9	55.3	79.1
Arkansas	9,628	11,340	13,259	268,131	273,882	287,131	35.9	41.4	46.2
California	123,382	151,021	169,623	3,488,933	3,700,882	3,975,377	35.4	40.8	42.7
Colorado	22,272	28,554	30,570	453,712	477,387	498,956	49.1	59.8	61.3
Connecticut	14,245	17,997	19,970	278,499	310,891	333,524	51.1	57.9	59.9
Delaware	4,504	5,410	5,877	78,530	84,759	92,520	57.4	63.8	63.5
District of Columbia	8,166	10,556	8,402	72,568	76,839	84,786	112.5	137.4	99.1
Florida	52,557	69,899	86,281	1,401,785	1,652,892	1,773,048	37.5	42.3	48.7
Georgia	28,790	36,332	45,075	866,190	915,634	996,088	33.2	39.7	45.3
Hawaii	4,896	5,813	5,751	120,970	131,489	133,388	40.5	44.2	43.1
Idaho	4,646	7,781	9,171	144,212	153,844	155,895	32.2	50.6	58.8
Illinois	55,633	68,016	71,580	1,230,513	1,238,706	1,246,926	45.2	54.9	57.4
Indiana	31,881	38,093	43,519	628,372	638,724	656,136	50.7	59.6	66.3
Iowa	18,652	21,435	36,266	303,271	312,319	310,985	61.5	68.6	116.6
Kansas	14,734	16,731	18,191	282,851	296,431	291,056	52.1	56.4	62.5
Kentucky	15,434	18,646	21,078	411,270	405,029	418,168	37.5	46.0	50.4
Louisiana	19,990	19,936	21,509	485,975	459,662	474,817	41.1	43.4	45.3
Maine	5,429	6,544	7,347	107,177	117,346	116,333	50.7	55.8	63.2
Maryland	23,001	26,685	30,264	470,318	525,903	567,560	48.9	50.7	53.3
Massachusetts	42,792	47,074	53,749	594,747	637,145	685,891	71.9	73.9	78.4
Michigan	46,115	51,756	56,217	955,459	975,541	986,710	48.3	53.1	57.0
Minnesota	23,355	28,927	33,386	486,444	517,679	505,955	48.0	55.9	66.0
Mississippi	11,232	11,803	13,230	316,243	306,076	308,468	35.5	38.6	42.9
Missouri	30,102	35,161	41,648	552,622	583,691	591,301	54.5	60.2	70.4
Montana	5,183	5,118	5,512	89,343	99,357	96,660	58.0	51.5	57.0
Nebraska	10,782	12,150	13,510	178,947	188,966	183,949	60.3	64.3	73.4
Nevada	4,358	6,595	7,556	190,232	229,614	250,650	22.9	28.7	30.1
New Hampshire	7,254	8,030	9,479	107,717	121,400	125,008	67.3	66.1	75.8
New Jersey	26,948	32,251	37,087	690,374	729,181	779,067	39.0	44.2	47.6
New Mexico	6,551	7,491	8,179	184,493	202,027	206,918	35.5	37.1	39.5
New York	97,415	113,094	128,472	1,802,422	1,869,014	1,996,795	54.0	60.5	64.3
North Carolina	34,767	39,969	48,670	824,717	876,910	953,966	42.2	45.6	51.0
North Dakota	4,688	5,487	5,674	76,459	85,992	83,807	61.3	63.8	67.7
Ohio	50,856	58,522	63,882	1,079,689	1,083,220	1,106,053	47.1	54.0	57.8
Oklahoma	15,932	18,909	19,511	369,614	381,715	385,762	43.1	49.5	50.6
Oregon	13,887	17,631	19,542	337,357	350,178	362,400	41.2	50.3	53.9
Pennsylvania	66,514	79,791	88,205	1,121,223	1,200,427	1,269,203	59.3	66.5	69.5
Rhode Island	8,222	9,636	10,863	109,990	116,788	120,607	74.8	82.5	90.1
South Carolina	16,316	19,313	23,034	418,111	440,769	481,483	39.0	43.8	47.8
South Dakota	4,223	4,850	5,211	79,716	84,428	82,667	53.0	57.4	63.0
Tennessee	22,823	26,330	31,026	563,268	572,909	613,516	40.5	46.0	50.6
Texas	76,074	92,027	107,438	2,283,119	2,463,849	2,628,169	33.3	37.4	40.9
Utah	17,091	20,677	24,461	328,513	322,408	321,208	52.0	64.1	76.2
Vermont	4,697	4,981	6,100	58,845	65,566	65,966	79.8	76.0	92.5
Virginia	32,822	38,775	49,077	706,828	781,520	815,225	46.4	49.6	60.2
Washington	23,441	28,570	31,398	586,456	628,998	665,328	40.0	45.4	47.2
West Virginia	8,704	10,033	12,978	174,409	168,204	170,502	49.9	59.6	76.1
Wisconsin	28,493	31,434	35,279	534,453	564,587	551,418	53.3	55.7	64.0
Wyoming	1,677	1,792	1,860	51,810	56,592	56,730	32.4	31.7	32.8
Puerto Rico	15,758	17,129	17,698	429,366	400,529	376,652	36.7	42.8	47.0

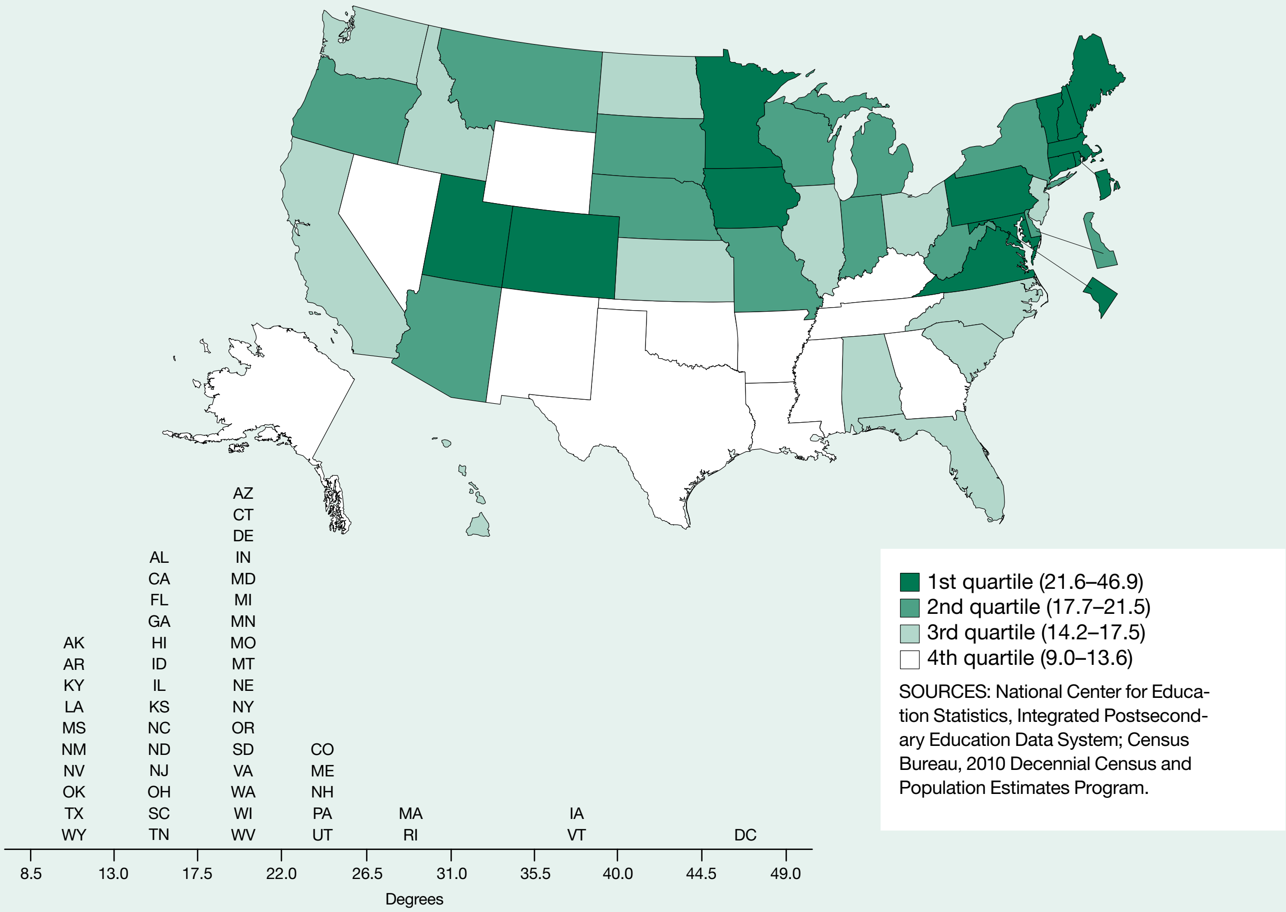
SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Census Bureau, 2000 and 2010 Decennial Censuses and Population Estimates Program (various years).

Science and Engineering Indicators 2014

Bachelor's Degrees in Science and Engineering Conferred per 1,000 Individuals 18–24 Years Old

Figure 8-18

Bachelor's degrees in science and engineering conferred per 1,000 individuals 18–24 years old: 2011



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Census Bureau, 2010 Decennial Census and Population Estimates Program.

Findings

- In 2011, nearly 550,000 bachelor's degrees in S&E fields were conferred nationally, which is up from 396,000 in 2001 and represents an increase of 39%.
- Between 2001 and 2011, the number of bachelor's degrees in S&E fields conferred per 1,000 individuals 18–24 years old in the population increased by nearly 25% nationwide.
- In 2011, state values on this indicator varied greatly. They ranged from 9.0 to 39.4 bachelor's degrees in S&E fields conferred per 1,000 individuals 18–24 years old.
- The number of bachelor's degrees in S&E fields conferred per 1,000 individuals 18–24 years old decreased in Kansas and the District of Columbia between 2001 and 2011.
- The states producing the largest numbers of S&E bachelor's degrees were the same as those producing the largest numbers of bachelor's degrees in natural sciences and engineering (see indicator 8-19).

Educational attainment in an S&E field gives people greater opportunities to work in higher-paying technical jobs than are generally available to those in other fields of study. Earning a bachelor's degree in an S&E field also prepares an individual for advanced technical education. S&E fields include the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology.

Educational attainment varies by several demographic characteristics including age. The cohort 18–24 years old was chosen to approximate the age range of most students who are pursuing an undergraduate degree. This indicator represents the extent to which a state provides bachelor's level training in S&E fields, controlling for the size of its college-age population.

The number of bachelor's degrees awarded in S&E fields is based on an actual count provided by the National Center for Education Statistics. Estimates of the population aged 18–24 years old are provided by the U.S. Census Bureau. Small differences in the indicator value between states or across time generally are not meaningful.

A high value for this indicator may suggest the successful provision of undergraduate training in S&E fields. Student mobility after graduation is not accounted for, which may make this indicator less meaningful in predicting the qualifications of a state's future technical workforce. A state's value for this indicator may also be high when its higher education system draws a large percentage of out-of-state students, a situation characteristic of the District of Columbia and of some states with small resident populations.

Table 8-18

Bachelor's degrees in science and engineering conferred per 1,000 individuals 18–24 years old, by state: 2001, 2006, and 2011

	S&E bachelor's degrees			Population 18–24 years old			Degrees/1,000 individuals 18–24 years old		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
EPSCoR states	56,960	65,336	74,420	4,617,353	4,785,938	4,930,966	12.3	13.7	15.1
Non-EPSCoR states	332,493	401,258	468,059	23,105,302	24,522,581	25,834,531	14.4	16.4	18.1
Average EPSCoR state value	na	na	na	na	na	na	14.1	15.3	17.3
Average non-EPSCoR state value	na	na	na	na	na	na	15.2	17.4	19.8
United States	396,149	474,650	549,871	27,992,652	29,602,839	31,067,478	14.2	16.0	17.7
Alabama	5,520	6,019	7,406	447,963	459,114	482,405	12.3	13.1	15.4
Alaska	420	515	693	61,774	74,369	77,271	6.8	6.9	9.0
Arizona	5,159	8,174	13,812	536,018	591,986	643,726	9.6	13.8	21.5
Arkansas	2,404	2,659	3,196	268,131	273,882	287,131	9.0	9.7	11.1
California	47,715	60,588	68,228	3,488,933	3,700,882	3,975,377	13.7	16.4	17.2
Colorado	8,727	11,024	11,173	453,712	477,387	498,956	19.2	23.1	22.4
Connecticut	5,161	6,272	7,213	278,499	310,891	333,524	18.5	20.2	21.6
Delaware	1,449	1,729	1,916	78,530	84,759	92,520	18.5	20.4	20.7
District of Columbia	3,880	4,814	3,979	72,568	76,839	84,786	53.5	62.7	46.9
Florida	14,374	20,500	25,263	1,401,785	1,652,892	1,773,048	10.3	12.4	14.2
Georgia	9,119	11,219	13,327	866,190	915,634	996,088	10.5	12.3	13.4
Hawaii	1,602	1,956	1,995	120,970	131,489	133,388	13.2	14.9	15.0
Idaho	1,415	2,159	2,444	144,212	153,844	155,895	9.8	14.0	15.7
Illinois	16,150	19,132	20,589	1,230,513	1,238,706	1,246,926	13.1	15.4	16.5
Indiana	8,748	10,397	12,224	628,372	638,724	656,136	13.9	16.3	18.6
Iowa	5,375	6,122	11,742	303,271	312,319	310,985	17.7	19.6	37.8
Kansas	4,405	4,598	4,515	282,851	296,431	291,056	15.6	15.5	15.5
Kentucky	4,041	4,830	5,271	411,270	405,029	418,168	9.8	11.9	12.6
Louisiana	5,490	5,574	5,925	485,975	459,662	474,817	11.3	12.1	12.5
Maine	2,062	2,390	2,854	107,177	117,346	116,333	19.2	20.4	24.5
Maryland	8,878	11,170	12,388	470,318	525,903	567,560	18.9	21.2	21.8
Massachusetts	16,189	17,794	20,023	594,747	637,145	685,891	27.2	27.9	29.2
Michigan	13,682	15,675	17,573	955,459	975,541	986,710	14.3	16.1	17.8
Minnesota	7,497	9,544	11,012	486,444	517,679	505,955	15.4	18.4	21.8
Mississippi	2,836	2,821	3,191	316,243	306,076	308,468	9.0	9.2	10.3
Missouri	8,360	9,605	10,473	552,622	583,691	591,301	15.1	16.5	17.7
Montana	1,718	1,763	1,888	89,343	99,357	96,660	19.2	17.7	19.5
Nebraska	2,564	3,064	3,415	178,947	188,966	183,949	14.3	16.2	18.6
Nevada	975	1,836	2,270	190,232	229,614	250,650	5.1	8.0	9.1
New Hampshire	2,477	2,811	3,284	107,717	121,400	125,008	23.0	23.2	26.3
New Jersey	10,617	11,668	12,819	690,374	729,181	779,067	15.4	16.0	16.5
New Mexico	1,819	2,163	2,466	184,493	202,027	206,918	9.9	10.7	11.9
New York	33,187	37,365	42,904	1,802,422	1,869,014	1,996,795	18.4	20.0	21.5
North Carolina	11,826	13,300	16,543	824,717	876,910	953,966	14.3	15.2	17.3
North Dakota	1,214	1,286	1,418	76,459	85,992	83,807	15.9	15.0	16.9
Ohio	14,001	15,723	17,872	1,079,689	1,083,220	1,106,053	13.0	14.5	16.2
Oklahoma	4,067	4,839	4,815	369,614	381,715	385,762	11.0	12.7	12.5
Oregon	5,177	6,456	7,242	337,357	350,178	362,400	15.3	18.4	20.0
Pennsylvania	21,007	25,095	28,273	1,121,223	1,200,427	1,269,203	18.7	20.9	22.3
Rhode Island	2,340	2,975	3,326	109,990	116,788	120,607	21.3	25.5	27.6
South Carolina	4,951	5,910	7,017	418,111	440,769	481,483	11.8	13.4	14.6
South Dakota	1,396	1,582	1,669	79,716	84,428	82,667	17.5	18.7	20.2
Tennessee	6,281	7,080	8,370	563,268	572,909	613,516	11.2	12.4	13.6
Texas	20,778	25,896	30,453	2,283,119	2,463,849	2,628,169	9.1	10.5	11.6
Utah	5,090	6,774	7,751	328,513	322,408	321,208	15.5	21.0	24.1
Vermont	1,834	2,020	2,596	58,845	65,566	65,966	31.2	30.8	39.4
Virginia	12,522	14,209	17,594	706,828	781,520	815,225	17.7	18.2	21.6
Washington	8,055	10,158	11,652	586,456	628,998	665,328	13.7	16.1	17.5
West Virginia	2,176	2,422	3,539	174,409	168,204	170,502	12.5	14.4	20.8
Wisconsin	8,818	10,318	11,546	534,453	564,587	551,418	16.5	18.3	20.9
Wyoming	601	657	724	51,810	56,592	56,730	11.6	11.6	12.8
Puerto Rico	4,208	4,076	4,370	429,366	400,529	376,652	9.8	10.2	11.6

na = not applicable.

EPSCoR = Experimental Program to Stimulate Competitive Research.

NOTE: For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

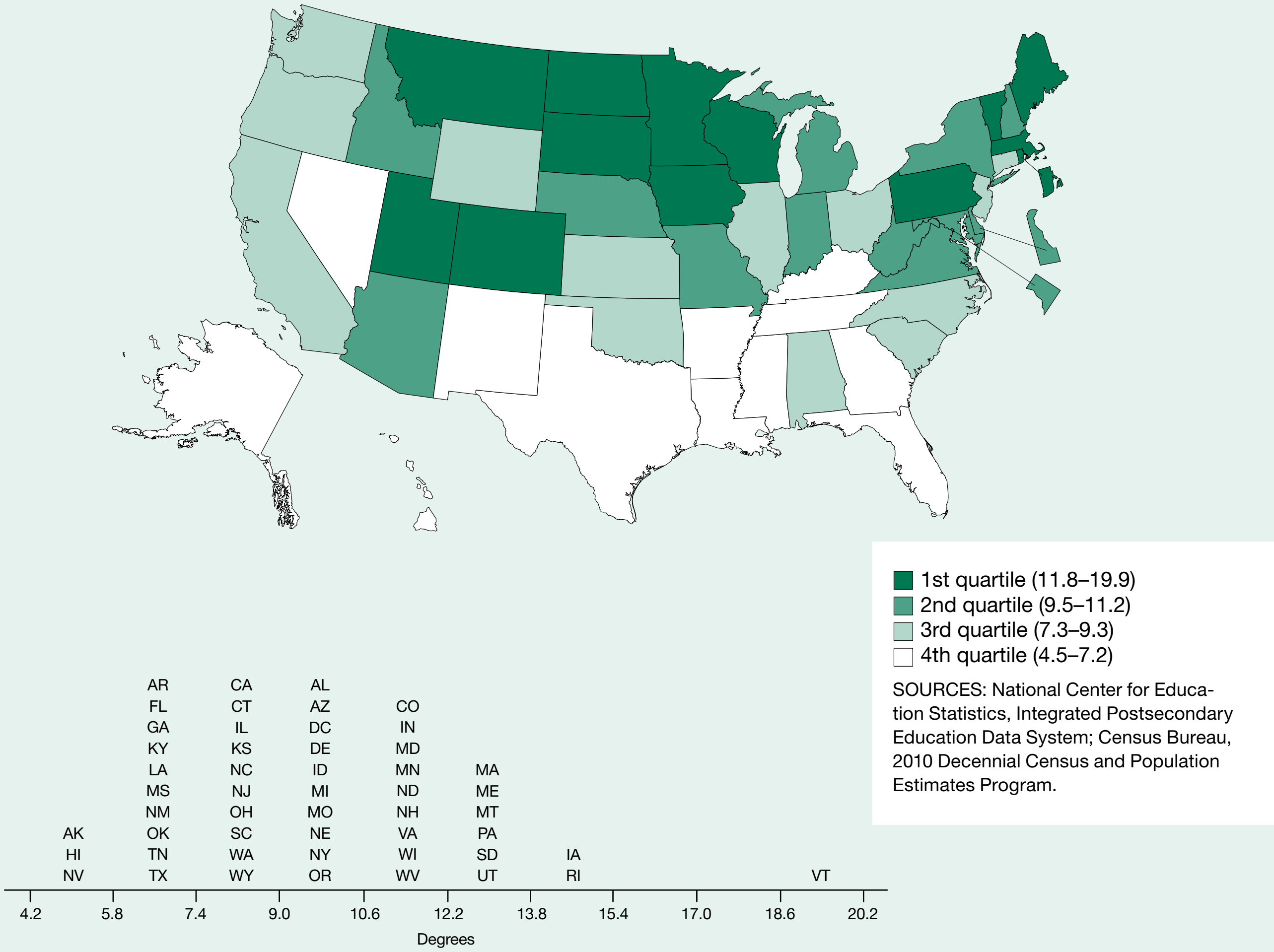
SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Census Bureau, 2000 and 2010 Decennial Censuses and Population Estimates Program (various years).

Science and Engineering Indicators 2014

Bachelor's Degrees in Natural Sciences and Engineering Conferred per 1,000 Individuals 18–24 Years Old

Figure 8-19

Bachelor's degrees in natural sciences and engineering conferred per 1,000 individuals 18–24 years old: 2011



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Census Bureau, 2010 Decennial Census and Population Estimates Program.

Findings

- Between 2001 and 2011, the value of this indicator nationwide increased from 7.5 to 8.9 bachelor's degrees conferred in NS&E fields per 1,000 individuals aged 18–24 years old.
- In 2011, the value of this indicator for individual states ranged from 4.5 to 19.9.
- The states conferring the largest number of bachelor's degrees in NS&E fields were California, New York, Texas, and Pennsylvania.
- States that ranked in the top two quartiles on this indicator were generally the same as those in the top two quartiles for the number of bachelor's degrees conferred per 1,000 individuals 18–24 years old (see indicator 8-17).

Natural sciences and engineering (NS&E) fields include the physical, earth, ocean, atmospheric, biological, agricultural, and computer sciences; mathematics; and engineering. NS&E fields do not include social sciences and psychology. This indicator is the ratio of new NS&E bachelor's degrees to the population aged 18–24 years old and represents the extent to which a state prepares young people to enter technology-intensive occupations that are fundamental to a knowledge-based, technology-driven economy. In addition, the presence of higher education institutions that produce such degrees may generate resources for the state. The cohort 18–24 years old was chosen to approximate the age range of most students who are pursuing an undergraduate degree.

The number of NS&E bachelor's degrees awarded is based on an actual count provided by the National Center for Education Statistics. Estimates of the population aged 18–24 years old are provided by the U.S. Census Bureau. Small differences in the value of the indicator between states or across time generally are not meaningful.

Because students often relocate after graduation, this measure does not necessarily indicate the qualifications of a state's future workforce. A state's value for this indicator may also be high when its higher education system draws a large number of out-of-state students who study NS&E fields—a situation characteristic of the District of Columbia and some states with small resident populations.

Table 8-19

Bachelor's degrees in natural sciences and engineering conferred per 1,000 individuals 18–24 years old, by state: 2001, 2006, and 2011

	NS&E bachelor's degrees			Population 18–24 years old			Degrees/1,000 individuals 18–24 years old		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
EPSCoR states	33,480	35,875	41,515	4,617,353	4,785,938	4,930,966	7.3	7.5	8.4
Non-EPSCoR states	172,100	199,802	233,396	23,105,302	24,522,581	25,834,531	7.4	8.1	9.0
Average EPSCoR state value	na	na	na	na	na	na	8.0	8.2	9.5
Average non-EPSCoR state value	na	na	na	na	na	na	7.9	8.7	9.8
United States	208,747	239,201	277,549	27,992,652	29,602,839	31,067,478	7.5	8.1	8.9
Alabama	3,659	3,662	4,499	447,963	459,114	482,405	8.2	8.0	9.3
Alaska	230	312	399	61,774	74,369	77,271	3.7	4.2	5.2
Arizona	3,110	5,423	6,285	536,018	591,986	643,726	5.8	9.2	9.8
Arkansas	1,492	1,531	1,897	268,131	273,882	287,131	5.6	5.6	6.6
California	22,337	27,014	30,766	3,488,933	3,700,882	3,975,377	6.4	7.3	7.7
Colorado	4,614	5,892	5,906	453,712	477,387	498,956	10.2	12.3	11.8
Connecticut	1,902	2,171	2,734	278,499	310,891	333,524	6.8	7.0	8.2
Delaware	689	729	895	78,530	84,759	92,520	8.8	8.6	9.7
District of Columbia	1,699	1,821	893	72,568	76,839	84,786	23.4	23.7	10.5
Florida	7,348	9,524	12,184	1,401,785	1,652,892	1,773,048	5.2	5.8	6.9
Georgia	5,206	6,009	7,208	866,190	915,634	996,088	6.0	6.6	7.2
Hawaii	670	790	746	120,970	131,489	133,388	5.5	6.0	5.6
Idaho	900	1,384	1,530	144,212	153,844	155,895	6.2	9.0	9.8
Illinois	9,184	10,920	11,153	1,230,513	1,238,706	1,246,926	7.5	8.8	8.9
Indiana	4,953	5,744	6,961	628,372	638,724	656,136	7.9	9.0	10.6
Iowa	3,055	3,327	4,533	303,271	312,319	310,985	10.1	10.7	14.6
Kansas	2,606	2,469	2,555	282,851	296,431	291,056	9.2	8.3	8.8
Kentucky	2,132	2,367	2,828	411,270	405,029	418,168	5.2	5.8	6.8
Louisiana	3,481	3,327	3,354	485,975	459,662	474,817	7.2	7.2	7.1
Maine	1,060	1,138	1,430	107,177	117,346	116,333	9.9	9.7	12.3
Maryland	4,737	5,793	6,287	470,318	525,903	567,560	10.1	11.0	11.1
Massachusetts	7,209	7,707	9,182	594,747	637,145	685,891	12.1	12.1	13.4
Michigan	8,348	9,265	10,044	955,459	975,541	986,710	8.7	9.5	10.2
Minnesota	4,026	5,016	6,027	486,444	517,679	505,955	8.3	9.7	11.9
Mississippi	1,755	1,659	1,856	316,243	306,076	308,468	5.5	5.4	6.0
Missouri	4,837	5,152	5,628	552,622	583,691	591,301	8.8	8.8	9.5
Montana	1,171	1,133	1,233	89,343	99,357	96,660	13.1	11.4	12.8
Nebraska	1,495	1,676	1,940	178,947	188,966	183,949	8.4	8.9	10.5
Nevada	527	883	1,137	190,232	229,614	250,650	2.8	3.8	4.5
New Hampshire	1,198	1,116	1,386	107,717	121,400	125,008	11.1	9.2	11.1
New Jersey	5,199	5,217	5,920	690,374	729,181	779,067	7.5	7.2	7.6
New Mexico	1,166	1,296	1,383	184,493	202,027	206,918	6.3	6.4	6.7
New York	15,134	16,418	19,196	1,802,422	1,869,014	1,996,795	8.4	8.8	9.6
North Carolina	6,183	6,396	8,342	824,717	876,910	953,966	7.5	7.3	8.7
North Dakota	798	913	999	76,459	85,992	83,807	10.4	10.6	11.9
Ohio	7,748	8,254	9,746	1,079,689	1,083,220	1,106,053	7.2	7.6	8.8
Oklahoma	2,491	2,672	2,808	369,614	381,715	385,762	6.7	7.0	7.3
Oregon	2,372	2,886	3,349	337,357	350,178	362,400	7.0	8.2	9.2
Pennsylvania	11,901	13,781	15,723	1,121,223	1,200,427	1,269,203	10.6	11.5	12.4
Rhode Island	1,202	1,531	1,744	109,990	116,788	120,607	10.9	13.1	14.5
South Carolina	2,760	3,201	3,878	418,111	440,769	481,483	6.6	7.3	8.1
South Dakota	913	1,052	1,070	79,716	84,428	82,667	11.5	12.5	12.9
Tennessee	3,281	3,491	4,330	563,268	572,909	613,516	5.8	6.1	7.1
Texas	11,798	14,150	17,196	2,283,119	2,463,849	2,628,169	5.2	5.7	6.5
Utah	2,797	3,432	4,028	328,513	322,408	321,208	8.5	10.6	12.5
Vermont	846	898	1,312	58,845	65,566	65,966	14.4	13.7	19.9
Virginia	5,956	6,519	8,632	706,828	781,520	815,225	8.4	8.3	10.6
Washington	3,861	4,631	5,416	586,456	628,998	665,328	6.6	7.4	8.1
West Virginia	1,296	1,407	1,918	174,409	168,204	170,502	7.4	8.4	11.2
Wisconsin	5,004	5,670	6,620	534,453	564,587	551,418	9.4	10.0	12.0
Wyoming	411	432	463	51,810	56,592	56,730	7.9	7.6	8.2
Puerto Rico	3,054	2,925	3,000	429,366	400,529	376,652	7.1	7.3	8.0

na = not applicable.

EPSCoR = Experimental Program to Stimulate Competitive Research; NS&E = natural sciences and engineering.

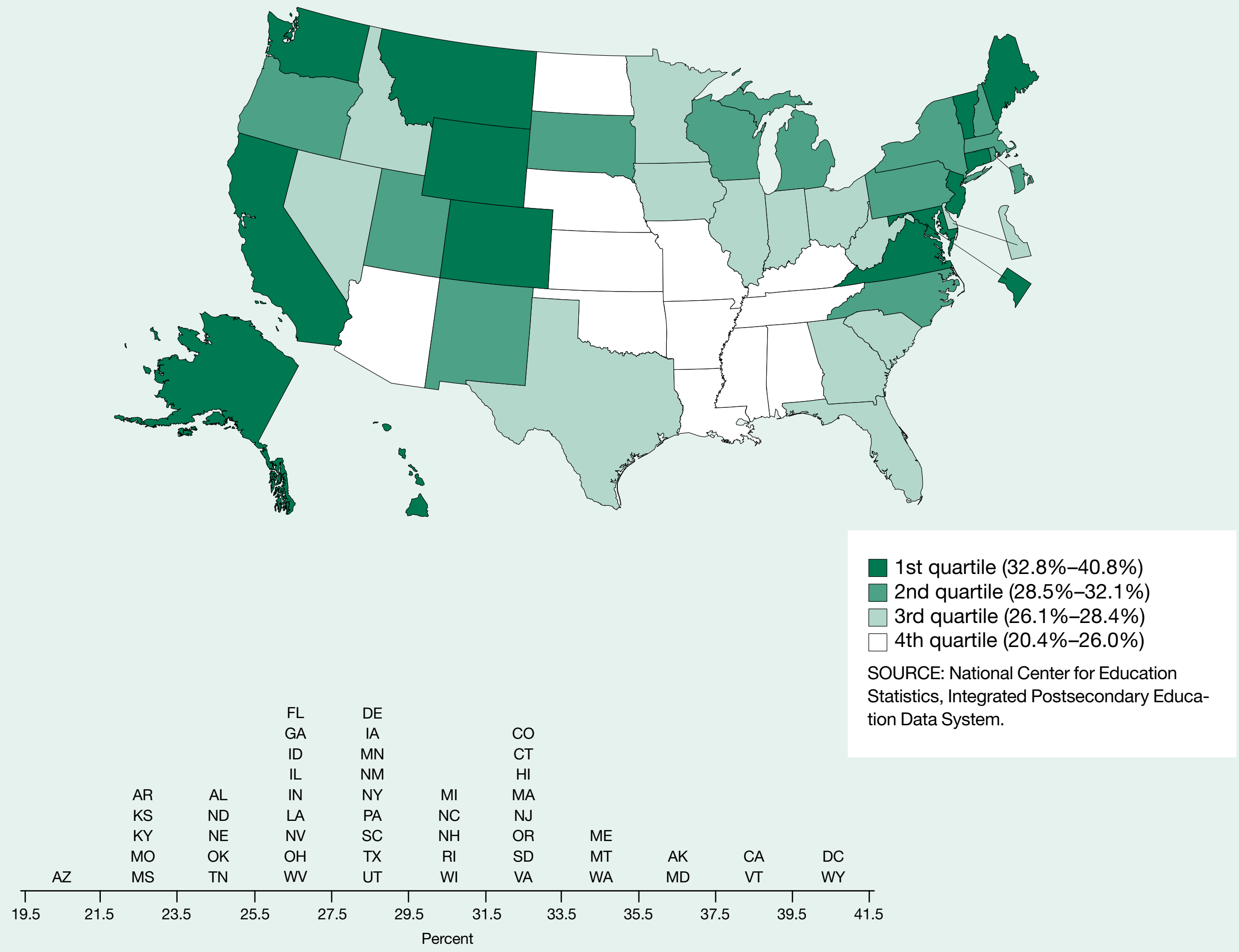
NOTE: For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Census Bureau, 2000 and 2010 Decennial Censuses and Population Estimates Program (various years).

Science and Engineering Indicators 2014

Science and Engineering Degrees as a Percentage of Higher Education Degrees Conferred

Figure 8-20
Science and engineering degrees as a percentage of higher education degrees conferred: 2011



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- In 2011, nearly 734,000 S&E bachelor's, master's, and doctoral degrees were conferred nationwide, an increase of 41% since 2001.
- Nationally, the proportion of S&E degrees as a share of total degrees conferred remained almost unchanged at 29% between 2001 and 2011.
- There are noteworthy differences in the proportions of S&E higher education degrees conferred in different states. In some states, only about 20% of higher education degrees were awarded in S&E fields. In others, nearly 40% of higher education degrees were awarded in S&E fields.
- The District of Columbia has a high value because of the large number of programs in political science and public administration at several of its academic institutions.

This indicator represents the extent to which a state's higher education programs are concentrated in S&E fields. S&E fields include the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Counts of both S&E degrees and higher education degrees conferred include bachelor's, master's, and doctoral degrees; associate's degrees are not included.

Degree data reflect the location of the degree-granting institution, not the state where degree-earning students permanently reside. The year indicates the end date of the academic year. For example, data for 2011 represent degrees conferred during the 2010–11 academic year. All degree data are actual counts.

Table 8-20

Science and engineering degrees as a percentage of higher education degrees conferred, by state: 2001, 2006, and 2011

State	All S&E degrees			All higher education degrees			All S&E degrees/ all higher education degrees (%)		
	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	520,476	625,163	733,609	1,757,551	2,135,374	2,506,134	29.6	29.3	29.3
Alabama	7,489	8,313	9,933	29,471	32,889	39,751	25.4	25.3	25.0
Alaska	604	719	921	1,771	2,176	2,509	34.1	33.0	36.7
Arizona	6,800	10,072	18,154	32,089	58,452	88,964	21.2	17.2	20.4
Arkansas	2,844	3,235	4,121	12,039	14,662	18,344	23.6	22.1	22.5
California	63,360	80,172	91,643	175,179	213,725	244,200	36.2	37.5	37.5
Colorado	11,606	14,320	15,209	31,418	41,242	45,772	36.9	34.7	33.2
Connecticut	6,929	8,341	9,790	22,459	27,331	29,759	30.9	30.5	32.9
Delaware	1,868	2,216	2,512	6,174	7,795	8,840	30.3	28.4	28.4
District of Columbia	6,870	8,294	7,743	16,005	20,458	19,033	42.9	40.5	40.7
Florida	18,843	25,887	32,260	74,159	96,870	121,004	25.4	26.7	26.7
Georgia	12,083	14,677	17,367	40,652	50,258	64,301	29.7	29.2	27.0
Hawaii	2,227	2,531	2,594	6,793	7,982	8,074	32.8	31.7	32.1
Idaho	1,756	2,661	2,942	5,809	9,613	11,076	30.2	27.7	26.6
Illinois	22,867	27,863	30,855	85,474	108,371	117,325	26.8	25.7	26.3
Indiana	11,188	13,241	15,768	41,533	50,859	59,294	26.9	26.0	26.6
Iowa	6,389	7,413	13,296	22,762	26,669	47,054	28.1	27.8	28.3
Kansas	5,576	5,872	6,012	20,315	23,069	25,962	27.4	25.5	23.2
Kentucky	5,015	6,317	6,883	20,615	26,057	29,932	24.3	24.2	23.0
Louisiana	6,908	7,282	7,562	26,403	26,933	29,072	26.2	27.0	26.0
Maine	2,236	2,625	3,103	6,659	8,238	9,173	33.6	31.9	33.8
Maryland	12,710	15,870	18,039	34,837	41,487	48,527	36.5	38.3	37.2
Massachusetts	22,843	25,439	28,989	70,397	77,949	90,422	32.4	32.6	32.1
Michigan	18,618	21,124	23,488	68,860	75,553	79,340	27.0	28.0	29.6
Minnesota	9,319	12,388	15,853	32,426	45,705	57,518	28.7	27.1	27.6
Mississippi	3,472	3,618	4,278	14,904	16,011	18,366	23.3	22.6	23.3
Missouri	11,306	12,690	14,323	44,466	53,706	63,525	25.4	23.6	22.5
Montana	2,076	2,189	2,313	6,216	6,333	6,814	33.4	34.6	33.9
Nebraska	3,261	3,892	4,478	14,309	16,517	18,564	22.8	23.6	24.1
Nevada	1,279	2,378	2,814	5,966	8,904	10,532	21.4	26.7	26.7
New Hampshire	3,082	3,520	4,047	9,767	11,273	13,293	31.6	31.2	30.4
New Jersey	13,842	15,603	17,439	37,760	46,061	52,919	36.7	33.9	33.0
New Mexico	2,558	3,164	3,339	9,412	11,117	11,725	27.2	28.5	28.5
New York	44,628	51,277	59,701	150,970	181,303	203,148	29.6	28.3	29.4
North Carolina	14,543	16,541	20,896	45,316	53,738	66,530	32.1	30.8	31.4
North Dakota	1,397	1,522	1,743	5,597	6,805	7,385	25.0	22.4	23.6
Ohio	18,238	20,505	23,094	70,489	81,292	88,516	25.9	25.2	26.1
Oklahoma	5,914	6,243	6,503	21,668	24,726	26,299	27.3	25.2	24.7
Oregon	6,473	8,004	8,767	19,198	24,144	27,306	33.7	33.2	32.1
Pennsylvania	26,514	32,358	37,253	90,967	110,726	127,084	29.1	29.2	29.3
Rhode Island	2,872	3,649	4,077	10,400	12,083	13,718	27.6	30.2	29.7
South Carolina	6,052	6,997	8,223	21,323	24,830	29,523	28.4	28.2	27.9
South Dakota	1,775	2,030	2,153	5,305	6,043	6,729	33.5	33.6	32.0
Tennessee	7,787	8,752	10,243	31,683	36,299	43,362	24.6	24.1	23.6
Texas	28,242	35,293	42,413	103,513	127,836	153,270	27.3	27.6	27.7
Utah	6,151	8,075	9,399	21,069	25,753	31,967	29.2	31.4	29.4
Vermont	2,153	2,576	3,343	6,116	6,827	8,535	35.2	37.7	39.2
Virginia	15,823	18,582	23,672	44,783	53,760	72,067	35.3	34.6	32.8
Washington	10,011	12,592	14,269	31,856	38,392	42,255	31.4	32.8	33.8
West Virginia	2,699	3,056	5,050	11,225	13,265	19,040	24.0	23.0	26.5
Wisconsin	10,549	12,328	13,761	36,813	40,999	46,009	28.7	30.1	29.9
Wyoming	831	857	981	2,161	2,288	2,407	38.5	37.5	40.8
Puerto Rico	4,847	4,992	5,437	18,678	22,551	23,611	26.0	22.1	23.0

NOTES: All S&E degrees include bachelor's, master's, and doctorate. All S&E degrees include physical, computer, agricultural, biological, earth, atmospheric, ocean, and social sciences; psychology; mathematics; and engineering. All higher education degrees include bachelor's, master's, and doctorate.

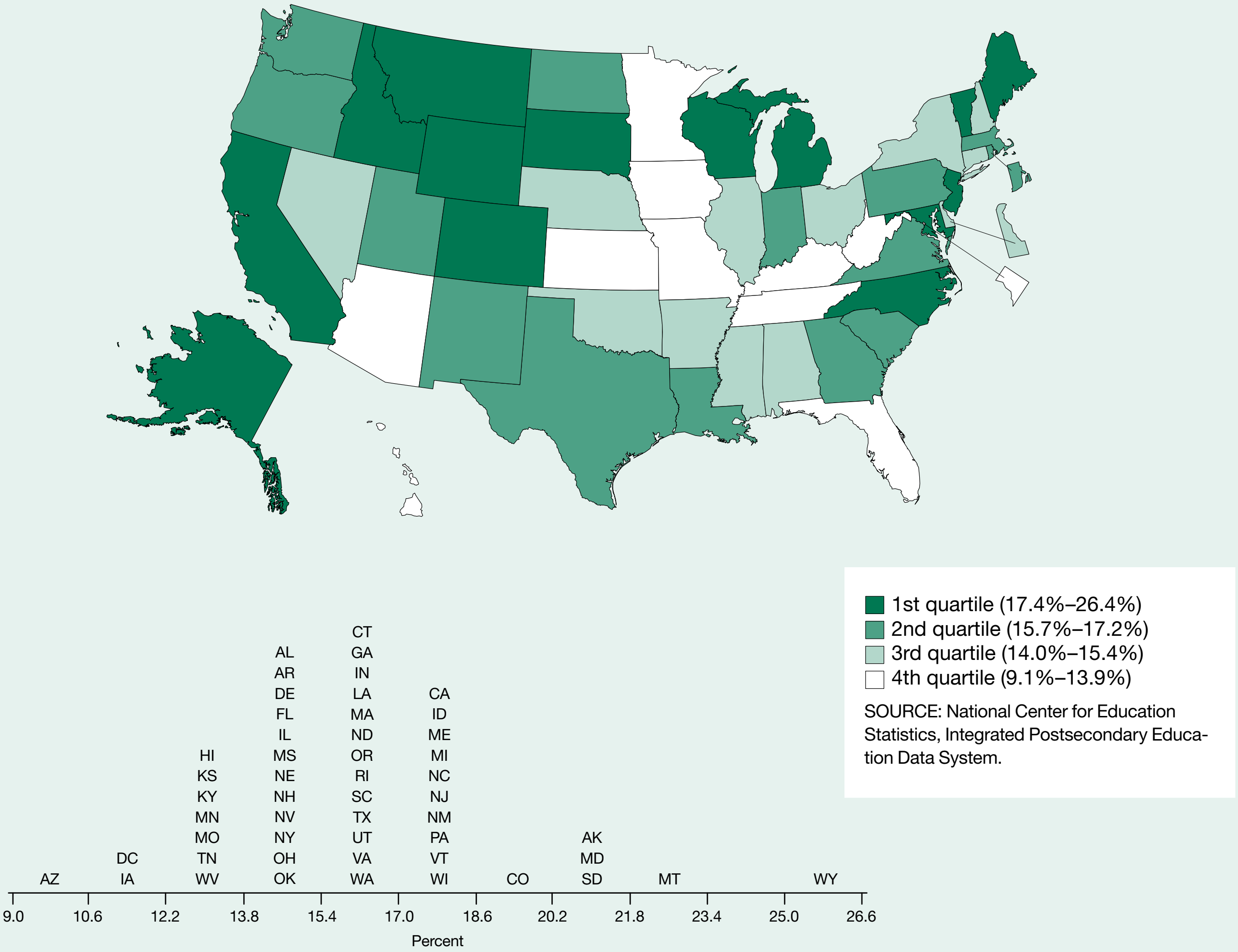
SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2014

Natural Sciences and Engineering Degrees as a Percentage of Higher Education Degrees Conferred

Figure 8-21

Natural sciences and engineering degrees as a percentage of higher education degrees conferred: 2011



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- In 2011, more than 392,000 NS&E bachelor's, master's, and doctoral degrees were conferred nationwide, an increase of 37% since 2001.
- The proportion of NS&E degrees as a share of total degrees conferred remained unchanged at 15.6% between 2006 and 2011.
- There are noteworthy differences in the proportions of NS&E higher education degrees conferred in different states. In 2011, the proportions ranged between 9.1% and 26.4%.
- Nationally, more than half (53%) of all S&E degrees were in NS&E fields in 2011, down from 55% of all S&E degrees in 2001.
- States with the highest percentage of higher education degrees in NS&E fields tended to be located in the western United States, and four of the top five are Experimental Program to Stimulate Competitive Research states.

This indicator represents the extent to which a state's higher education programs are concentrated in natural sciences and engineering (NS&E) fields. The indicator is expressed as the percentage of higher education degrees that were conferred in NS&E fields.

NS&E fields include the physical, life, earth, ocean, atmospheric, and computer sciences; mathematics; and engineering. Social sciences such as anthropology, economics, political science and public administration, psychology, and sociology are not included. Counts of both NS&E degrees and higher education degrees conferred include bachelor's, master's, and doctoral degrees; associate's degrees are not included.

Degree data reflect the location of the degree-granting institution, not the state in which degree-earning students permanently reside. The year reflects the end date of the academic year. For example, data for 2010 represent degrees conferred during the 2009–10 academic year. All degree data are actual counts.

Table 8-21

Natural sciences and engineering degrees as a percentage of higher education degrees conferred, by state: 2001, 2006, and 2011

	NS&E degrees			All higher education degrees			NS&E degrees/higher education degrees (%)		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	287,290	333,677	392,170	1,757,551	2,135,374	2,506,134	16.3	15.6	15.6
Alabama	4,578	4,854	5,927	29,471	32,889	39,751	15.5	14.8	14.9
Alaska	346	451	543	1,771	2,176	2,509	19.5	20.7	21.6
Arizona	4,251	6,666	8,107	32,089	58,452	88,964	13.2	11.4	9.1
Arkansas	1,783	1,932	2,608	12,039	14,662	18,344	14.8	13.2	14.2
California	31,205	38,756	44,876	175,179	213,725	244,200	17.8	18.1	18.4
Colorado	6,514	8,017	8,532	31,418	41,242	45,772	20.7	19.4	18.6
Connecticut	3,078	3,637	4,592	22,459	27,331	29,759	13.7	13.3	15.4
Delaware	906	1,021	1,271	6,174	7,795	8,840	14.7	13.1	14.4
District of Columbia	3,230	3,100	2,243	16,005	20,458	19,033	20.2	15.2	11.8
Florida	10,142	12,964	16,847	74,159	96,870	121,004	13.7	13.4	13.9
Georgia	7,296	8,233	10,120	40,652	50,258	64,301	17.9	16.4	15.7
Hawaii	983	1,042	1,041	6,793	7,982	8,074	14.5	13.1	12.9
Idaho	1,174	1,797	1,939	5,809	9,613	11,076	20.2	18.7	17.5
Illinois	13,417	16,244	17,297	85,474	108,371	117,325	15.7	15.0	14.7
Indiana	6,455	7,596	9,295	41,533	50,859	59,294	15.5	14.9	15.7
Iowa	3,830	4,300	5,672	22,762	26,669	47,054	16.8	16.1	12.1
Kansas	3,368	3,309	3,533	20,315	23,069	25,962	16.6	14.3	13.6
Kentucky	2,705	3,247	3,656	20,615	26,057	29,932	13.1	12.5	12.2
Louisiana	4,480	4,522	4,550	26,403	26,933	29,072	17.0	16.8	15.7
Maine	1,198	1,301	1,604	6,659	8,238	9,173	18.0	15.8	17.5
Maryland	7,300	9,075	10,167	34,837	41,487	48,527	21.0	21.9	21.0
Massachusetts	11,261	12,275	14,560	70,397	77,949	90,422	16.0	15.7	16.1
Michigan	12,070	13,262	14,238	68,860	75,553	79,340	17.5	17.6	17.9
Minnesota	5,083	6,492	7,767	32,426	45,705	57,518	15.7	14.2	13.5
Mississippi	2,242	2,265	2,660	14,904	16,011	18,366	15.0	14.1	14.5
Missouri	6,125	6,760	7,733	44,466	53,706	63,525	13.8	12.6	12.2
Montana	1,448	1,433	1,530	6,216	6,333	6,814	23.3	22.6	22.5
Nebraska	1,943	2,209	2,602	14,309	16,517	18,564	13.6	13.4	14.0
Nevada	728	1,232	1,498	5,966	8,904	10,532	12.2	13.8	14.2
New Hampshire	1,648	1,545	1,953	9,767	11,273	13,293	16.9	13.7	14.7
New Jersey	7,530	7,769	9,266	37,760	46,061	52,919	19.9	16.9	17.5
New Mexico	1,666	1,988	2,021	9,412	11,117	11,725	17.7	17.9	17.2
New York	21,845	24,238	29,236	150,970	181,303	203,148	14.5	13.4	14.4
North Carolina	8,204	8,745	11,550	45,316	53,738	66,530	18.1	16.3	17.4
North Dakota	928	1,087	1,226	5,597	6,805	7,385	16.6	16.0	16.6
Ohio	10,649	11,501	13,299	70,489	81,292	88,516	15.1	14.1	15.0
Oklahoma	3,361	3,658	3,875	21,668	24,726	26,299	15.5	14.8	14.7
Oregon	3,162	3,799	4,359	19,198	24,144	27,306	16.5	15.7	16.0
Pennsylvania	15,425	18,459	21,701	90,967	110,726	127,084	17.0	16.7	17.1
Rhode Island	1,537	1,935	2,207	10,400	12,083	13,718	14.8	16.0	16.1
South Carolina	3,635	4,004	4,789	21,323	24,830	29,523	17.0	16.1	16.2
South Dakota	1,159	1,325	1,369	5,305	6,043	6,729	21.8	21.9	20.3
Tennessee	4,235	4,522	5,509	31,683	36,299	43,362	13.4	12.5	12.7
Texas	17,085	20,867	25,952	103,513	127,836	153,270	16.5	16.3	16.9
Utah	3,477	4,377	5,136	21,069	25,753	31,967	16.5	17.0	16.1
Vermont	1,001	1,158	1,553	6,116	6,827	8,535	16.4	17.0	18.2
Virginia	8,032	9,182	11,887	44,783	53,760	72,067	17.9	17.1	16.5
Washington	5,102	6,009	6,907	31,856	38,392	42,255	16.0	15.7	16.3
West Virginia	1,629	1,861	2,428	11,225	13,265	19,040	14.5	14.0	12.8
Wisconsin	6,269	7,099	8,303	36,813	40,999	46,009	17.0	17.3	18.0
Wyoming	572	557	636	2,161	2,288	2,407	26.5	24.3	26.4
Puerto Rico	3,417	3,392	3,520	18,678	22,551	23,611	18.3	15.0	14.9

NS&E = natural sciences and engineering.

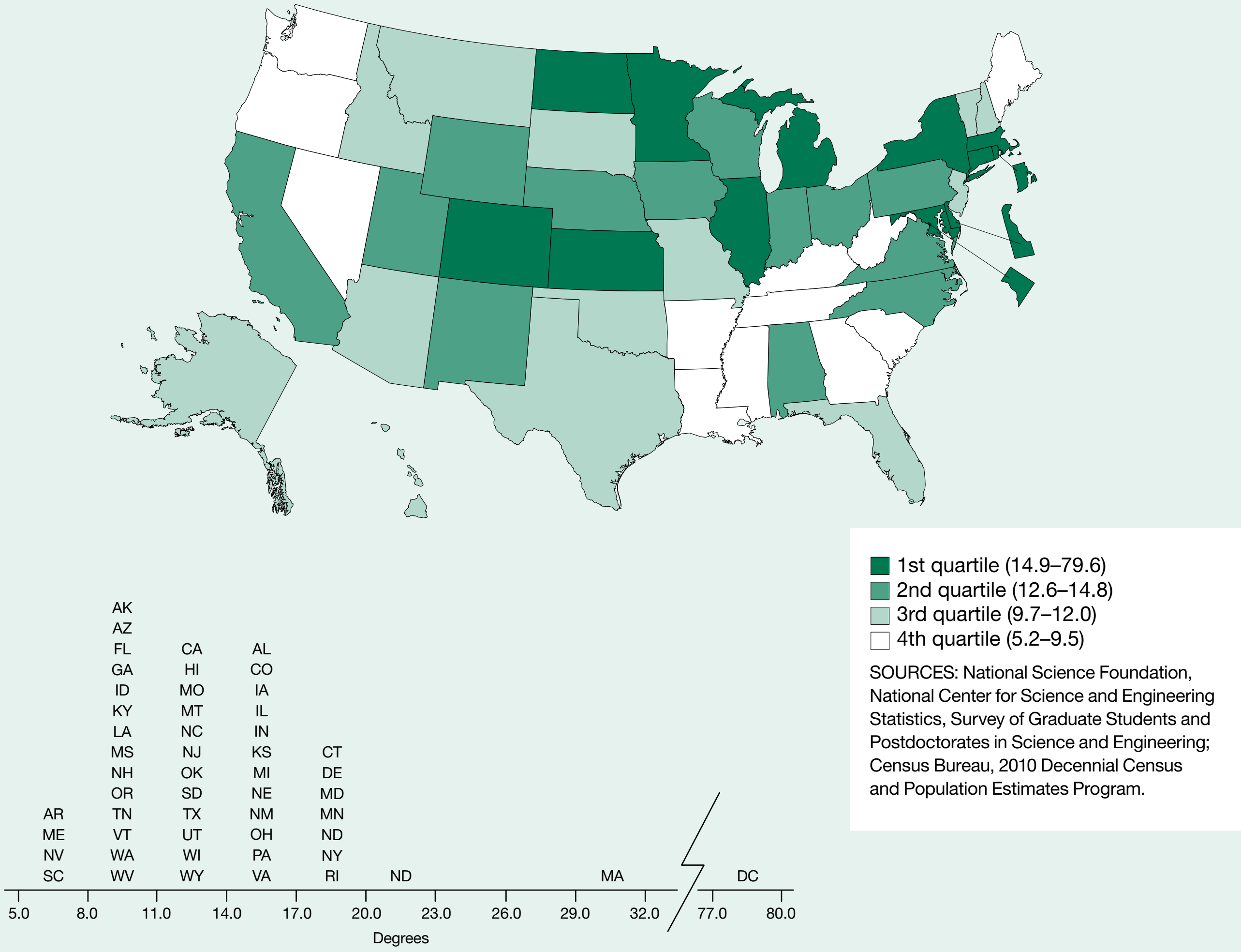
NOTES: NS&E degrees include bachelor's, master's, and doctorate. NS&E degrees include physical, computer, agricultural, biological, earth, atmospheric, and ocean sciences; mathematics; and engineering. All higher education degrees include bachelor's, master's, and doctorate.

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2014

Science and Engineering Graduate Students per 1,000 Individuals 25–34 Years Old

Figure 8-22
Science and engineering graduate students per 1,000 individuals 25–34 years old: 2011



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering; Census Bureau, 2010 Decennial Census and Population Estimates Program.

Graduate students in S&E fields may become the technical leaders of the future. This indicator is a relative measure of a state's population with graduate training in S&E and is defined as the ratio of S&E graduate students to a state's population aged 25–34.

Graduate students are counted on the basis of their university enrollment and include state residents, residents of other states, and noncitizens. The cohort includes all state residents aged 25–34 and was chosen to approximate the age of most graduate students.

Data on S&E graduate students are counts obtained from all academic institutions in the United States that offer doctoral or master's degree programs in any S&E field, including the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Graduate students enrolled in schools of nursing, public health, dentistry, veterinary medicine, and other health-related disciplines are not included.

Estimates of the population aged 25–34 years old are provided by the U.S. Census Bureau. Small differences in the value of the indicator between states or across years generally are not meaningful.

Findings

- The number of S&E graduate students in the United States grew from approximately 426,000 in 2001 to 558,000 in 2011, a 31% increase.
- Among the 50 states, the value of this indicator ranged from 5.2 to 30.5.
- Growth in the number of S&E graduate students was most significant in Texas and California during this period. Other states with sizeable increases included New York, Florida, Minnesota, and Maryland.

Table 8-22

Science and engineering graduate students per 1,000 individuals 25–34 years old, by state: 2001, 2006, and 2011

State	S&E graduate students			Population 25–34 years old			S&E graduate students/1,000 individuals 25–34 years old		
	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	426,094	482,626	557,993	39,471,522	39,395,179	41,797,950	10.8	12.3	13.3
Alabama	5,257	6,097	8,639	588,949	591,061	614,667	8.9	10.3	14.1
Alaska	619	825	1,139	87,154	89,788	106,872	7.1	9.2	10.7
Arizona	6,789	7,395	9,398	748,567	838,414	867,462	9.1	8.8	10.8
Arkansas	2,069	2,677	2,533	348,283	366,132	381,599	5.9	7.3	6.6
California	54,730	64,120	68,576	5,234,401	5,169,993	5,405,582	10.5	12.4	12.7
Colorado	9,048	9,316	12,326	674,645	673,414	746,654	13.4	13.8	16.5
Connecticut	6,937	7,308	8,309	437,292	403,277	428,825	15.9	18.1	19.4
Delaware	1,461	1,817	2,055	106,005	107,873	114,146	13.8	16.8	18.0
District of Columbia	7,448	9,798	10,626	102,420	105,154	133,464	72.7	93.2	79.6
Florida	16,414	19,550	23,822	2,071,777	2,221,655	2,348,449	7.9	8.8	10.1
Georgia	9,345	10,848	12,473	1,295,862	1,312,377	1,357,886	7.2	8.3	9.2
Hawaii	1,455	1,896	2,142	168,560	176,055	192,265	8.6	10.8	11.1
Idaho	1,547	1,841	2,039	169,900	191,279	210,906	9.1	9.6	9.7
Illinois	24,266	24,483	27,237	1,788,465	1,737,829	1,787,899	13.6	14.1	15.2
Indiana	8,510	9,761	12,125	817,892	812,260	835,258	10.4	12.0	14.5
Iowa	4,705	5,124	5,601	356,466	352,021	389,147	13.2	14.6	14.4
Kansas	5,846	5,722	5,958	343,487	343,137	383,886	17.0	16.7	15.5
Kentucky	4,017	4,693	4,543	556,948	555,069	569,299	7.2	8.5	8.0
Louisiana	5,739	5,515	5,980	587,213	560,262	643,209	9.8	9.8	9.3
Maine	605	675	761	152,867	143,767	146,381	4.0	4.7	5.2
Maryland	9,209	11,219	13,688	733,474	725,791	784,346	12.6	15.5	17.5
Massachusetts	20,191	23,011	26,539	907,376	818,399	870,207	22.3	28.1	30.5
Michigan	15,695	15,206	17,439	1,327,644	1,219,056	1,172,148	11.8	12.5	14.9
Minnesota	6,663	11,940	13,443	666,671	661,468	729,934	10.0	18.1	18.4
Mississippi	2,629	3,010	3,419	374,462	373,805	389,945	7.0	8.1	8.8
Missouri	6,320	7,687	8,715	727,911	736,036	787,984	8.7	10.4	11.1
Montana	1,268	1,456	1,496	101,315	107,547	125,164	12.5	13.5	12.0
Nebraska	2,428	2,905	3,598	220,445	223,330	250,051	11.0	13.0	14.4
Nevada	1,584	2,053	2,133	314,776	367,992	388,454	5.0	5.6	5.5
New Hampshire	1,337	1,426	1,608	156,956	144,611	146,960	8.5	9.9	10.9
New Jersey	11,322	12,513	12,676	1,164,876	1,091,700	1,124,825	9.7	11.5	11.3
New Mexico	3,269	3,656	4,045	229,301	247,445	273,317	14.3	14.8	14.8
New York	38,946	44,139	49,332	2,705,918	2,560,803	2,716,521	14.4	17.2	18.2
North Carolina	10,640	12,419	16,027	1,207,640	1,192,318	1,261,660	8.8	10.4	12.7
North Dakota	1,078	1,362	1,890	74,377	75,538	94,738	14.5	18.0	19.9
Ohio	16,388	18,161	20,589	1,481,232	1,420,465	1,425,637	11.1	12.8	14.4
Oklahoma	4,166	4,095	6,113	445,894	463,304	515,926	9.3	8.8	11.8
Oregon	3,990	4,409	5,064	472,656	488,957	530,602	8.4	9.0	9.5
Pennsylvania	18,585	20,218	22,851	1,514,109	1,460,972	1,547,226	12.3	13.8	14.8
Rhode Island	1,646	1,885	2,376	137,032	128,875	128,843	12.0	14.6	18.4
South Carolina	3,240	3,397	4,202	551,336	564,942	600,606	5.9	6.0	7.0
South Dakota	982	924	1,272	89,533	92,913	108,359	11.0	9.9	11.7
Tennessee	5,797	6,302	7,081	800,705	809,202	834,804	7.2	7.8	8.5
Texas	28,440	33,083	42,542	3,186,416	3,361,877	3,690,821	8.9	9.8	11.5
Utah	4,034	5,049	5,755	333,952	395,758	449,404	12.1	12.8	12.8
Vermont	597	610	685	72,130	66,702	70,651	8.3	9.1	9.7
Virginia	12,286	13,044	15,984	1,025,675	1,023,967	1,121,245	12.0	12.7	14.3
Washington	5,891	6,542	8,741	837,266	855,936	961,616	7.0	7.6	9.1
West Virginia	2,031	2,166	2,101	222,472	221,677	221,255	9.1	9.8	9.5
Wisconsin	7,871	8,460	9,227	692,200	678,122	731,644	11.4	12.5	12.6
Wyoming	764	818	1,080	58,619	64,854	79,201	13.0	12.6	13.6
Puerto Rico	3,062	3,585	2,842	533,518	551,751	480,337	5.7	6.5	5.9

NOTE: S&E graduate students include students pursuing degrees in physical, computer, agricultural, biological, earth, atmospheric, ocean, and social sciences; psychology; mathematics; and engineering.

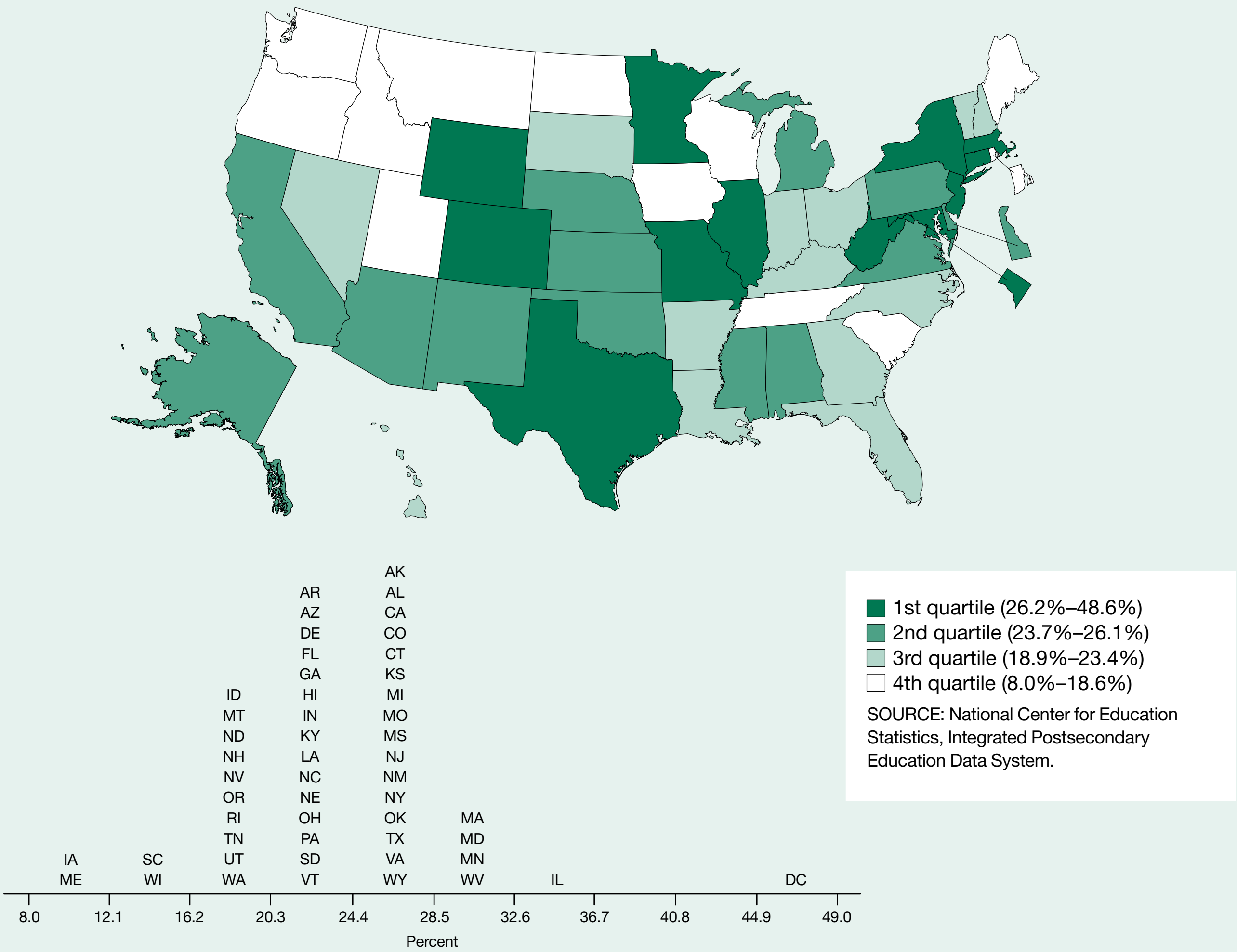
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering; Census Bureau, 2000 and 2010 Decennial Censuses and Population Estimates Program (various years).

Science and Engineering Indicators 2014

Advanced Science and Engineering Degrees as a Percentage of S&E Degrees Conferred

Figure 8-23

Advanced science and engineering degrees as a percentage of S&E degrees conferred: 2011



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- In 2011, nearly 184,000 advanced S&E degrees were awarded nationwide, 48% more degrees than were awarded in 2001. The share of advanced degrees as a percentage of all S&E degrees conferred increased by 5% between 2001 and 2011.
- In 2011, the value of this indicator for individual states ranged from 8.0% to 33.3% of S&E graduates completing training at the master's or doctoral level. Between 2001 and 2011, 29 states and the District of Columbia showed increases in the share of their S&E graduates completing training at the master's or doctoral level and 21 states showed decreases.
- In states with few S&E graduate programs, the number of advanced S&E degrees conferred varies considerably from year to year. Readers should use caution when making annual comparisons for those states with small numbers of S&E graduate students.

This indicator represents the extent to which a state's higher education programs in S&E are concentrated at the graduate level. S&E fields include the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Advanced S&E degrees include master's and doctoral degrees. Total S&E degrees include bachelor's, master's, and doctoral degrees but exclude associate's degrees.

The indicator value is computed by dividing the number of advanced S&E degrees by the total number of S&E degrees awarded by the higher education institutions within the state. The number of degrees are actual counts provided by the National Center for Education Statistics.

Table 8-23
Advanced science and engineering degrees as a percentage of S&E degrees conferred, by state: 2001, 2006, and 2011

State	Advanced S&E degrees			All S&E degrees			Advanced S&E degrees/all S&E degrees (%)		
	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	124,327	150,513	183,738	520,476	625,163	733,609	23.9	24.1	25.0
Alabama	1,969	2,294	2,527	7,489	8,313	9,933	26.3	27.6	25.4
Alaska	184	204	228	604	719	921	30.5	28.4	24.8
Arizona	1,641	1,898	4,342	6,800	10,072	18,154	24.1	18.8	23.9
Arkansas	440	576	925	2,844	3,235	4,121	15.5	17.8	22.4
California	15,645	19,584	23,415	63,360	80,172	91,643	24.7	24.4	25.6
Colorado	2,879	3,296	4,036	11,606	14,320	15,209	24.8	23.0	26.5
Connecticut	1,768	2,069	2,577	6,929	8,341	9,790	25.5	24.8	26.3
Delaware	419	487	596	1,868	2,216	2,512	22.4	22.0	23.7
District of Columbia	2,990	3,480	3,764	6,870	8,294	7,743	43.5	42.0	48.6
Florida	4,469	5,387	6,997	18,843	25,887	32,260	23.7	20.8	21.7
Georgia	2,964	3,458	4,040	12,083	14,677	17,367	24.5	23.6	23.3
Hawaii	625	575	599	2,227	2,531	2,594	28.1	22.7	23.1
Idaho	341	502	498	1,756	2,661	2,942	19.4	18.9	16.9
Illinois	6,717	8,731	10,266	22,867	27,863	30,855	29.4	31.3	33.3
Indiana	2,440	2,844	3,544	11,188	13,241	15,768	21.8	21.5	22.5
Iowa	1,014	1,291	1,554	6,389	7,413	13,296	15.9	17.4	11.7
Kansas	1,171	1,274	1,497	5,576	5,872	6,012	21.0	21.7	24.9
Kentucky	974	1,487	1,612	5,015	6,317	6,883	19.4	23.5	23.4
Louisiana	1,418	1,708	1,637	6,908	7,282	7,562	20.5	23.5	21.6
Maine	174	235	249	2,236	2,625	3,103	7.8	9.0	8.0
Maryland	3,832	4,700	5,651	12,710	15,870	18,039	30.1	29.6	31.3
Massachusetts	6,654	7,645	8,966	22,843	25,439	28,989	29.1	30.1	30.9
Michigan	4,936	5,449	5,915	18,618	21,124	23,488	26.5	25.8	25.2
Minnesota	1,822	2,844	4,841	9,319	12,388	15,853	19.6	23.0	30.5
Mississippi	636	797	1,087	3,472	3,618	4,278	18.3	22.0	25.4
Missouri	2,946	3,085	3,850	11,306	12,690	14,323	26.1	24.3	26.9
Montana	358	426	425	2,076	2,189	2,313	17.2	19.5	18.4
Nebraska	697	828	1,063	3,261	3,892	4,478	21.4	21.3	23.7
Nevada	304	542	544	1,279	2,378	2,814	23.8	22.8	19.3
New Hampshire	605	709	763	3,082	3,520	4,047	19.6	20.1	18.9
New Jersey	3,225	3,935	4,620	13,842	15,603	17,439	23.3	25.2	26.5
New Mexico	739	1,001	873	2,558	3,164	3,339	28.9	31.6	26.1
New York	11,441	13,912	16,797	44,628	51,277	59,701	25.6	27.1	28.1
North Carolina	2,717	3,241	4,353	14,543	16,541	20,896	18.7	19.6	20.8
North Dakota	183	236	325	1,397	1,522	1,743	13.1	15.5	18.6
Ohio	4,237	4,782	5,222	18,238	20,505	23,094	23.2	23.3	22.6
Oklahoma	1,847	1,404	1,688	5,914	6,243	6,503	31.2	22.5	26.0
Oregon	1,296	1,548	1,525	6,473	8,004	8,767	20.0	19.3	17.4
Pennsylvania	5,507	7,263	8,980	26,514	32,358	37,253	20.8	22.4	24.1
Rhode Island	532	674	751	2,872	3,649	4,077	18.5	18.5	18.4
South Carolina	1,101	1,087	1,206	6,052	6,997	8,223	18.2	15.5	14.7
South Dakota	379	448	484	1,775	2,030	2,153	21.4	22.1	22.5
Tennessee	1,506	1,672	1,873	7,787	8,752	10,243	19.3	19.1	18.3
Texas	7,464	9,397	11,960	28,242	35,293	42,413	26.4	26.6	28.2
Utah	1,061	1,301	1,648	6,151	8,075	9,399	17.2	16.1	17.5
Vermont	319	556	747	2,153	2,576	3,343	14.8	21.6	22.3
Virginia	3,301	4,373	6,078	15,823	18,582	23,672	20.9	23.5	25.7
Washington	1,956	2,434	2,617	10,011	12,592	14,269	19.5	19.3	18.3
West Virginia	523	634	1,511	2,699	3,056	5,050	19.4	20.7	29.9
Wisconsin	1,731	2,010	2,215	10,549	12,328	13,761	16.4	16.3	16.1
Wyoming	230	200	257	831	857	981	27.7	23.3	26.2
Puerto Rico	639	916	1,067	4,847	4,992	5,437	13.2	18.3	19.6

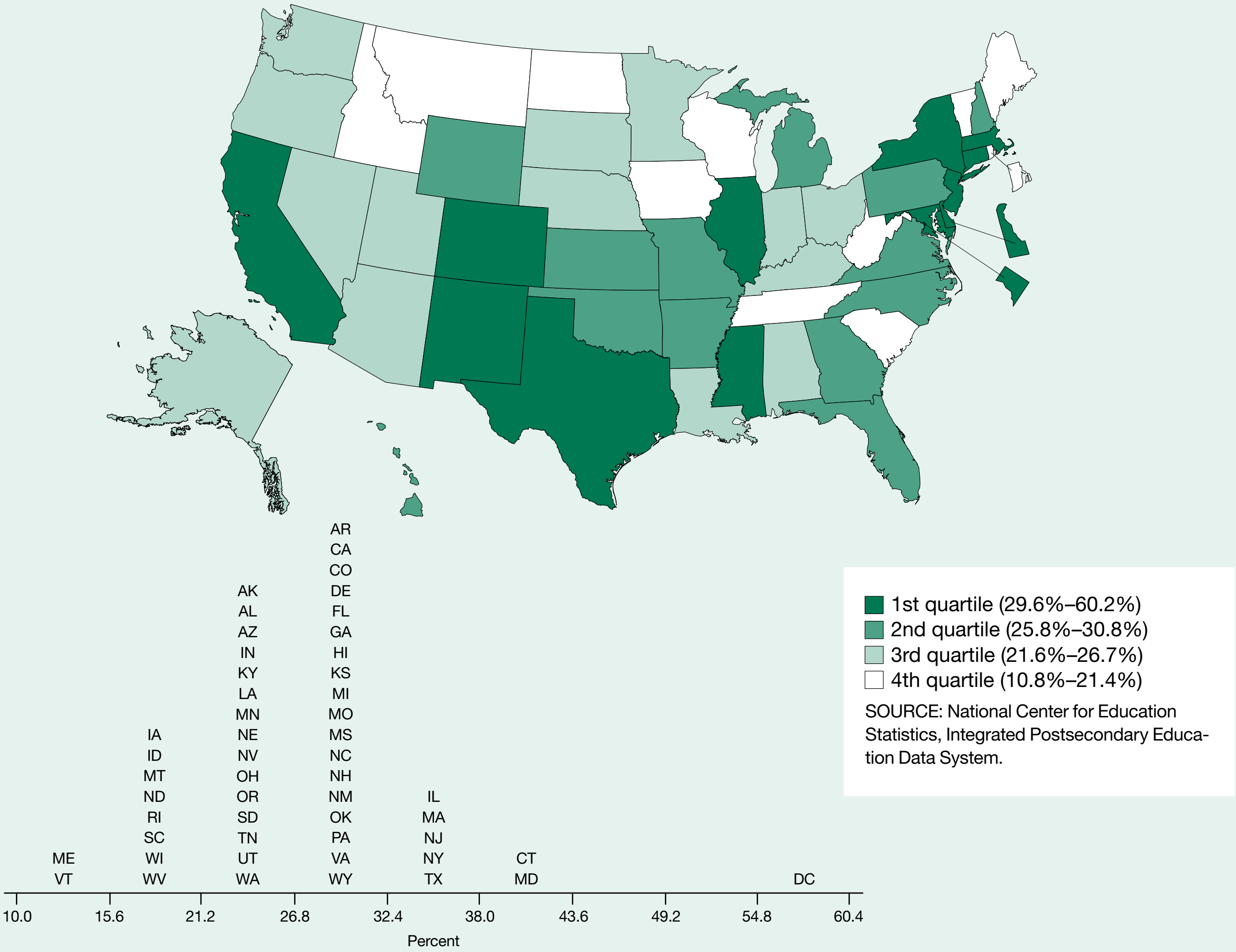
NOTES: Advanced S&E degrees include only master's and doctorate. All S&E degrees include bachelor's, master's, and doctorate. S&E degrees include physical, computer, agricultural, biological, earth, atmospheric, ocean, and social sciences; psychology; mathematics; and engineering.

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2014

Advanced Natural Sciences and Engineering Degrees as a Percentage of NS&E Degrees Conferred

Figure 8-24
Advanced natural sciences and engineering degrees as a percentage of NS&E degrees conferred: 2011



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- In 2011, nearly 115,000 advanced natural sciences and engineering (NS&E) degrees were awarded nationwide. This total represented approximately 46% more than were awarded in 2001. The share of advanced degrees as a percentage of all NS&E degrees conferred rose by 1.9 percentage points between 2001 and 2011.
- In 2011, the value of this indicator for states ranged from a low of 10.8% to a high of 40.5%.
- Nationally, about 62% of all advanced S&E degrees were in NS&E fields in 2011, a slight decline from 63% in 2001.
- In states with few NS&E graduate programs, the number of advanced NS&E degrees conferred varies considerably from year to year. Readers should use caution when making annual comparisons for those states with small numbers of NS&E graduate students.

This indicator represents the extent to which a state's higher education programs in NS&E are concentrated at the graduate level. NS&E fields include the physical, life, earth, ocean, atmospheric, and computer sciences; mathematics; and engineering. The social sciences, including anthropology, economics, political science and public administration, psychology, and sociology, are not included. Advanced NS&E degrees include master's and doctoral degrees. Total NS&E degrees include bachelor's, master's, and doctoral degrees but exclude associate's degrees.

The indicator value is computed by dividing the number of advanced NS&E degrees by the total number of NS&E degrees awarded by the higher education institutions within the state.

The number of degrees are actual counts provided by the National Center for Education Statistics.

Table 8-24

Advanced natural sciences and engineering degrees as a percentage of NS&E degrees conferred, by state: 2001, 2006, and 2011

State	Advanced NS&E degrees			NS&E degrees conferred			Advanced NS&E degrees/NS&E degrees conferred (%)		
	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	78,543	94,476	114,621	287,290	333,677	392,170	27.3	28.3	29.2
Alabama	919	1,192	1,428	4,578	4,854	5,927	20.1	24.6	24.1
Alaska	116	139	144	346	451	543	33.5	30.8	26.5
Arizona	1,141	1,243	1,822	4,251	6,666	8,107	26.8	18.6	22.5
Arkansas	291	401	711	1,783	1,932	2,608	16.3	20.8	27.3
California	8,868	11,742	14,110	31,205	38,756	44,876	28.4	30.3	31.4
Colorado	1,900	2,125	2,626	6,514	8,017	8,532	29.2	26.5	30.8
Connecticut	1,176	1,466	1,858	3,078	3,637	4,592	38.2	40.3	40.5
Delaware	217	292	376	906	1,021	1,271	24.0	28.6	29.6
District of Columbia	1,531	1,279	1,350	3,230	3,100	2,243	47.4	41.3	60.2
Florida	2,794	3,440	4,663	10,142	12,964	16,847	27.5	26.5	27.7
Georgia	2,090	2,224	2,912	7,296	8,233	10,120	28.6	27.0	28.8
Hawaii	313	252	295	983	1,042	1,041	31.8	24.2	28.3
Idaho	274	413	409	1,174	1,797	1,939	23.3	23.0	21.1
Illinois	4,233	5,324	6,144	13,417	16,244	17,297	31.5	32.8	35.5
Indiana	1,502	1,852	2,334	6,455	7,596	9,295	23.3	24.4	25.1
Iowa	775	973	1,139	3,830	4,300	5,672	20.2	22.6	20.1
Kansas	762	840	978	3,368	3,309	3,533	22.6	25.4	27.7
Kentucky	573	880	828	2,705	3,247	3,656	21.2	27.1	22.6
Louisiana	999	1,195	1,196	4,480	4,522	4,550	22.3	26.4	26.3
Maine	138	163	174	1,198	1,301	1,604	11.5	12.5	10.8
Maryland	2,563	3,282	3,880	7,300	9,075	10,167	35.1	36.2	38.2
Massachusetts	4,052	4,568	5,378	11,261	12,275	14,560	36.0	37.2	36.9
Michigan	3,722	3,997	4,194	12,070	13,262	14,238	30.8	30.1	29.5
Minnesota	1,057	1,476	1,740	5,083	6,492	7,767	20.8	22.7	22.4
Mississippi	487	606	804	2,242	2,265	2,660	21.7	26.8	30.2
Missouri	1,288	1,608	2,105	6,125	6,760	7,733	21.0	23.8	27.2
Montana	277	300	297	1,448	1,433	1,530	19.1	20.9	19.4
Nebraska	448	533	662	1,943	2,209	2,602	23.1	24.1	25.4
Nevada	201	349	361	728	1,232	1,498	27.6	28.3	24.1
New Hampshire	450	429	567	1,648	1,545	1,953	27.3	27.8	29.0
New Jersey	2,331	2,552	3,346	7,530	7,769	9,266	31.0	32.8	36.1
New Mexico	500	692	638	1,666	1,988	2,021	30.0	34.8	31.6
New York	6,711	7,820	10,040	21,845	24,238	29,236	30.7	32.3	34.3
North Carolina	2,021	2,349	3,208	8,204	8,745	11,550	24.6	26.9	27.8
North Dakota	130	174	227	928	1,087	1,226	14.0	16.0	18.5
Ohio	2,901	3,247	3,553	10,649	11,501	13,299	27.2	28.2	26.7
Oklahoma	870	986	1,067	3,361	3,658	3,875	25.9	27.0	27.5
Oregon	790	913	1,010	3,162	3,799	4,359	25.0	24.0	23.2
Pennsylvania	3,524	4,678	5,978	15,425	18,459	21,701	22.8	25.3	27.5
Rhode Island	335	404	463	1,537	1,935	2,207	21.8	20.9	21.0
South Carolina	875	803	911	3,635	4,004	4,789	24.1	20.1	19.0
South Dakota	246	273	299	1,159	1,325	1,369	21.2	20.6	21.8
Tennessee	954	1,031	1,179	4,235	4,522	5,509	22.5	22.8	21.4
Texas	5,287	6,717	8,756	17,085	20,867	25,952	30.9	32.2	33.7
Utah	680	945	1,108	3,477	4,377	5,136	19.6	21.6	21.6
Vermont	155	260	241	1,001	1,158	1,553	15.5	22.5	15.5
Virginia	2,076	2,663	3,255	8,032	9,182	11,887	25.8	29.0	27.4
Washington	1,241	1,378	1,491	5,102	6,009	6,907	24.3	22.9	21.6
West Virginia	333	454	510	1,629	1,861	2,428	20.4	24.4	21.0
Wisconsin	1,265	1,429	1,683	6,269	7,099	8,303	20.2	20.1	20.3
Wyoming	161	125	173	572	557	636	28.1	22.4	27.2
Puerto Rico	363	467	520	3,417	3,392	3,520	10.6	13.8	14.8

NS&E = natural sciences and engineering.

NOTES: Advanced NS&E degrees include only master's and doctorate. NS&E degrees conferred includes bachelor's, master's, and doctorate. NS&E degrees include physical, computer, agricultural, biological, earth, atmospheric, and ocean sciences; mathematics; and engineering.

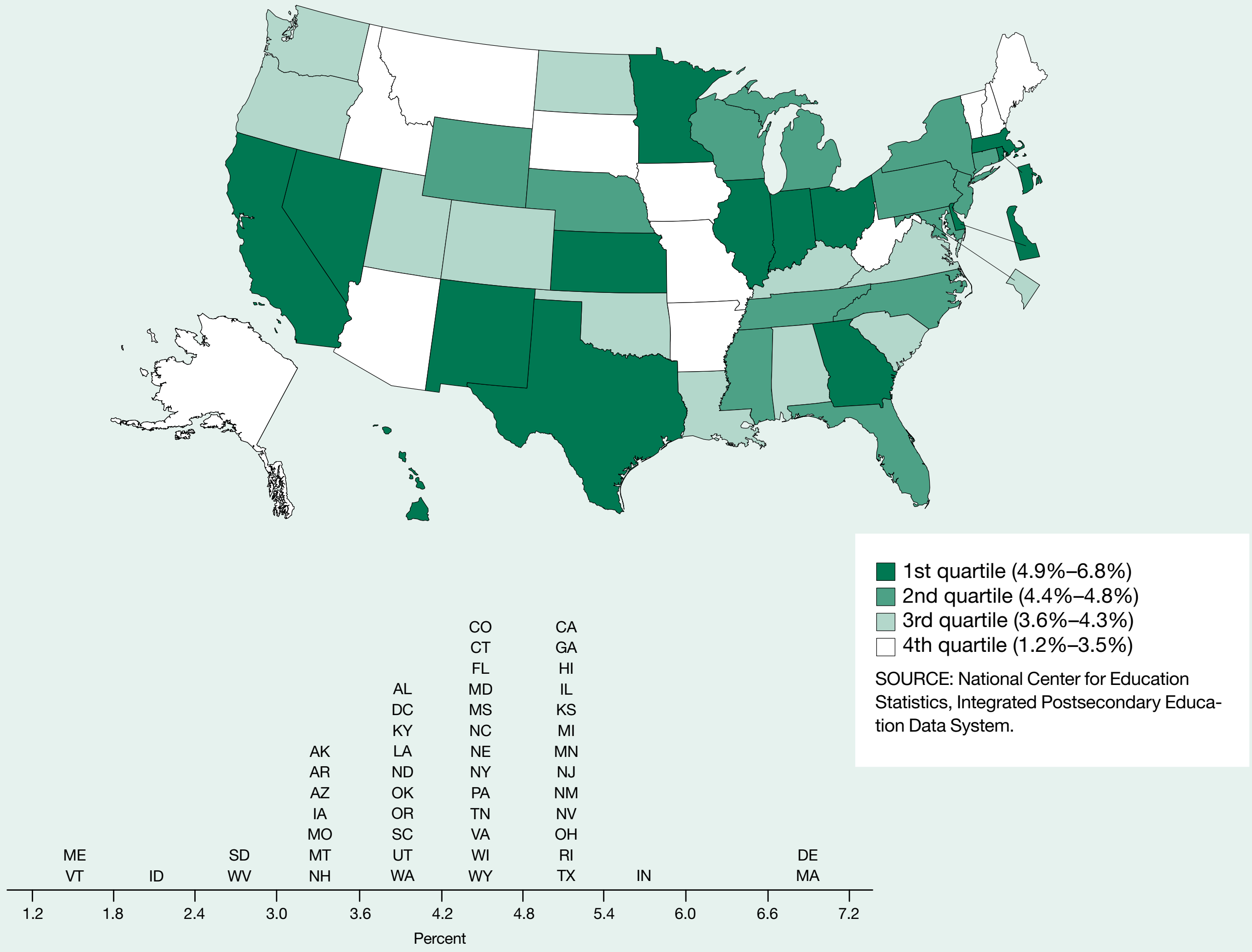
SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2014

Science and Engineering Doctoral Degrees as a Percentage of S&E Degrees Conferred

Figure 8-25

Science and engineering doctoral degrees as a percentage of S&E degrees conferred: 2011



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- The number of S&E doctoral degrees awarded nationwide rose from 25,000 in 2001 to 34,000 in 2011, an increase of 34%. California showed the largest increase in the number of S&E doctorates awarded during this period.
- Nationally, the percentage of S&E degrees awarded that were doctoral degrees has declined from 4.9% in 2001 to 4.6% in 2011.
- In 2011, the value of this indicator for individual states ranged from a low of 1.2% to a high of 6.8%.
- In states with a small number of S&E graduate programs, the number of S&E doctoral degrees awarded varies considerably from year to year. Readers should use caution when making annual comparisons for those states with small numbers of S&E doctorates.

This indicator represents the extent to which a state's higher education programs in S&E are focused on producing individuals with the highest level of technical expertise. The academic and technical leaders of the future are often drawn from individuals receiving S&E doctoral degrees. S&E fields include the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Total S&E degrees conferred include bachelor's, master's, and doctoral degrees but exclude associate's degrees.

The indicator value is computed by dividing the number of doctoral degrees awarded in S&E fields by the total number of S&E degrees awarded by the higher education institutions within the state. The number of degrees are counts provided by the National Center for Education Statistics.

Table 8-25

Science and engineering doctoral degrees as a percentage of S&E degrees conferred, by state: 2001, 2006, and 2011

	S&E doctoral degrees			S&E degrees conferred			S&E doctoral/S&E degrees conferred (%)		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	25,352	30,291	34,045	520,476	625,163	733,609	4.9	4.8	4.6
Alabama	268	309	367	7,489	8,313	9,933	3.6	3.7	3.7
Alaska	22	18	29	604	719	921	3.6	2.5	3.1
Arizona	392	514	626	6,800	10,072	18,154	5.8	5.1	3.4
Arkansas	61	106	127	2,844	3,235	4,121	2.1	3.3	3.1
California	3,664	4,365	4,805	63,360	80,172	91,643	5.8	5.4	5.2
Colorado	511	546	647	11,606	14,320	15,209	4.4	3.8	4.3
Connecticut	370	453	457	6,929	8,341	9,790	5.3	5.4	4.7
Delaware	108	135	170	1,868	2,216	2,512	5.8	6.1	6.8
District of Columbia	306	363	321	6,870	8,294	7,743	4.5	4.4	4.1
Florida	838	1,211	1,466	18,843	25,887	32,260	4.4	4.7	4.5
Georgia	607	819	901	12,083	14,677	17,367	5.0	5.6	5.2
Hawaii	141	110	136	2,227	2,531	2,594	6.3	4.3	5.2
Idaho	50	72	68	1,756	2,661	2,942	2.8	2.7	2.3
Illinois	1,528	1,603	1,541	22,867	27,863	30,855	6.7	5.8	5.0
Indiana	621	700	848	11,188	13,241	15,768	5.6	5.3	5.4
Iowa	322	373	442	6,389	7,413	13,296	5.0	5.0	3.3
Kansas	236	247	302	5,576	5,872	6,012	4.2	4.2	5.0
Kentucky	174	254	264	5,015	6,317	6,883	3.5	4.0	3.8
Louisiana	317	289	309	6,908	7,282	7,562	4.6	4.0	4.1
Maine	30	27	44	2,236	2,625	3,103	1.3	1.0	1.4
Maryland	604	791	822	12,710	15,870	18,039	4.8	5.0	4.6
Massachusetts	1,436	1,689	1,909	22,843	25,439	28,989	6.3	6.6	6.6
Michigan	868	1,060	1,132	18,618	21,124	23,488	4.7	5.0	4.8
Minnesota	531	705	847	9,319	12,388	15,853	5.7	5.7	5.3
Mississippi	115	142	201	3,472	3,618	4,278	3.3	3.9	4.7
Missouri	412	512	496	11,306	12,690	14,323	3.6	4.0	3.5
Montana	39	66	80	2,076	2,189	2,313	1.9	3.0	3.5
Nebraska	131	136	195	3,261	3,892	4,478	4.0	3.5	4.4
Nevada	50	93	138	1,279	2,378	2,814	3.9	3.9	4.9
New Hampshire	111	129	126	3,082	3,520	4,047	3.6	3.7	3.1
New Jersey	652	708	835	13,842	15,603	17,439	4.7	4.5	4.8
New Mexico	134	181	165	2,558	3,164	3,339	5.2	5.7	4.9
New York	2,157	2,495	2,730	44,628	51,277	59,701	4.8	4.9	4.6
North Carolina	665	805	974	14,543	16,541	20,896	4.6	4.9	4.7
North Dakota	43	45	68	1,397	1,522	1,743	3.1	3.0	3.9
Ohio	1,023	1,138	1,167	18,238	20,505	23,094	5.6	5.5	5.1
Oklahoma	198	195	239	5,914	6,243	6,503	3.3	3.1	3.7
Oregon	298	320	324	6,473	8,004	8,767	4.6	4.0	3.7
Pennsylvania	1,143	1,551	1,724	26,514	32,358	37,253	4.3	4.8	4.6
Rhode Island	168	223	207	2,872	3,649	4,077	5.8	6.1	5.1
South Carolina	205	231	294	6,052	6,997	8,223	3.4	3.3	3.6
South Dakota	31	38	55	1,775	2,030	2,153	1.7	1.9	2.6
Tennessee	351	395	486	7,787	8,752	10,243	4.5	4.5	4.7
Texas	1,500	1,845	2,228	28,242	35,293	42,413	5.3	5.2	5.3
Utah	197	225	348	6,151	8,075	9,399	3.2	2.8	3.7
Vermont	52	49	40	2,153	2,576	3,343	2.4	1.9	1.2
Virginia	667	787	984	15,823	18,582	23,672	4.2	4.2	4.2
Washington	422	525	578	10,011	12,592	14,269	4.2	4.2	4.1
West Virginia	56	102	122	2,699	3,056	5,050	2.1	3.3	2.4
Wisconsin	494	559	618	10,549	12,328	13,761	4.7	4.5	4.5
Wyoming	33	37	43	831	857	981	4.0	4.3	4.4
Puerto Rico	101	161	160	4,847	4,992	5,437	2.1	3.2	2.9

NOTES: S&E degrees conferred include bachelor's, master's, and doctorate. S&E degrees include physical, computer, agricultural, biological, earth, atmospheric, ocean, and social sciences; psychology; mathematics; and engineering.

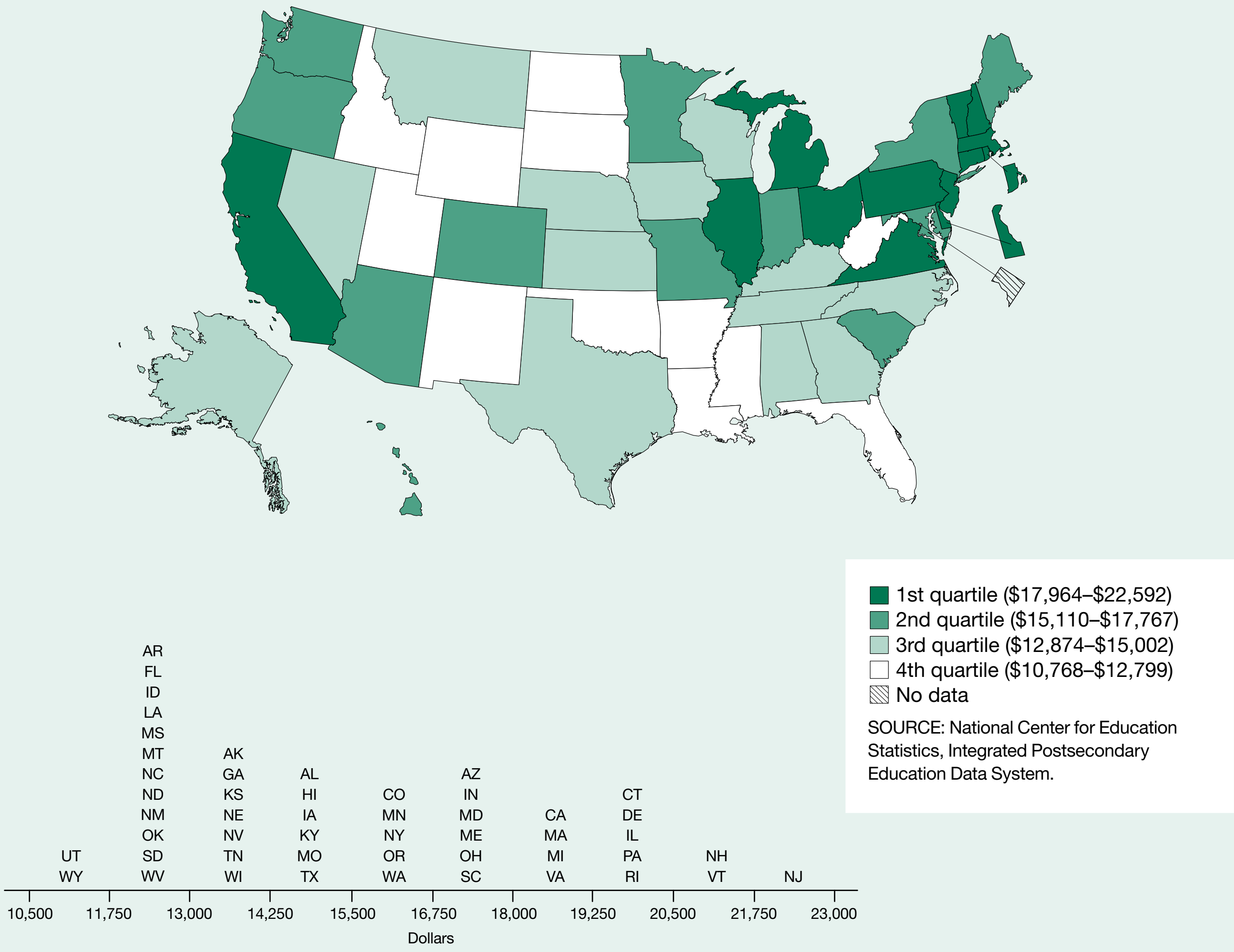
SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2014

Average Undergraduate Charge at Public 4-Year Institutions

Figure 8-26

Average undergraduate charge at public 4-year institutions: 2011



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- During 2011, the total annual nominal charge for a full-time undergraduate student to attend a public 4-year institution averaged $15,918 nationally, an increase of 84% since 2001. This was equivalent to an increase of approximately 47% after adjusting for inflation.
- All states showed major increases in undergraduate charges at public institutions from 2001 to 2011. In several states, undergraduate charges more than doubled during this period.
- In 2011, the state average for a year of undergraduate education at a public 4-year institution ranged from a low of $10,768 to a high of $22,592.
- Tuition and required fees averaged 47% of the total charges at public 4-year institutions in 2011, but individual states had different cost structures.

The average annual charge for an undergraduate student to attend a public 4-year academic institution is one indicator of how accessible higher education is to a state's students. The annual charge includes standard in-state charges for tuition, required fees, room, and board for a full-time undergraduate student who is a resident of that state. These charges were weighted by the number of full-time undergraduates attending each public institution within the state. The total charge for all public 4-year institutions in the state was divided by the total number of full-time undergraduates attending all public 4-year institutions in the state. The year is the end date of the academic year. For example, data for 2011 represent costs for the 2010–11 academic year.

To improve educational attainment, the federal government, state governments, and academic institutions provide various kinds of financial aid that reduce the charge to students. The data in this indicator do not include any adjustments for such financial aid.

Table 8-26

Average undergraduate charge at public 4-year institutions, by state: 2001, 2006, and 2011

(Dollars)

State	2001	2006	2011
United States	8,653	12,108	15,918
Alabama	7,349	9,625	14,416
Alaska	8,390	10,620	14,053
Arizona	7,874	11,480	17,083
Arkansas	6,797	9,192	12,580
California	9,590	13,685	18,933
Colorado	8,362	11,569	16,208
Connecticut	10,521	14,658	19,400
Delaware	10,283	14,326	19,541
District of Columbia	NA	NA	NA
Florida	7,947	10,141	12,774
Georgia	7,463	10,062	14,019
Hawaii	8,272	9,042	15,133
Idaho	6,765	8,982	11,773
Illinois	9,532	13,976	20,054
Indiana	9,239	12,388	16,912
Iowa	7,587	12,329	14,855
Kansas	6,654	9,980	13,229
Kentucky	6,923	10,663	15,002
Louisiana	6,329	8,506	11,856
Maine	9,371	12,568	17,767
Maryland	10,834	14,793	16,963
Massachusetts	9,207	14,651	19,164
Michigan	9,825	13,693	18,333
Minnesota	8,127	12,777	16,385
Mississippi	7,195	9,461	12,051
Missouri	8,203	11,861	15,110
Montana	7,615	10,613	12,891
Nebraska	7,355	11,286	14,081
Nevada	8,247	10,865	14,172
New Hampshire	11,720	15,479	21,481
New Jersey	12,007	17,708	22,592
New Mexico	7,086	9,579	12,520
New York	10,260	13,275	16,606
North Carolina	7,076	9,675	12,874
North Dakota	6,418	9,829	12,503
Ohio	10,451	16,032	17,964
Oklahoma	6,022	9,404	11,938
Oregon	9,394	12,720	16,402
Pennsylvania	11,091	15,464	19,916
Rhode Island	11,095	14,315	19,815
South Carolina	9,096	13,145	17,641
South Dakota	6,975	9,493	12,603
Tennessee	7,658	9,956	13,759
Texas	7,614	10,973	14,585
Utah	6,598	8,745	10,768
Vermont	12,847	16,571	21,530
Virginia	8,751	12,279	18,110
Washington	8,909	12,384	16,253
West Virginia	7,290	9,992	12,799
Wisconsin	7,396	10,560	13,819
Wyoming	7,017	8,946	11,467
Puerto Rico	NA	NA	NA

NA = not available.

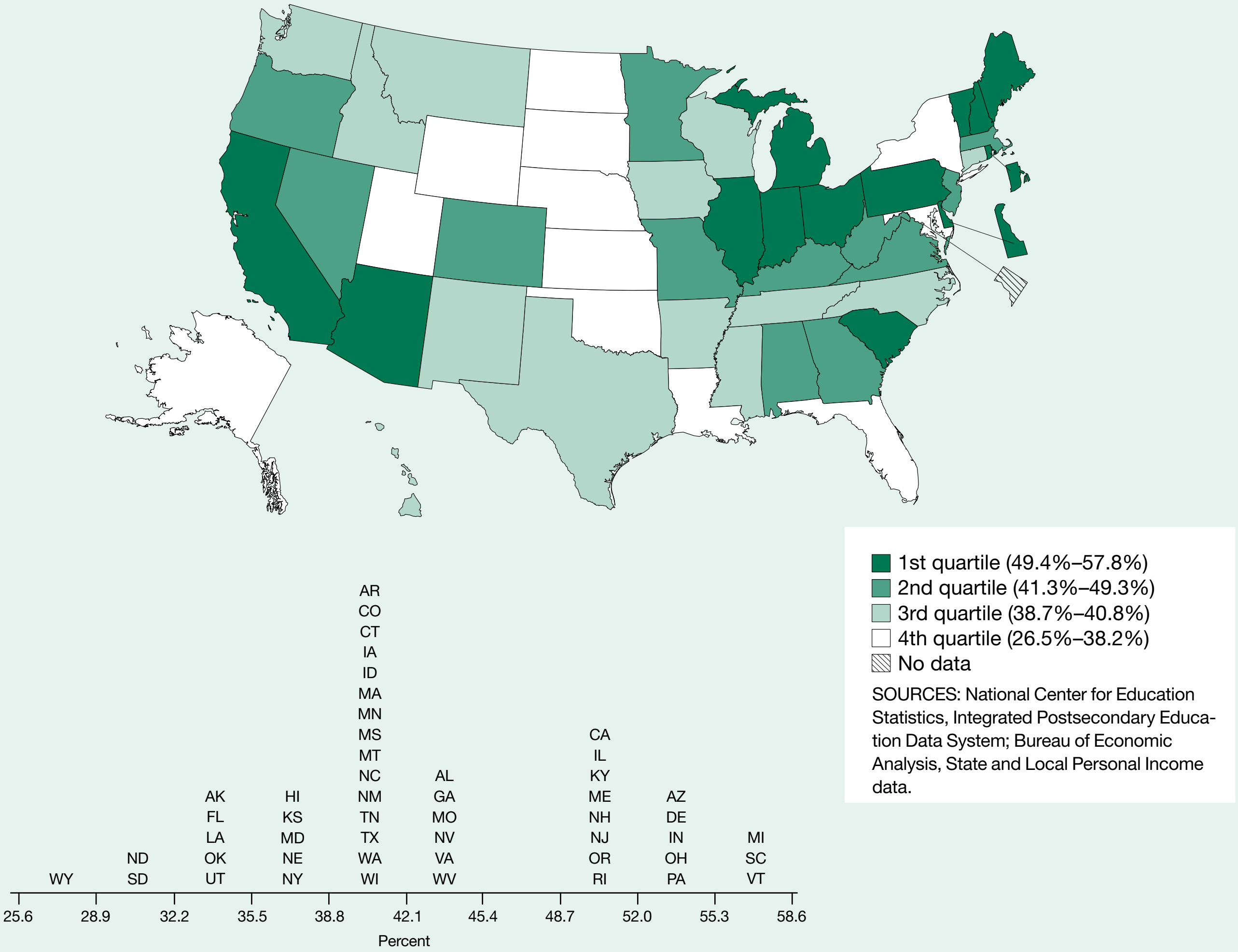
NOTES: The national average for the United States is from the *Digest of Education Statistics*. Average charges are for full-time equivalent students but are not adjusted for student residency. Average charges include tuition, fees, room, and board.

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2014

Average Undergraduate Charge at Public 4-Year Institutions as a Percentage of Disposable Personal Income

Figure 8-27
Average undergraduate charge at public 4-year institutions as a percentage of disposable personal income: 2011



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Bureau of Economic Analysis, State and Local Personal Income data.

Findings

- In 2011, a year of undergraduate education at a state institution would have consumed, on average, 42.9% of a resident's disposable income, an increase from the 32.3% it would have consumed in 2001.
- The cost of a year of undergraduate education at a public institution exceeded 50% of the per capita disposable income for residents of 12 states in 2011.
- All states showed an increase in this indicator between 2001 and 2011.
- Residents in 26 states experienced major increases in the cost of a year of undergraduate education relative to their purchasing power (in excess of 10 percentage points of their per capita disposable income) between 2001 and 2011.

This indicator represents a broad measure of how affordable higher education at a public institution is for the average resident. It is calculated by dividing the average undergraduate charge at all public 4-year institutions in the state by the per capita disposable personal income of state residents. The average undergraduate charge includes standard in-state tuition, room, board, and required fees for a student who is a resident of the state. The year is the end date of the academic year. For example, data for 2011 represent costs for the 2010–11 academic year.

Disposable personal income is the income available to state residents for spending or saving. It is calculated as personal income minus personal current taxes paid to federal, state, and local governments. High values indicate that a year of undergraduate education consumes a high percentage of the disposable personal income of state residents. However, the data in this indicator do not include any adjustment for financial aid that a student might receive.

Table 8-27

Average undergraduate charge at public 4-year institutions as a percentage of disposable personal income, by state: 2001, 2006, and 2011

	Average undergraduate charge ($)			Per capita disposable personal income ($)			Undergraduate charge/ disposable personal income (%)		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	8,653	12,108	15,918	26,828	33,197	37,078	32.3	36.5	42.9
Alabama	7,349	9,625	14,416	22,353	28,054	31,854	32.9	34.3	45.3
Alaska	8,390	10,620	14,053	28,711	35,380	41,420	29.2	30.0	33.9
Arizona	7,874	11,480	17,083	23,815	30,557	32,015	33.1	37.6	53.4
Arkansas	6,797	9,192	12,580	21,291	26,627	30,819	31.9	34.5	40.8
California	9,590	13,685	18,933	28,526	36,042	38,308	33.6	38.0	49.4
Colorado	8,362	11,569	16,208	30,455	36,194	39,221	27.5	32.0	41.3
Connecticut	10,521	14,658	19,400	35,266	43,728	48,873	29.8	33.5	39.7
Delaware	10,283	14,326	19,541	27,520	33,875	36,721	37.4	42.3	53.2
District of Columbia	NA	NA	NA	38,342	52,769	65,233	NA	NA	NA
Florida	7,947	10,141	12,774	26,158	33,847	36,173	30.4	30.0	35.3
Georgia	7,463	10,062	14,019	25,438	30,144	32,430	29.3	33.4	43.2
Hawaii	8,272	9,042	15,133	25,706	33,249	39,073	32.2	27.2	38.7
Idaho	6,765	8,982	11,773	22,558	28,045	30,111	30.0	32.0	39.1
Illinois	9,532	13,976	20,054	28,564	35,081	38,797	33.4	39.8	51.7
Indiana	9,239	12,388	16,912	24,560	29,146	32,199	37.6	42.5	52.5
Iowa	7,587	12,329	14,855	24,736	30,320	37,406	30.7	40.7	39.7
Kansas	6,654	9,980	13,229	26,012	31,761	36,807	25.6	31.4	35.9
Kentucky	6,923	10,663	15,002	22,221	26,894	30,758	31.2	39.6	48.8
Louisiana	6,329	8,506	11,856	22,635	30,118	35,308	28.0	28.2	33.6
Maine	9,371	12,568	17,767	24,610	29,915	34,713	38.1	42.0	51.2
Maryland	10,834	14,793	16,963	30,640	38,686	44,404	35.4	38.2	38.2
Massachusetts	9,207	14,651	19,164	32,414	40,663	45,960	28.4	36.0	41.7
Michigan	9,825	13,693	18,333	26,080	29,830	32,651	37.7	45.9	56.1
Minnesota	8,127	12,777	16,385	28,570	34,831	39,257	28.4	36.7	41.7
Mississippi	7,195	9,461	12,051	20,699	25,681	29,514	34.8	36.8	40.8
Missouri	8,203	11,861	15,110	25,010	30,394	34,383	32.8	39.0	43.9
Montana	7,615	10,613	12,891	22,509	28,655	32,618	33.8	37.0	39.5
Nebraska	7,355	11,286	14,081	26,293	31,715	38,457	28.0	35.6	36.6
Nevada	8,247	10,865	14,172	27,199	34,314	33,536	30.3	31.7	42.3
New Hampshire	11,720	15,479	21,481	30,157	36,822	41,472	38.9	42.0	51.8
New Jersey	12,007	17,708	22,592	33,318	41,046	45,850	36.0	43.1	49.3
New Mexico	7,086	9,579	12,520	22,162	27,241	31,392	32.0	35.2	39.9
New York	10,260	13,275	16,606	29,031	37,417	43,524	35.3	35.5	38.2
North Carolina	7,076	9,675	12,874	24,715	29,553	32,505	28.6	32.7	39.6
North Dakota	6,418	9,829	12,503	23,915	29,891	42,492	26.8	32.9	29.4
Ohio	10,451	16,032	17,964	25,361	30,027	33,943	41.2	53.4	52.9
Oklahoma	6,022	9,404	11,938	23,198	29,555	34,327	26.0	31.8	34.8
Oregon	9,394	12,720	16,402	25,252	30,299	33,361	37.2	42.0	49.2
Pennsylvania	11,091	15,464	19,916	26,546	32,603	37,647	41.8	47.4	52.9
Rhode Island	11,095	14,315	19,815	26,918	33,819	39,383	41.2	42.3	50.3
South Carolina	9,096	13,145	17,641	22,722	27,646	30,528	40.0	47.5	57.8
South Dakota	6,975	9,493	12,603	25,253	31,024	41,133	27.6	30.6	30.6
Tennessee	7,658	9,956	13,759	24,845	30,026	33,954	30.8	33.2	40.5
Texas	7,614	10,973	14,585	25,867	31,844	36,631	29.4	34.5	39.8
Utah	6,598	8,745	10,768	22,576	27,468	30,405	29.2	31.8	35.4
Vermont	12,847	16,571	21,530	25,754	31,946	37,714	49.9	51.9	57.1
Virginia	8,751	12,279	18,110	28,302	35,857	40,608	30.9	34.2	44.6
Washington	8,909	12,384	16,253	28,868	35,545	39,960	30.9	34.8	40.7
West Virginia	7,290	9,992	12,799	21,093	25,747	30,369	34.6	38.8	42.1
Wisconsin	7,396	10,560	13,819	26,038	31,404	35,359	28.4	33.6	39.1
Wyoming	7,017	8,946	11,467	27,278	38,553	43,194	25.7	23.2	26.5
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available.

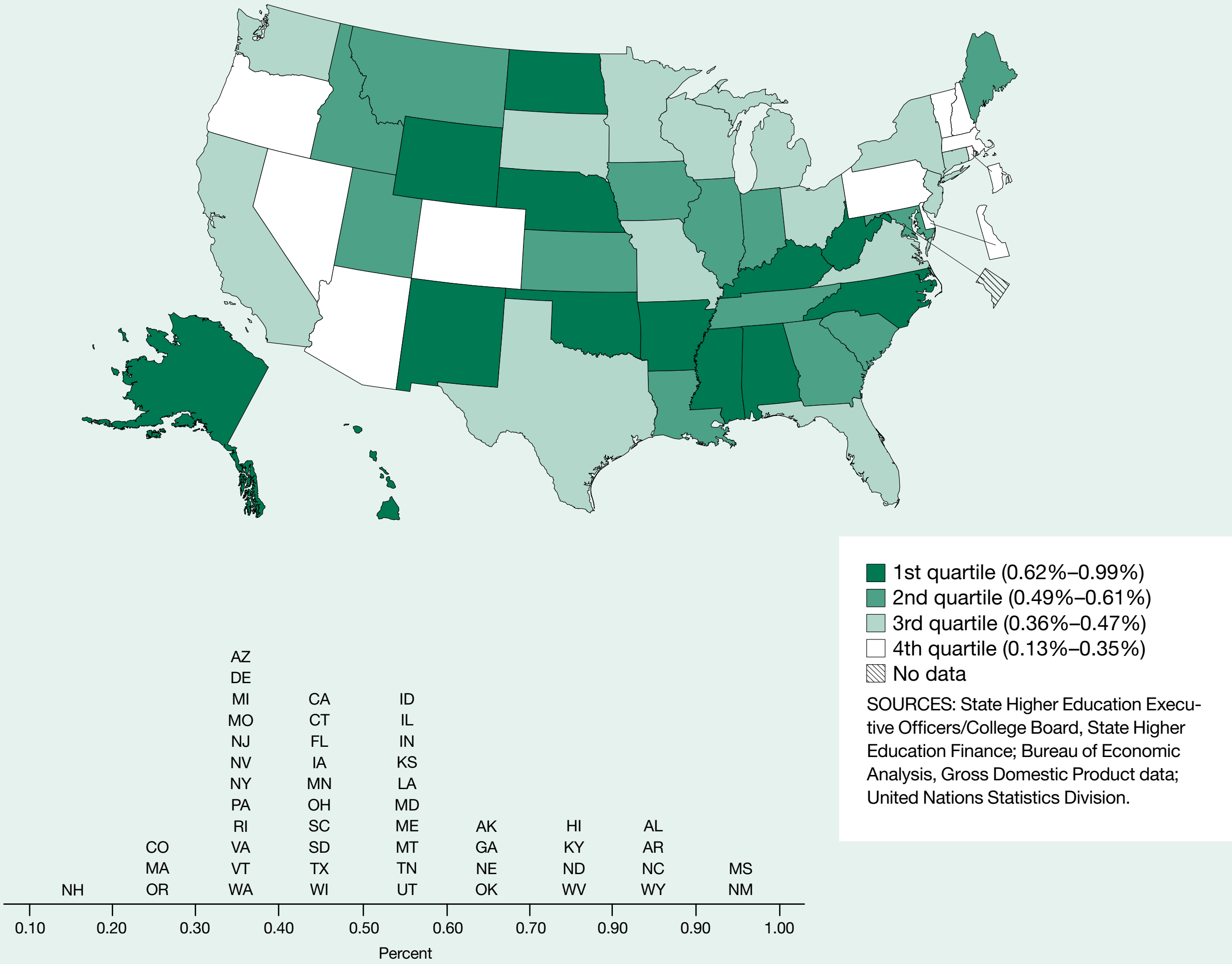
NOTES: The national average for the United States is from the *Digest of Education Statistics*. Average charges are for full-time equivalent students but are not adjusted for student residency. Average charges include tuition, fees, room, and board.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Bureau of Economic Analysis, State and Local Personal Income data.

Science and Engineering Indicators 2014

Appropriations of State Tax Funds for Operating Expenses of Higher Education as a Percentage of Gross Domestic Product

Figure 8-28
Appropriations of state tax funds for operating expenses of higher education as a percentage of gross domestic product: 2012



SOURCES: State Higher Education Executive Officers/College Board, State Higher Education Finance; Bureau of Economic Analysis, Gross Domestic Product data; United Nations Statistics Division.

Findings

- Nationally, state appropriations for operating expenses of higher education as a share of the state's gross domestic product (GDP) decreased from 0.53% in 2004 to 0.46% in 2012.
- In 2012, the value of this indicator ranged from 0.13% to 0.99% across the states.
- Between 2004 and 2012, 38 states increased their appropriations for higher education. The states that showed the largest increase in appropriations of state tax funds for the operating expenses of higher education were North Carolina, New York, Texas, and Illinois.
- While many states reduced the percentage of their GDP that was allocated to higher education, the states of North Carolina and Alaska made significant increases between 2004 and 2012.

This indicator represents the extent of state spending for higher education operating expenses as a proportion of its GDP. A higher value on this indicator indicates that a state has made financial support of its higher education system more of a priority.

Because of decreases in state tax collections in FY 2009–11, state monies allocated to higher education decreased in many states. This decrease was offset to a degree by federal stimulus funds that were used to restore the level of state support for public higher education. The state monies used to calculate this indicator do not include federal stimulus funds for education stabilization or government funds for the modernization, renovation, or repair of higher education facilities.

Table 8-28

Appropriations of state tax funds for operating expenses of higher education as a percentage of gross domestic product, by state: 2004, 2008, and 2012

	Appropriations of state tax funds for operating expenses of higher education ($millions)			State GDP ($millions)			Appropriations of state tax funds for operating expenses of higher education/state GDP (%)		
State	2004	2008	2012	2004	2008	2012	2004	2008	2012
United States	62,375	80,698	72,220	11,774,408	14,193,121	15,566,076	0.53	0.57	0.46
Alabama	1,168	1,962	1,495	141,974	170,203	183,547	0.82	1.15	0.81
Alaska	216	299	357	34,367	49,809	51,859	0.63	0.60	0.69
Arizona	922	1,326	824	201,006	261,128	266,891	0.46	0.51	0.31
Arkansas	661	880	904	83,806	100,369	109,557	0.79	0.88	0.83
California	8,715	11,634	9,379	1,569,816	1,900,463	2,003,479	0.56	0.61	0.47
Colorado	578	747	647	201,564	252,487	274,048	0.29	0.30	0.24
Connecticut	748	1,034	950	187,545	219,449	229,317	0.40	0.47	0.41
Delaware	191	243	213	50,575	57,974	65,984	0.38	0.42	0.32
District of Columbia	NA	NA	NA	77,737	96,792	109,793	NA	NA	NA
Florida	3,285	4,449	3,631	621,417	748,117	777,164	0.53	0.59	0.47
Georgia	2,356	2,960	2,635	342,863	404,335	433,569	0.69	0.73	0.61
Hawaii	399	554	512	52,290	65,978	72,424	0.76	0.84	0.71
Idaho	340	411	334	44,069	55,143	58,243	0.77	0.75	0.57
Illinois	2,682	2,949	3,594	545,591	631,962	695,238	0.49	0.47	0.52
Indiana	1,360	1,525	1,549	231,762	260,971	298,625	0.59	0.58	0.52
Iowa	738	874	740	115,581	133,910	152,436	0.64	0.65	0.49
Kansas	686	826	740	99,733	124,330	138,953	0.69	0.66	0.53
Kentucky	1,109	1,321	1,238	131,701	153,570	173,466	0.84	0.86	0.71
Louisiana	1,245	1,708	1,237	171,461	213,970	243,264	0.73	0.80	0.51
Maine	232	271	269	44,352	49,500	53,656	0.52	0.55	0.50
Maryland	1,149	1,555	1,613	231,963	281,112	317,678	0.50	0.55	0.51
Massachusetts	915	1,347	1,158	310,341	361,716	403,823	0.29	0.37	0.29
Michigan	1,984	2,034	1,548	365,609	368,963	400,504	0.54	0.55	0.39
Minnesota	1,286	1,561	1,284	227,091	262,105	294,729	0.57	0.60	0.44
Mississippi	767	1,046	954	77,539	95,461	101,490	0.99	1.10	0.94
Missouri	905	1,022	933	208,375	241,406	258,832	0.43	0.42	0.36
Montana	151	197	202	27,831	35,802	40,422	0.54	0.55	0.50
Nebraska	509	657	650	69,572	85,181	99,557	0.73	0.77	0.65
Nevada	480	620	473	100,663	131,976	133,584	0.48	0.47	0.35
New Hampshire	112	133	83	51,335	58,473	64,697	0.22	0.23	0.13
New Jersey	1,741	2,045	1,998	410,790	482,099	508,003	0.42	0.42	0.39
New Mexico	710	1,016	799	64,196	77,117	80,600	1.11	1.32	0.99
New York	3,313	4,853	4,719	891,462	1,079,719	1,205,930	0.37	0.45	0.39
North Carolina	2,475	3,837	3,915	327,343	407,360	455,973	0.76	0.94	0.86
North Dakota	200	254	344	23,333	31,769	46,016	0.86	0.80	0.75
Ohio	2,072	2,288	2,014	428,172	465,527	509,393	0.48	0.49	0.40
Oklahoma	766	1,099	998	112,298	153,223	160,953	0.68	0.72	0.62
Oregon	589	726	566	137,290	174,990	198,702	0.43	0.41	0.28
Pennsylvania	1,947	2,193	1,801	461,721	544,712	600,897	0.42	0.40	0.30
Rhode Island	184	191	161	42,925	47,231	50,956	0.43	0.40	0.32
South Carolina	926	1,211	859	134,793	159,203	176,217	0.69	0.76	0.49
South Dakota	154	199	181	30,569	37,266	42,464	0.50	0.53	0.43
Tennessee	1,090	1,640	1,415	213,537	247,961	277,036	0.51	0.66	0.51
Texas	5,190	6,348	6,464	903,679	1,209,267	1,397,369	0.57	0.52	0.46
Utah	614	812	729	82,463	113,789	130,486	0.74	0.71	0.56
Vermont	77	91	90	21,876	24,445	27,296	0.35	0.37	0.33
Virginia	1,346	1,886	1,624	329,557	397,894	445,876	0.41	0.47	0.36
Washington	1,361	1,768	1,362	257,979	333,720	375,730	0.53	0.53	0.36
West Virginia	405	562	543	48,691	58,227	69,380	0.83	0.97	0.78
Wisconsin	1,125	1,243	1,154	208,904	236,094	261,548	0.54	0.53	0.44
Wyoming	201	291	338	23,301	38,853	38,422	0.86	0.75	0.88
Puerto Rico	NA	NA	NA	82,809	95,708	NA	NA	NA	NA

NA = not available.

GDP = gross domestic product.

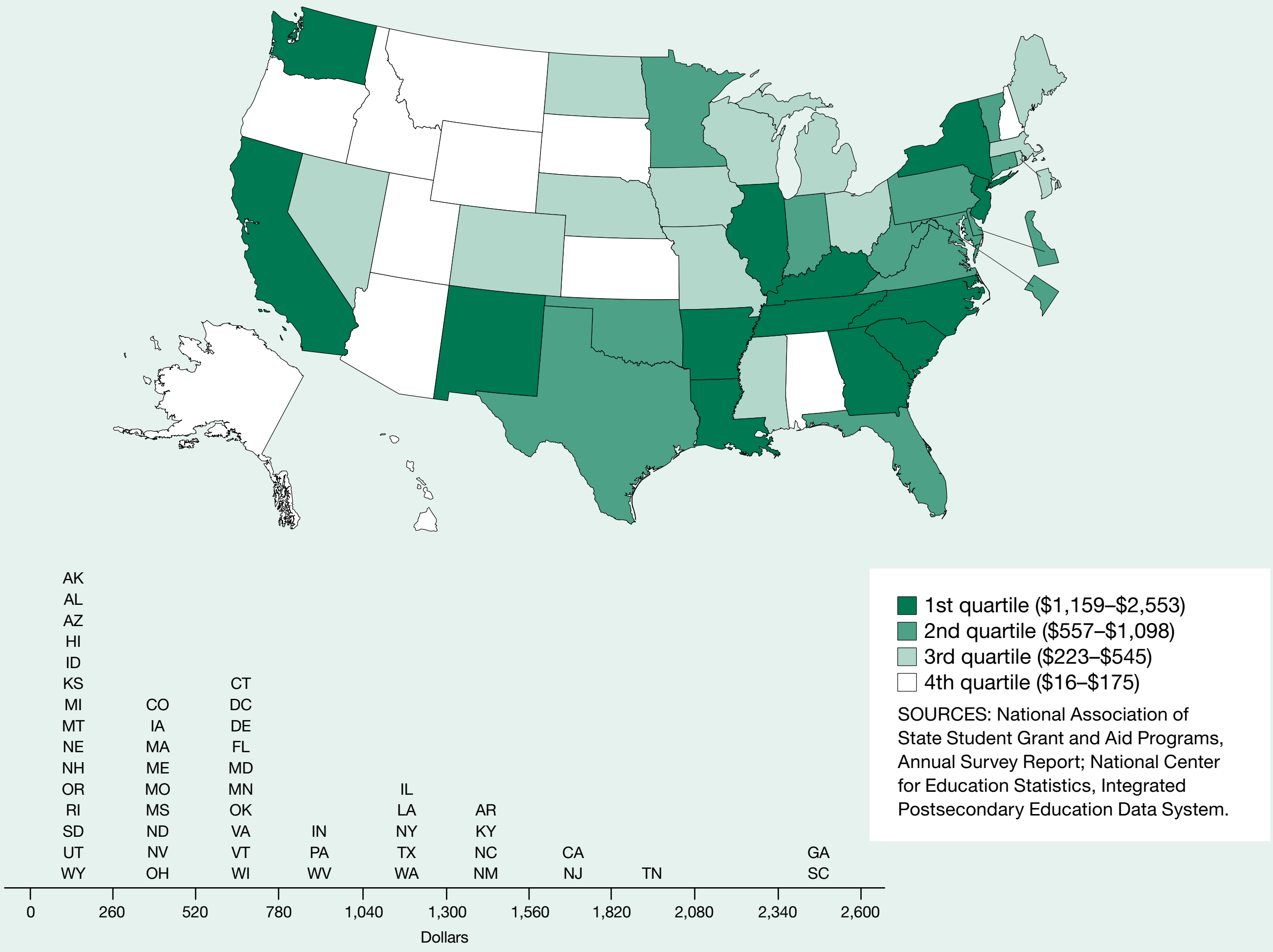
SOURCES: State Higher Education Executive Officers College Board, State Higher Education Finance (various years); Bureau of Economic Analysis, Gross Domestic Product data (June 2013).

Science and Engineering Indicators 2014

State Expenditures on Student Aid per Full-Time Undergraduate Student

Figure 8-29

State expenditures on student aid per full-time undergraduate student: 2011



SOURCES: National Association of State Student Grant and Aid Programs, Annual Survey Report; National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- The total amount of state financial aid from grants provided to undergraduates doubled nationwide, increasing from $4.6 billion in 2001 to $9.1 billion in 2011.
- On a per-student basis, state funding for student grants across the United States increased from $613 per undergraduate in 2001 to $858 per undergraduate in 2011.
- There are major differences in the amount of state aid provided to undergraduate students in different states. State values for this indicator ranged from $16 to $2,553 in 2011. Seven jurisdictions averaged less than $100 per undergraduate student, while 14 provided more than $1,000 per student.
- Eleven states reported spending less per student for student financial aid in 2011 than in 2001, even though the cost of undergraduate education rose rapidly during this period.

The cost of an undergraduate education can be reduced with financial assistance from the state or federal government or from an academic institution. This indicator is calculated by dividing the amount of financial support from state grants by the number of full-time undergraduate students who attend both public and private institutions in the state. A high value is one indicator of state efforts to provide access to higher education at a time of escalating undergraduate costs. The actual distribution of state grants to individual students may be affected by the percentage of undergraduates who are state residents.

This indicator should be viewed relative to the tuition charged to undergraduates in a state, as some states have chosen to subsidize tuition for all students at public institutions rather than provide grants. Other differences between states, such as the amount of scholarship aid available from other sources, the percentage of students attending out-of-state institutions, and their eligibility for state funding, mean that readers should exercise caution when making comparisons between states and examining changes over time.

Total state grant expenditures for financial aid include need-based and non–need-based grants. State assistance through subsidized or unsubsidized loans and awards to students at the graduate and first professional degree levels is not included. The year is the end date of the academic year. For example, data for 2011 represent costs for the 2010–11 academic year.

Table 8-29

State expenditures on student aid per full-time undergraduate student, by state: 2001, 2006, and 2011

	State expenditures on student aid ($thousands)			Undergraduate enrollment at 4-year institutions			State expenditures on student aid/ undergraduate enrollment at 4-year institutions ($)		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	4,565,162	6,789,273	9,052,204	7,450,520	8,653,820	10,547,386	613	785	858
Alabama	7,413	7,626	19,193	127,475	143,386	176,759	58	53	109
Alaska	NA	502	1,514	24,939	26,382	30,749	NA	19	49
Arizona	2,990	2,798	19,932	124,389	262,642	433,785	24	11	46
Arkansas	39,151	28,364	146,496	73,369	82,437	97,013	534	344	1,510
California	461,914	757,809	1,269,917	636,105	714,347	809,090	726	1,061	1,570
Colorado	54,151	60,737	70,970	138,846	168,860	196,643	390	360	361
Connecticut	44,763	39,366	63,611	87,335	93,832	106,932	513	420	595
Delaware	1,432	10,240	19,435	28,125	28,268	31,640	51	362	614
District of Columbia	781	33,856	34,713	52,262	65,318	48,459	15	518	716
Florida	302,633	410,758	577,736	310,145	504,557	884,228	976	814	653
Georgia	310,995	461,615	768,449	198,254	236,664	322,458	1,569	1,951	2,383
Hawaii	535	410	3,339	27,637	33,963	38,071	19	12	88
Idaho	1,138	5,424	5,064	50,969	57,505	65,074	22	94	78
Illinois	382,566	380,349	407,825	281,619	330,331	351,725	1,358	1,151	1,159
Indiana	111,618	182,281	251,254	222,510	243,669	288,387	502	748	871
Iowa	53,100	53,815	57,848	99,468	127,886	221,384	534	421	261
Kansas	12,819	15,168	17,590	86,126	92,962	100,750	149	163	175
Kentucky	66,931	172,866	193,206	112,935	127,630	146,072	593	1,354	1,323
Louisiana	91,166	116,432	178,753	146,230	141,348	144,475	623	824	1,237
Maine	11,961	13,387	15,230	43,082	44,270	43,972	278	302	346
Maryland	50,416	76,362	90,535	122,430	135,317	155,690	412	564	582
Massachusetts	116,892	80,093	87,823	235,697	246,799	268,140	496	325	328
Michigan	102,164	197,674	85,612	295,912	320,345	341,985	345	617	250
Minnesota	120,465	131,010	130,073	152,381	170,616	203,079	791	768	641
Mississippi	20,163	22,285	22,198	62,595	65,791	75,152	322	339	295
Missouri	43,882	42,068	90,774	182,463	212,159	254,357	240	198	357
Montana	3,195	3,760	5,877	33,462	33,677	39,110	95	112	150
Nebraska	5,975	9,918	15,671	59,388	63,983	70,231	101	155	223
Nevada	13,449	39,671	47,838	34,274	81,180	93,013	392	489	514
New Hampshire	1,497	3,753	2,967	42,534	44,860	48,794	35	84	61
New Jersey	197,619	256,047	333,404	161,329	171,282	201,059	1,225	1,495	1,658
New Mexico	38,736	61,780	89,254	43,285	50,546	59,125	895	1,222	1,510
New York	659,394	895,129	896,266	581,671	624,730	712,725	1,134	1,433	1,258
North Carolina	121,153	192,018	378,366	196,748	230,576	259,914	616	833	1,456
North Dakota	1,152	1,864	12,198	29,951	34,017	41,423	38	55	294
Ohio	173,868	221,411	109,731	309,285	337,332	412,936	562	656	266
Oklahoma	29,035	58,216	92,122	102,808	114,011	128,649	282	511	716
Oregon	19,711	29,429	19,287	80,385	91,031	112,271	245	323	172
Pennsylvania	325,234	403,957	368,459	386,220	423,915	457,606	842	953	805
Rhode Island	6,164	12,883	13,170	50,452	54,189	56,056	122	238	235
South Carolina	98,095	255,744	325,348	95,652	105,408	127,415	1,026	2,426	2,553
South Dakota	NA	3,367	4,418	33,125	37,090	42,527	NA	91	104
Tennessee	30,156	173,907	353,309	142,697	162,843	192,406	211	1,068	1,836
Texas	108,628	366,873	684,905	449,177	538,069	623,983	242	682	1,098
Utah	2,511	7,409	9,674	128,285	140,967	190,067	20	53	51
Vermont	14,414	17,560	17,328	26,395	28,648	31,116	546	613	557
Virginia	115,242	132,720	188,585	180,228	218,857	285,448	639	606	661
Washington	98,533	173,835	234,238	110,310	128,585	183,650	893	1,352	1,275
West Virginia	18,217	70,981	100,916	69,795	66,302	111,857	261	1,071	902
Wisconsin	71,145	93,583	119,616	170,859	184,922	219,649	416	506	545
Wyoming	NA	163	167	8,907	9,516	10,287	NA	17	16
Puerto Rico	40,231	33,840	53,318	156,795	165,366	181,489	257	205	294

NA = not available.

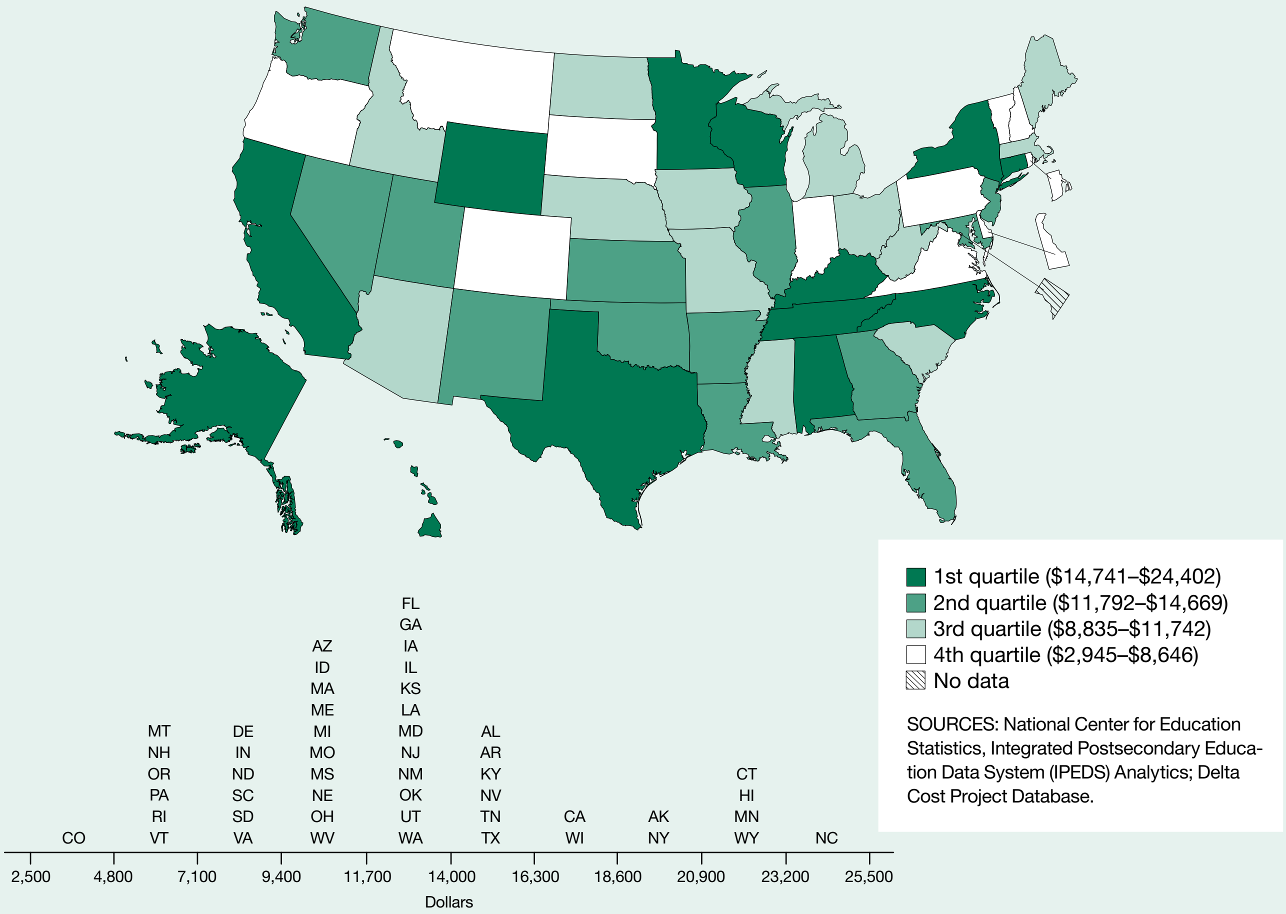
SOURCES: National Association of State Student Grant and Aid Programs, Annual Survey Report (various years); National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2014

State Funding for Public Research Universities per Full-Time Equivalent Student

Figure 8-30

State funding for major public research universities per full-time equivalent student: 2010



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS) Analytics; Delta Cost Project Database.

Findings

- Across the nation, state funding for public research universities and their branch campuses increased from nearly $25 billion in 2000 to nearly $37 billion in 2010. Only two states did not increase their funding for public research universities and their branch campuses during this period.
- When adjusted for inflation, total state expenditures for public research universities increased by 18% between 2000 and 2010, while FTE enrollment increased by over 22%.
- Between 2000 and 2010, per-student state support to public research universities dropped by an average of 3% in inflation-adjusted dollars.

Public research universities rely on state support for a substantial share of their operating revenues, most of which support their education function. The amount of funding provided per full-time equivalent (FTE) student is an indicator of states' investment in the education of their students. Eventually, changes in these funds affect the institutions' financial health and the quality of education they provide.

Data for this indicator cover 101 public research universities with broad educational missions (excluding freestanding medical and engineering schools when possible). These institutions are either the leading recipient of academic R&D funding in their state or among the nation's top 100 recipients of academic R&D funding to public universities in 2008. State funds include state and local operating grants and contracts as well as state appropriations. Enrollment includes total FTE enrollment measured in the fall of each academic year.

Data were drawn from the National Center for Education Statistics Integrated Postsecondary Education Data System (IPEDS) Analytics: Delta Cost Project Database: 2000–2010. To maintain comparability over time, the database groups institutions that included data for branch campuses in their reporting to IPEDS in 1 or more years. Specifically, for 34 institutions in the database, data cover branch campuses with little or no research activity as well as main campuses for which research is central to the university's mission. Comparison between states and analysis of funding trends at the nation's most research-intensive institutions should take this into account.

State funds are one of many sources of public university revenue. This indicator does not include changes in these other revenue sources.

Table 8-30

State funding for public research universities per full-time equivalent student, by state: 2000, 2005, and 2010

State	State funding for major public research universities ($thousands) 2000	2005	2010	FTE enrolled students 2000	2005	2010	State funding for public research universities/ FTE enrolled student ($) 2000	2005	2010
United States	24,865,422	31,273,013	36,859,219	2,353,173	2,622,287	2,877,469	10,567	11,926	12,810
Alabama	404,754	531,561	620,604	37,325	39,842	42,101	10,844	13,342	14,741
Alaska	185,564	286,687	400,048	16,096	18,722	19,614	11,529	15,313	20,396
Arizona	621,501	758,956	918,021	66,712	75,172	95,139	9,316	10,096	9,649
Arkansas	176,714	200,887	251,151	13,196	14,605	17,121	13,391	13,755	14,669
California	2,618,451	3,337,918	4,082,603	193,944	221,004	244,519	13,501	15,103	16,696
Colorado	218,806	223,086	161,033	47,525	52,820	54,687	4,604	4,224	2,945
Connecticut	380,456	445,039	608,193	19,219	24,158	26,294	19,796	18,422	23,130
Delaware	109,653	131,880	148,308	18,722	19,350	19,506	5,857	6,816	7,603
District of Columbia	NA	NA	NA	NA	NA	NA	NA	NA	NA
Florida	1,455,743	2,298,758	2,616,966	140,621	172,048	188,691	10,352	13,361	13,869
Georgia	920,671	986,136	1,055,577	58,504	67,614	76,588	15,737	14,585	13,783
Hawaii	183,164	296,004	359,025	14,398	17,103	16,899	12,721	17,307	21,245
Idaho	108,404	144,959	122,931	9,585	11,014	10,513	11,310	13,161	11,693
Illinois	927,641	1,001,944	1,122,660	79,863	82,597	86,474	11,615	12,131	12,983
Indiana	518,069	630,767	669,915	69,150	72,063	77,482	7,492	8,753	8,646
Iowa	563,423	591,598	611,004	48,712	49,286	52,037	11,566	12,003	11,742
Kansas	319,712	367,085	563,987	40,721	43,759	46,904	7,851	8,389	12,024
Kentucky	499,773	615,607	653,892	35,765	39,764	42,144	13,974	15,482	15,516
Louisiana	278,804	342,635	348,428	28,644	30,035	26,914	9,733	11,408	12,946
Maine	192,289	243,768	261,284	24,276	27,369	27,088	7,921	8,907	9,646
Maryland	433,340	588,915	593,753	37,442	41,522	44,629	11,574	14,183	13,304
Massachusetts	519,962	614,223	632,434	46,182	46,238	54,469	11,259	13,284	11,611
Michigan	1,002,738	1,253,549	1,241,363	94,551	102,013	107,487	10,605	12,288	11,549
Minnesota	592,159	783,777	1,001,761	35,330	41,521	43,254	16,761	18,877	23,160
Mississippi	260,204	267,310	294,249	24,684	27,367	31,205	10,541	9,768	9,430
Missouri	470,857	530,539	632,596	43,157	49,720	56,507	10,910	10,671	11,195
Montana	55,167	64,978	73,074	10,467	10,533	10,617	5,271	6,169	6,883
Nebraska	256,913	278,534	350,481	29,715	30,523	33,970	8,646	9,125	10,317
Nevada	135,194	198,948	197,496	9,677	13,039	13,946	13,971	15,258	14,161
New Hampshire	82,863	115,288	149,608	20,933	23,263	26,275	3,958	4,956	5,694
New Jersey	570,620	689,066	731,360	47,407	49,603	55,272	12,037	13,892	13,232
New Mexico	403,774	519,765	651,942	40,718	45,155	51,884	9,916	11,511	12,565
New York	725,971	1,063,088	1,547,586	63,096	69,203	77,091	11,506	15,362	20,075
North Carolina	794,917	990,950	1,350,270	45,492	49,458	55,334	17,474	20,036	24,402
North Dakota	136,245	178,899	258,148	21,900	26,713	27,976	6,221	6,697	9,227
Ohio	779,803	972,021	1,143,700	91,254	98,065	110,237	8,545	9,912	10,375
Oklahoma	346,788	390,760	506,624	37,533	43,948	41,226	9,240	8,891	12,289
Oregon	220,361	235,773	243,593	30,644	36,497	40,774	7,191	6,460	5,974
Pennsylvania	692,819	857,409	952,440	117,563	126,593	139,967	5,893	6,773	6,805
Rhode Island	81,968	95,139	71,880	11,806	12,618	14,566	6,943	7,540	4,935
South Carolina	376,372	389,544	383,147	35,248	38,235	43,365	10,678	10,188	8,835
South Dakota	48,496	64,110	78,464	7,252	9,163	10,367	6,687	6,997	7,569
Tennessee	444,873	794,529	706,906	37,970	38,289	43,905	11,716	20,751	16,101
Texas	2,293,537	2,781,144	3,914,463	190,114	225,357	246,847	12,064	12,341	15,858
Utah	321,948	476,882	541,400	35,839	41,437	44,037	8,983	11,509	12,294
Vermont	35,626	77,270	76,552	8,922	9,745	12,172	3,993	7,929	6,289
Virginia	815,759	866,207	933,792	94,170	104,625	120,454	8,663	8,279	7,752
Washington	565,588	726,238	822,927	52,296	58,997	69,789	10,815	12,310	11,792
West Virginia	219,310	239,083	281,888	22,640	26,121	29,613	9,687	9,153	9,519
Wisconsin	396,056	573,924	678,788	36,825	37,769	38,822	10,755	15,196	17,485
Wyoming	101,602	159,876	240,903	9,368	10,632	10,697	10,846	15,037	22,521
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available.

FTE = full-time equivalent.

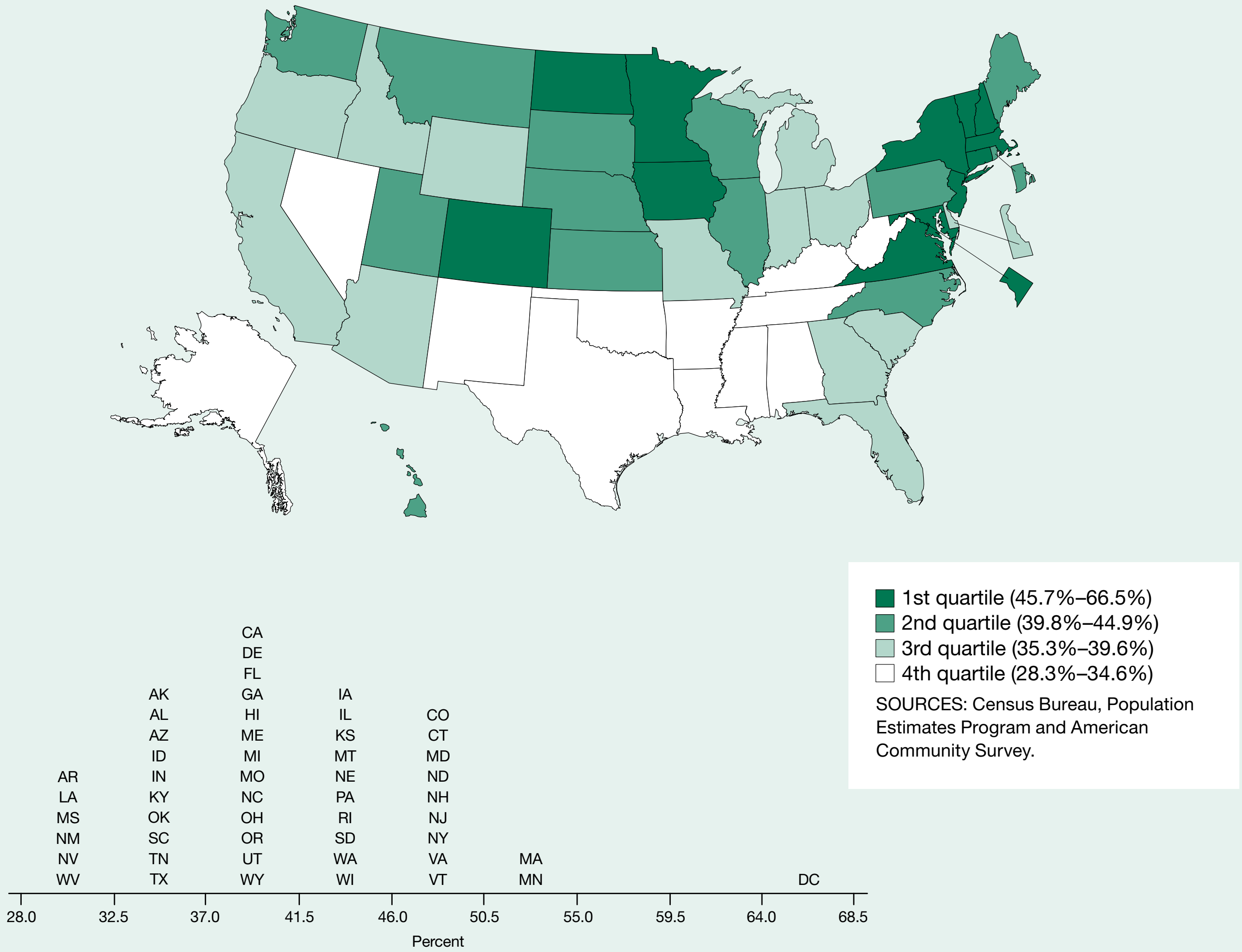
SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS) Analytics; Delta Cost Project Database: 2000–2010.

Science and Engineering Indicators 2014

Postsecondary Degree Holders among Individuals 25–44 Years Old

Figure 8-31

Postsecondary degree holders among individuals 25–44 years old: 2011



SOURCES: Census Bureau, Population Estimates Program and American Community Survey.

Findings

- The early- to midcareer population with a postsecondary degree was 40.4% nationwide in 2011, an increase from 35.3% in 2001.
- In 2011, the percentage of this cohort with a postsecondary degree varied greatly among states, ranging from 28.3% to 53.5%.
- Between 2001 and 2011, all states, except Rhode Island and Kansas, showed an increase in the percentage of their early- to midcareer population with a postsecondary degree, ranging from approximately 2 to 9 percentage points over the time period.
- States with the lowest cost of living tended to rank lowest on this indicator.

This indicator represents the percentage of the early- to midcareer population that has earned a postsecondary degree. That degree may be an associate's, bachelor's, master's, or doctoral degree. The indicator represents where postsecondary degree holders live rather than where they were educated. The age cohort of 25–44 years represents the group most likely to have completed a postsecondary program.

Estimates of educational attainment and of the population of individuals aged 25–44 years old are provided by the U.S. Census Bureau. Small differences in the value of this indicator between states and across time generally are not meaningful.

Table 8-31
Postsecondary degree holders among individuals 25–44 years old, by state: 2001, 2006, and 2011

State	Postsecondary degree holders 25–44 years old			Individuals 25–44 years old			Postsecondary degree holders/ individuals 25–44 years old (%)		
	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	29,834,331	31,653,483	33,261,456	84,523,274	82,638,980	82,432,298	35.3	38.3	40.4
Alabama	368,495	382,124	410,753	1,266,952	1,233,767	1,223,076	29.1	31.0	33.6
Alaska	59,787	63,331	68,881	198,158	188,470	198,914	30.2	33.6	34.6
Arizona	460,938	586,052	595,767	1,526,458	1,664,223	1,688,279	30.2	35.2	35.3
Arkansas	185,372	202,594	225,881	743,315	747,504	745,421	24.9	27.1	30.3
California	3,618,304	3,942,407	4,095,176	10,750,718	10,578,738	10,565,342	33.7	37.3	38.8
Colorado	591,620	616,562	686,256	1,412,620	1,380,451	1,448,033	41.9	44.7	47.4
Connecticut	445,850	425,024	426,066	1,017,477	944,217	898,232	43.8	45.0	47.4
Delaware	81,009	92,375	89,768	233,890	232,516	227,578	34.6	39.7	39.4
District of Columbia	94,690	110,819	143,688	190,251	187,870	216,233	49.8	59.0	66.5
Florida	1,564,716	1,766,287	1,807,574	4,591,807	4,804,621	4,758,046	34.1	36.8	38.0
Georgia	874,366	993,730	1,032,857	2,668,017	2,727,666	2,741,412	32.8	36.4	37.7
Hawaii	129,438	149,841	151,199	357,271	358,311	366,855	36.2	41.8	41.2
Idaho	102,492	133,521	145,300	362,154	383,267	402,781	28.3	34.8	36.1
Illinois	1,488,602	1,515,472	1,567,172	3,756,180	3,572,420	3,491,104	39.6	42.4	44.9
Indiana	561,655	582,550	614,145	1,769,492	1,705,535	1,665,758	31.7	34.2	36.9
Iowa	299,357	314,362	342,653	793,288	747,836	749,530	37.7	42.0	45.7
Kansas	304,258	288,709	308,235	755,887	713,707	727,160	40.3	40.5	42.4
Kentucky	321,357	367,007	377,645	1,194,291	1,162,541	1,138,883	26.9	31.6	33.2
Louisiana	318,160	316,725	365,789	1,268,704	1,152,042	1,203,069	25.1	27.5	30.4
Maine	121,914	126,998	127,825	364,111	337,692	312,002	33.5	37.6	41.0
Maryland	690,575	727,195	732,628	1,652,198	1,598,650	1,565,884	41.8	45.5	46.8
Massachusetts	974,665	925,921	929,155	1,967,815	1,795,786	1,738,118	49.5	51.6	53.5
Michigan	1,030,376	1,001,040	940,460	2,905,689	2,658,755	2,414,603	35.5	37.7	38.9
Minnesota	665,624	674,897	710,688	1,486,814	1,412,852	1,400,438	44.8	47.8	50.7
Mississippi	218,184	230,625	241,695	794,888	767,066	760,122	27.4	30.1	31.8
Missouri	518,314	560,544	602,937	1,606,777	1,547,126	1,523,458	32.3	36.2	39.6
Montana	79,849	90,992	99,689	238,899	228,548	237,269	33.4	39.8	42.0
Nebraska	194,601	198,392	207,888	478,968	458,133	469,737	40.6	43.3	44.3
Nevada	152,489	208,988	216,971	648,880	747,896	766,544	23.5	27.9	28.3
New Hampshire	164,905	161,622	151,036	378,536	348,846	319,411	43.6	46.3	47.3
New Jersey	1,137,167	1,115,872	1,105,760	2,603,347	2,446,589	2,338,637	43.7	45.6	47.3
New Mexico	141,690	160,603	166,658	506,151	507,378	519,946	28.0	31.7	32.1
New York	2,335,677	2,450,307	2,534,197	5,775,563	5,417,603	5,280,570	40.4	45.2	48.0
North Carolina	826,717	921,080	1,024,597	2,504,293	2,518,651	2,577,307	33.0	36.6	39.8
North Dakota	73,317	74,021	82,796	168,631	156,114	170,010	43.5	47.4	48.7
Ohio	1,104,034	1,085,140	1,110,323	3,259,384	3,037,836	2,873,075	33.9	35.7	38.6
Oklahoma	264,301	290,732	329,554	960,435	938,630	975,445	27.5	31.0	33.8
Oregon	337,122	377,058	404,801	992,783	994,743	1,031,267	34.0	37.9	39.3
Pennsylvania	1,262,106	1,282,537	1,335,850	3,435,158	3,224,924	3,123,097	36.7	39.8	42.8
Rhode Island	126,318	124,009	113,495	306,912	284,670	261,020	41.2	43.6	43.5
South Carolina	380,304	383,505	424,313	1,175,787	1,179,555	1,193,581	32.3	32.5	35.5
South Dakota	78,120	81,430	85,994	202,454	193,284	201,235	38.6	42.1	42.7
Tennessee	495,231	524,652	574,932	1,699,828	1,690,961	1,678,144	29.1	31.0	34.3
Texas	1,979,704	2,183,005	2,486,642	6,529,822	6,742,164	7,180,834	30.3	32.4	34.6
Utah	222,744	278,685	323,281	633,099	701,224	793,074	35.2	39.7	40.8
Vermont	70,565	68,160	70,427	172,405	155,997	146,497	40.9	43.7	48.1
Virginia	892,862	949,488	1,049,674	2,227,441	2,190,642	2,215,775	40.1	43.3	47.4
Washington	704,284	771,750	813,490	1,805,606	1,791,998	1,868,055	39.0	43.1	43.5
West Virginia	110,362	130,214	143,431	487,860	468,119	455,269	22.6	27.8	31.5
Wisconsin	568,689	599,292	610,184	1,561,327	1,479,447	1,440,314	36.4	40.5	42.4
Wyoming	41,055	45,237	55,280	134,483	131,399	145,854	30.5	34.4	37.9
Puerto Rico	NA	411,191	390,538	1,055,380	1,080,801	955,369	NA	38.0	40.9

NA = not available.

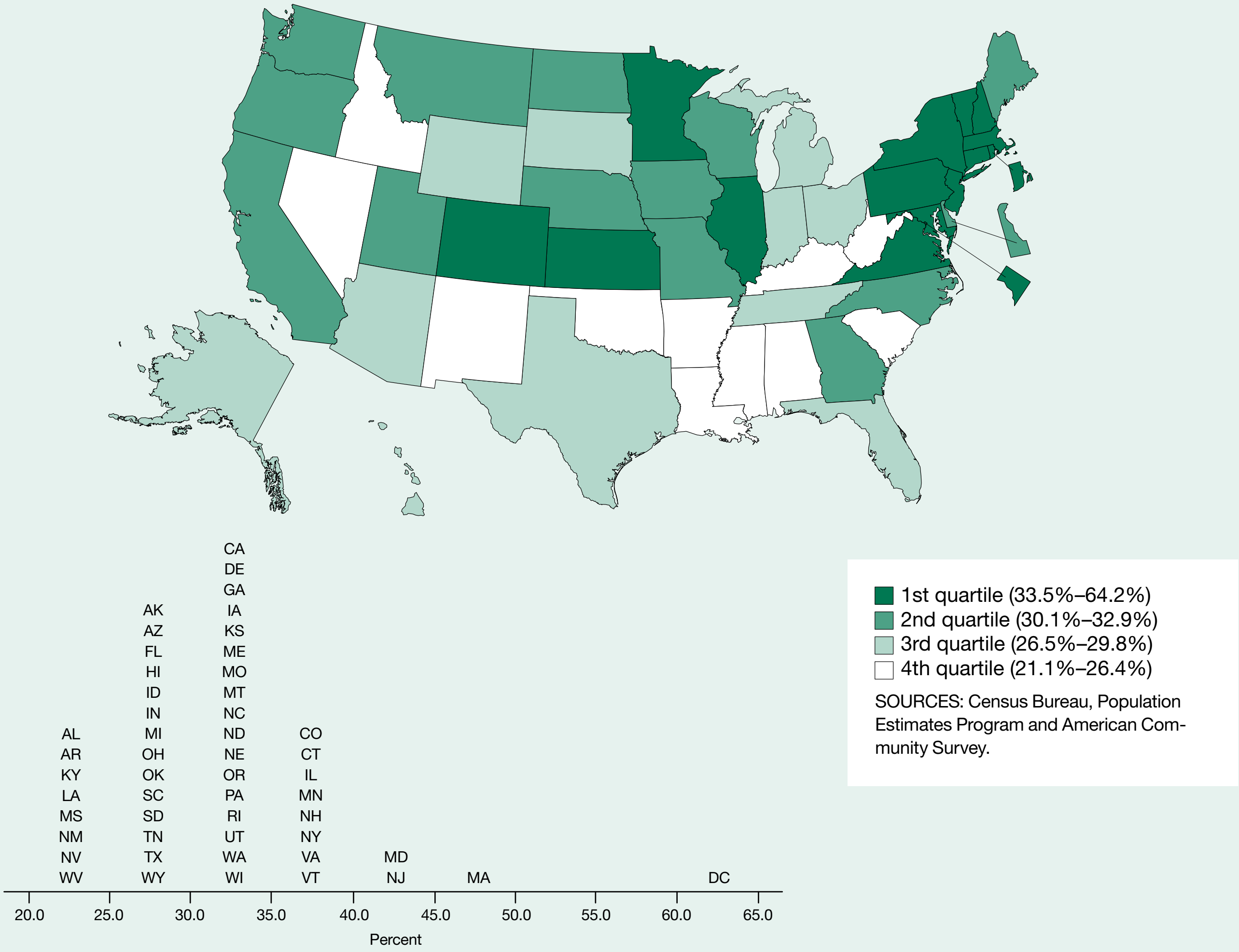
SOURCES: Census Bureau, 2000 and 2010 Decennial Censuses, Population Estimates Program (various years), and American Community Survey (various years).

Science and Engineering Indicators 2014

Bachelor's Degree Holders among Individuals 25–44 Years Old

Figure 8-32

Bachelor's degree holders among individuals 25–44 years old: 2011



SOURCES: Census Bureau, Population Estimates Program and American Community Survey.

Findings

- The early- to midcareer population with at least a bachelor's degree was 31.7% nationwide in 2011, an increase from 27.4% in 2001.
- All states, except South Dakota and New Mexico, showed an increase in the percentage of their early-career population with at least a bachelor's degree between 2001 and 2011.
- In 2011, the percentage of the early-career population with at least a bachelor's degree varied among states, ranging from 21.1 % to 45.8%. The highest percentages tended to be found in the New England and Middle Atlantic states.
- States with the lowest cost of living tended to rank lowest on this indicator.
- The difference between Experimental Program to Stimulate Competitive Research (EPSCoR) and non-EPSCoR states, as a group, remained relatively unchanged and may have increased slightly between 2001 and 2011.

This indicator represents the percentage of the early- to midcareer population that has earned at least a 4-year undergraduate degree. The indicator represents where college degree holders live rather than where they were educated. The age cohort of 25–44 years represents a group of individuals who are potential long-term participants in a state's workforce.

Estimates of educational attainment are developed by the U.S. Census Bureau. Small differences in the value of this indicator between states and across time generally are not meaningful.

Table 8-32

Bachelor's degree holders among individuals 25–44 years old, by state: 2001, 2006, and 2011

	Bachelor's degree holders 25–44 years old			Individuals 25–44 years old			Bachelor's degree holders/individuals 25–44 years old (%)		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
EPSCoR states	2,881,370	3,071,085	3,318,921	12,874,120	12,561,027	12,630,814	22.0	24.0	26.0
Non-EPSCoR states	20,034,473	21,178,682	22,506,261	70,933,001	69,375,658	69,048,386	28.0	31.0	33.0
Average EPSCoR state value	na	na	na	na	na	na	23.6	26.2	28.1
Average non-EPSCoR state value	na	na	na	na	na	na	28.7	31.1	33.2
United States	23,146,638	24,511,980	26,126,620	84,523,274	82,638,980	82,432,298	27.4	29.7	31.7
Alabama	260,871	279,106	302,531	1,266,952	1,233,767	1,223,076	20.6	22.6	24.7
Alaska	41,179	49,715	54,019	198,158	188,470	198,914	20.8	26.4	27.2
Arizona	345,585	439,549	447,271	1,526,458	1,664,223	1,688,279	22.6	26.4	26.5
Arkansas	140,169	154,707	171,718	743,315	747,504	745,421	18.9	20.7	23.0
California	2,902,253	3,139,598	3,325,565	10,750,718	10,578,738	10,565,342	27.0	29.7	31.5
Colorado	479,814	502,928	559,124	1,412,620	1,380,451	1,448,033	34.0	36.4	38.6
Connecticut	364,317	353,075	357,969	1,017,477	944,217	898,232	35.8	37.4	39.9
Delaware	62,714	73,850	73,414	233,890	232,516	227,578	26.8	31.8	32.3
District of Columbia	90,167	104,724	138,826	190,251	187,870	216,233	47.4	55.7	64.2
Florida	1,116,118	1,261,961	1,291,828	4,591,807	4,804,621	4,758,046	24.3	26.3	27.2
Georgia	711,728	788,910	829,700	2,668,017	2,727,666	2,741,412	26.7	28.9	30.3
Hawaii	91,816	108,311	106,724	357,271	358,311	366,855	25.7	30.2	29.1
Idaho	74,079	94,112	106,168	362,154	383,267	402,781	20.5	24.6	26.4
Illinois	1,188,735	1,207,920	1,280,116	3,756,180	3,572,420	3,491,104	31.6	33.8	36.7
Indiana	414,582	421,398	448,594	1,769,492	1,705,535	1,665,758	23.4	24.7	26.9
Iowa	210,690	219,911	238,650	793,288	747,836	749,530	26.6	29.4	31.8
Kansas	234,772	228,389	243,650	755,887	713,707	727,160	31.1	32.0	33.5
Kentucky	242,002	265,168	279,374	1,194,291	1,162,541	1,138,883	20.3	22.8	24.5
Louisiana	258,592	250,100	283,642	1,268,704	1,152,042	1,203,069	20.4	21.7	23.6
Maine	85,043	90,374	96,292	364,111	337,692	312,002	23.4	26.8	30.9
Maryland	580,246	605,876	627,067	1,652,198	1,598,650	1,565,884	35.1	37.9	40.0
Massachusetts	797,799	775,630	795,926	1,967,815	1,795,786	1,738,118	40.5	43.2	45.8
Michigan	765,478	759,116	711,953	2,905,689	2,658,755	2,414,603	26.3	28.6	29.5
Minnesota	500,619	500,908	535,146	1,486,814	1,412,852	1,400,438	33.7	35.5	38.2
Mississippi	154,507	159,018	162,731	794,888	767,066	760,122	19.4	20.7	21.4
Missouri	421,368	436,851	466,569	1,606,777	1,547,126	1,523,458	26.2	28.2	30.6
Montana	60,140	68,280	76,273	238,899	228,548	237,269	25.2	29.9	32.1
Nebraska	138,097	145,722	153,063	478,968	458,133	469,737	28.8	31.8	32.6
Nevada	112,005	151,981	161,563	648,880	747,896	766,544	17.3	20.3	21.1
New Hampshire	119,801	121,670	118,254	378,536	348,846	319,411	31.6	34.9	37.0
New Jersey	965,627	940,691	945,454	2,603,347	2,446,589	2,338,637	37.1	38.4	40.4
New Mexico	107,707	116,419	119,738	506,151	507,378	519,946	21.3	22.9	23.0
New York	1,807,717	1,934,138	2,066,561	5,775,563	5,417,603	5,280,570	31.3	35.7	39.1
North Carolina	620,220	689,731	776,393	2,504,293	2,518,651	2,577,307	24.8	27.4	30.1
North Dakota	48,812	49,178	55,888	168,631	156,114	170,010	28.9	31.5	32.9
Ohio	829,739	820,656	840,370	3,259,384	3,037,836	2,873,075	25.5	27.0	29.2
Oklahoma	203,189	217,214	249,805	960,435	938,630	975,445	21.2	23.1	25.6
Oregon	256,959	291,514	317,301	992,783	994,743	1,031,267	25.9	29.3	30.8
Pennsylvania	966,550	981,799	1,045,715	3,435,158	3,224,924	3,123,097	28.1	30.4	33.5
Rhode Island	92,810	98,999	91,168	306,912	284,670	261,020	30.2	34.8	34.9
South Carolina	274,797	276,216	315,050	1,175,787	1,179,555	1,193,581	23.4	23.4	26.4
South Dakota	56,014	56,968	59,989	202,454	193,284	201,235	27.7	29.5	29.8
Tennessee	390,824	406,110	455,453	1,699,828	1,690,961	1,678,144	23.0	24.0	27.1
Texas	1,562,573	1,710,381	1,972,064	6,529,822	6,742,164	7,180,834	23.9	25.4	27.5
Utah	156,274	201,175	238,953	633,099	701,224	793,074	24.7	28.7	30.1
Vermont	53,430	51,825	56,930	172,405	155,997	146,497	31.0	33.2	38.9
Virginia	739,779	777,630	878,899	2,227,441	2,190,642	2,215,775	33.2	35.5	39.7
Washington	534,153	578,583	610,787	1,805,606	1,791,998	1,868,055	29.6	32.3	32.7
West Virginia	78,782	91,847	104,925	487,860	468,119	455,269	16.1	19.6	23.0
Wisconsin	404,726	432,643	442,833	1,561,327	1,479,447	1,440,314	25.9	29.2	30.7
Wyoming	30,670	29,405	38,624	134,483	131,399	145,854	22.8	22.4	26.5
Puerto Rico	NA	279,953	278,782	1,055,380	1,080,801	955,369	NA	25.9	29.2

na = not applicable; NA = not available.

EPSCoR = Experimental Program to Stimulate Competitive Research.

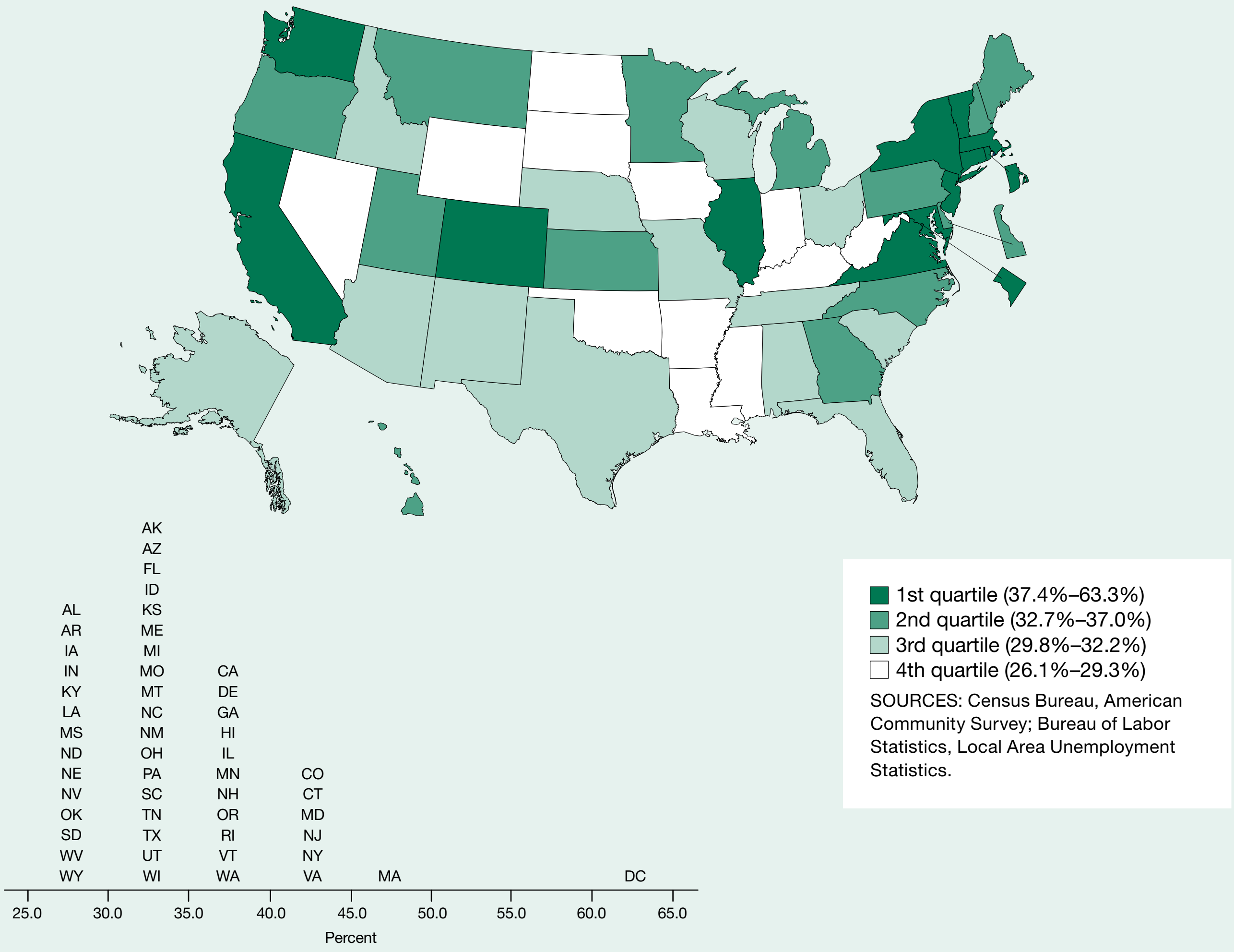
NOTE: For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

SOURCES: Census Bureau, 2000 and 2010 Decennial Censuses, Population Estimates Program (various years), and American Community Survey (various years).

Science and Engineering Indicators 2014

Bachelor’s Degree Holders Potentially in the Workforce

Figure 8-33
Bachelor’s degree holders potentially in the workforce: 2011



SOURCES: Census Bureau, American Community Survey; Bureau of Labor Statistics, Local Area Unemployment Statistics.

Findings

- In 2011, nearly 50 million individuals between ages 25 and 64 held bachelor’s degrees in the United States, up from nearly 41 million in 2001.
- Nationwide, the ratio of bachelor’s degree holders to the size of the workforce rose from 29.6% in 2001 to 35.4% in 2011. This ratio varied considerably among the states, ranging from 26.1% to 47.2% in 2011.
- The value of this indicator increased in all jurisdictions, except Alaska, between 2001 and 2011. This increase may reflect a replacement of older cohorts of workers with younger, more educated ones. It may also indicate the restructuring of state economies to emphasize work that requires a higher level of education or credentials.
- In 2011, the jurisdictions in which the highest concentrations of bachelor’s degree holders lived included the District of Columbia, Massachusetts, New Jersey, Colorado, and Maryland.

The ratio of degree holders (bachelor’s, graduate, or professional) to the population potentially available for work is an indicator of the concentration of individuals with higher education qualifications in a jurisdiction. This indicator does not imply that all degree holders are currently employed; rather, it indicates the educational level of the workforce if all degree holders were employed. Knowledge-intensive businesses seeking to relocate may be attracted to states with high values on this indicator. Workers with at least a bachelor’s degree have a clear advantage over less-educated workers in expected lifetime earnings.

Estimates of degree data are provided by the U.S. Census Bureau and are limited to individuals 25–64 years old, the age range most representative of a jurisdiction’s workforce. Individuals younger than age 25 are considered to be in the process of completing their education. Individuals older than 64 are considered to be largely retired, so their educational attainment would have limited applicability to the quality of the workforce. Employed workforce data are Bureau of Labor Statistics estimates of employed civilians based on Local Area Unemployment Statistics. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-33

Bachelor's degree holders potentially in the workforce, by state: 2001, 2006, and 2011

State	Bachelor's degree holders 25–64 years old			Employed workforce			Bachelor's degree holders/employed workforce (%)		
	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	40,527,497	45,935,309	49,761,556	137,107,779	143,729,350	140,695,662	29.6	32.0	35.4
Alabama	476,157	550,302	593,859	2,034,909	2,098,462	1,992,522	23.4	26.2	29.8
Alaska	89,504	102,153	105,780	301,694	326,109	337,796	29.7	31.3	31.3
Arizona	621,567	834,211	881,399	2,453,453	2,836,638	2,761,984	25.3	29.4	31.9
Arkansas	260,535	289,510	326,754	1,194,024	1,286,887	1,251,877	21.8	22.5	26.1
California	5,140,460	5,788,525	6,209,917	16,220,033	16,821,266	16,237,286	31.7	34.4	38.2
Colorado	851,265	949,265	1,067,811	2,303,494	2,541,828	2,490,004	37.0	37.3	42.9
Connecticut	656,272	693,564	740,397	1,700,046	1,745,993	1,732,807	38.6	39.7	42.7
Delaware	111,152	131,601	143,550	404,135	424,618	407,772	27.5	31.0	35.2
District of Columbia	141,159	160,332	197,942	286,649	303,791	312,859	49.2	52.8	63.3
Florida	2,086,928	2,516,214	2,657,913	7,624,718	8,584,095	8,322,237	27.4	29.3	31.9
Georgia	1,144,463	1,426,071	1,524,738	4,112,868	4,500,150	4,295,113	27.8	31.7	35.5
Hawaii	180,610	218,941	221,769	589,216	617,807	614,824	30.7	35.4	36.1
Idaho	152,726	184,486	210,656	644,816	718,077	702,920	23.7	25.7	30.0
Illinois	1,987,145	2,143,825	2,307,808	6,113,536	6,225,095	5,942,809	32.5	34.4	38.8
Indiana	707,529	782,232	843,402	3,020,985	3,080,047	2,874,722	23.4	25.4	29.3
Iowa	368,722	408,648	449,951	1,568,638	1,595,136	1,562,156	23.5	25.6	28.8
Kansas	407,954	440,261	474,072	1,347,715	1,403,938	1,401,055	30.3	31.4	33.8
Kentucky	410,170	495,800	529,836	1,852,056	1,904,467	1,875,447	22.1	26.0	28.3
Louisiana	453,105	477,352	528,592	1,922,110	1,900,240	1,919,021	23.6	25.1	27.5
Maine	171,041	199,868	217,867	650,699	665,856	649,312	26.3	30.0	33.6
Maryland	1,015,855	1,144,963	1,228,462	2,712,268	2,892,733	2,868,191	37.5	39.6	42.8
Massachusetts	1,350,105	1,423,262	1,519,049	3,275,343	3,255,504	3,216,160	41.2	43.7	47.2
Michigan	1,330,224	1,427,656	1,422,628	4,876,338	4,722,716	4,189,792	27.3	30.2	34.0
Minnesota	822,940	914,823	994,234	2,755,808	2,774,524	2,777,285	29.9	33.0	35.8
Mississippi	284,057	295,278	317,872	1,229,884	1,199,871	1,197,641	23.1	24.6	26.5
Missouri	731,969	818,224	889,754	2,867,853	2,889,461	2,767,043	25.5	28.3	32.2
Montana	127,026	146,640	155,461	447,827	476,412	466,372	28.4	30.8	33.3
Nebraska	242,112	271,596	287,925	925,783	943,176	961,786	26.2	28.8	29.9
Nevada	214,614	292,151	329,238	1,042,182	1,222,277	1,207,799	20.6	23.9	27.3
New Hampshire	215,907	248,086	258,118	680,706	708,748	697,383	31.7	35.0	37.0
New Jersey	1,644,820	1,745,454	1,835,382	4,117,543	4,257,899	4,120,017	39.9	41.0	44.5
New Mexico	227,129	261,942	274,058	821,003	886,708	862,043	27.7	29.5	31.8
New York	3,054,065	3,493,031	3,725,582	8,743,924	9,062,464	8,740,642	34.9	38.5	42.6
North Carolina	1,043,271	1,265,162	1,461,123	3,929,977	4,261,325	4,183,052	26.5	29.7	34.9
North Dakota	85,926	92,568	103,117	336,228	349,368	368,677	25.6	26.5	28.0
Ohio	1,423,694	1,528,942	1,623,724	5,566,735	5,602,764	5,303,655	25.6	27.3	30.6
Oklahoma	379,436	433,967	490,304	1,614,627	1,650,070	1,678,953	23.5	26.3	29.2
Oregon	497,208	587,174	629,810	1,711,041	1,792,039	1,785,400	29.1	32.8	35.3
Pennsylvania	1,676,416	1,863,711	2,006,801	5,874,153	6,021,084	5,892,519	28.5	31.0	34.1
Rhode Island	167,178	182,749	188,849	520,677	543,973	499,481	32.1	33.6	37.8
South Carolina	495,647	546,986	607,286	1,834,871	1,970,912	1,941,654	27.0	27.8	31.3
South Dakota	98,686	108,994	116,560	400,352	421,799	422,696	24.6	25.8	27.6
Tennessee	676,912	765,687	863,852	2,728,523	2,852,509	2,828,617	24.8	26.8	30.5
Texas	2,714,923	3,162,391	3,660,238	9,991,920	10,757,510	11,493,519	27.2	29.4	31.8
Utah	266,153	354,651	410,367	1,108,547	1,285,389	1,254,151	24.0	27.6	32.7
Vermont	107,928	118,680	126,695	330,099	343,149	338,632	32.7	34.6	37.4
Virginia	1,292,274	1,467,254	1,640,903	3,537,719	3,862,508	3,928,267	36.5	38.0	41.8
Washington	988,658	1,123,956	1,215,053	2,863,705	3,155,384	3,161,818	34.5	35.6	38.4
West Virginia	156,241	179,015	202,206	758,904	777,210	740,175	20.6	23.0	27.3
Wisconsin	714,317	812,662	865,610	2,897,937	2,932,482	2,832,826	24.6	27.7	30.6
Wyoming	63,342	64,493	77,282	259,508	276,882	284,893	24.4	23.3	27.1
Puerto Rico	NA	465,722	498,515	1,128,704	1,270,693	1,032,765	NA	36.7	48.3

NA = not available.

NOTES: Bachelor's degree holders include those who completed a bachelor's or higher degree. Workforce represents the employed component of the civilian labor force and is reported as annual data not seasonally adjusted.

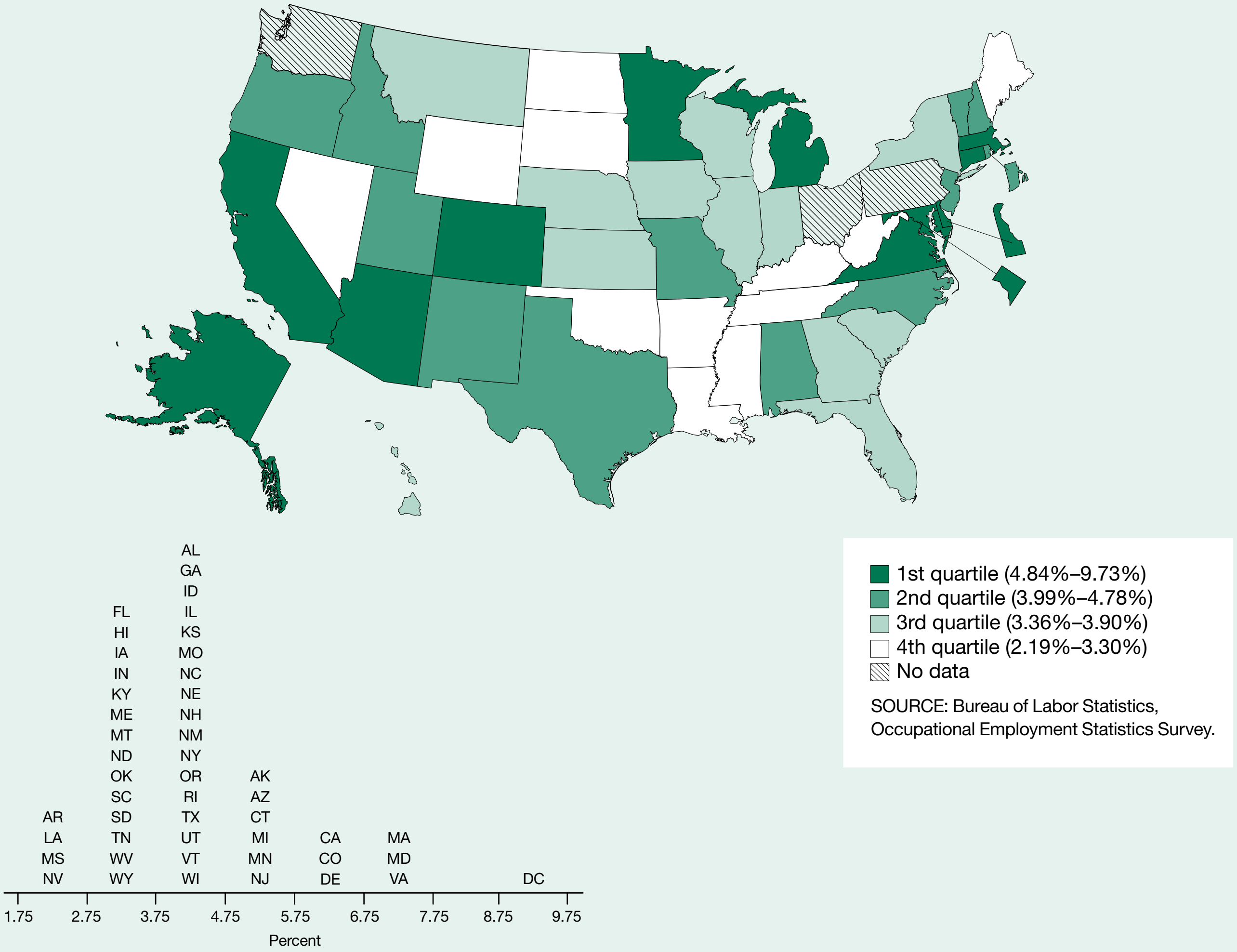
SOURCES: Census Bureau, 2000 and 2010 Decennial Censuses, and American Community Survey (various years); Bureau of Labor Statistics, Local Area Unemployment Statistics (various years).

Science and Engineering Indicators 2014

Individuals in Science and Engineering Occupations as a Percentage of All Occupations

Figure 8-34

Individuals in science and engineering occupations as a percentage of all occupations: 2012



SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey.

Findings

- In 2012, about 5.97 million people worked in occupations classified as S&E. This is an increase from the 4.96 million S&E workers in 2003.
- In 2012, the percentage of the workforce engaged in S&E occupations ranged from 2.19% to 7.63% in individual states.
- The highest percentages of employment in S&E occupations were found in the District of Columbia and the adjacent states of Maryland and Virginia as well as in Massachusetts and Colorado in 2012.

This indicator represents the extent to which a state's workforce is employed in S&E occupations. A high value indicates that a state's economy has a high percentage of technical jobs relative to other states.

S&E occupations are defined by standard occupational codes. They include engineers and computer, mathematical, life, physical, and social scientists. Managers, technicians, elementary and secondary schoolteachers, and medical personnel are not included.

Data on individuals in S&E occupations and total occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics from data provided by state workforce agencies. Due to the way the data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations.

Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-34

Individuals in science and engineering occupations as a percentage of all occupations, by state: 2003, 2008, and 2012

State	Individuals in S&E occupations			All occupations			S&E occupations/ all occupations (%)		
	2003	2008	2012	2003	2008	2012	2003	2008	2012
United States	4,961,550	5,781,460	5,968,240	127,420,170	135,185,230	130,287,700	3.89	4.28	4.58
Alabama	56,380	68,580	72,880	1,817,240	1,945,300	1,824,400	3.10	3.53	3.99
Alaska	10,600	13,260	16,260	290,740	307,790	318,700	3.65	4.31	5.10
Arizona	92,120	102,100	116,930	2,275,410	2,637,830	2,414,340	4.05	3.87	4.84
Arkansas	21,340	29,310	29,530	1,118,690	1,176,050	1,155,020	1.91	2.49	2.56
California	676,180	791,750	821,780	14,460,860	15,212,610	14,303,630	4.68	5.20	5.75
Colorado	124,140	147,000	149,020	2,097,650	2,302,340	2,226,160	5.92	6.38	6.69
Connecticut	81,380	80,290	78,450	1,631,610	1,697,810	1,620,620	4.99	4.73	4.84
Delaware	17,370	22,330	23,440	403,650	425,210	405,750	4.30	5.25	5.78
District of Columbia	54,890	63,360	63,600	595,220	635,500	653,760	9.22	9.97	9.73
Florida	221,070	248,200	248,300	7,217,400	7,771,740	7,273,850	3.06	3.19	3.41
Georgia	144,170	147,380	148,830	3,770,430	4,068,270	3,815,530	3.82	3.62	3.90
Hawaii	16,090	18,830	20,930	557,400	612,420	588,210	2.89	3.07	3.56
Idaho	22,150	23,310	25,260	563,200	650,240	598,540	3.93	3.58	4.22
Illinois	211,230	224,370	220,170	5,719,150	5,910,630	5,640,740	3.69	3.80	3.90
Indiana	78,410	90,840	94,620	2,851,210	2,927,620	2,811,920	2.75	3.10	3.36
Iowa	37,320	46,180	50,950	1,413,220	1,502,600	1,470,740	2.64	3.07	3.46
Kansas	51,970	54,260	50,930	1,292,170	1,374,560	1,320,920	4.02	3.95	3.86
Kentucky	45,230	NA	51,830	1,719,620	1,817,860	1,764,750	2.63	NA	2.94
Louisiana	41,900	41,790	45,920	1,851,870	1,887,370	1,868,210	2.26	2.21	2.46
Maine	15,020	17,000	17,910	591,750	604,150	581,110	2.54	2.81	3.08
Maryland	149,250	167,070	179,550	2,448,580	2,561,530	2,510,680	6.10	6.52	7.15
Massachusetts	184,690	217,310	229,160	3,130,720	3,234,860	3,202,080	5.90	6.72	7.16
Michigan	182,940	204,290	198,610	4,310,420	4,142,750	3,918,120	4.24	4.93	5.07
Minnesota	117,120	134,440	131,690	2,591,720	2,704,860	2,641,110	4.52	4.97	4.99
Mississippi	22,190	27,270	23,640	1,089,350	1,138,210	1,080,420	2.04	2.40	2.19
Missouri	84,150	105,390	109,650	2,623,020	2,740,170	2,605,910	3.21	3.85	4.21
Montana	11,450	NA	15,360	394,820	444,090	432,380	2.90	NA	3.55
Nebraska	30,710	31,820	34,720	879,550	928,120	914,830	3.49	3.43	3.80
Nevada	22,330	27,300	27,000	1,086,110	1,278,230	1,127,160	2.06	2.14	2.40
New Hampshire	23,430	29,150	28,950	607,570	634,570	612,710	3.86	4.59	4.72
New Jersey	161,420	198,060	181,480	3,878,020	3,986,310	3,793,720	4.16	4.97	4.78
New Mexico	33,600	34,560	35,310	747,050	819,480	773,860	4.50	4.22	4.56
New York	272,440	326,510	321,480	8,236,200	8,633,580	8,542,280	3.31	3.78	3.76
North Carolina	132,440	153,680	167,900	3,702,170	4,063,420	3,878,800	3.58	3.78	4.33
North Dakota	8,430	9,450	13,120	314,620	350,360	403,290	2.68	2.70	3.25
Ohio	177,100	206,320	NA	5,308,270	5,323,130	5,054,250	3.34	3.88	NA
Oklahoma	44,360	48,900	50,420	1,416,640	1,557,750	1,529,900	3.13	3.14	3.30
Oregon	61,230	70,070	75,780	1,537,000	1,706,740	1,609,900	3.98	4.11	4.71
Pennsylvania	185,560	227,170	NA	5,494,430	5,705,170	5,596,480	3.38	3.98	NA
Rhode Island	18,740	18,090	20,180	477,320	478,420	453,020	3.93	3.78	4.45
South Carolina	48,740	57,770	63,170	1,764,170	1,892,690	1,796,550	2.76	3.05	3.52
South Dakota	9,150	11,870	12,000	364,970	395,960	398,680	2.51	3.00	3.01
Tennessee	63,680	72,760	79,830	2,614,830	2,755,800	2,657,280	2.44	2.64	3.00
Texas	365,270	463,850	493,980	9,248,660	10,391,420	10,579,400	3.95	4.46	4.67
Utah	45,570	52,570	54,720	1,043,500	1,230,320	1,200,850	4.37	4.27	4.56
Vermont	11,420	12,360	12,870	291,400	301,130	294,090	3.92	4.10	4.38
Virginia	209,280	259,280	274,280	3,412,070	3,670,980	3,597,100	6.13	7.06	7.63
Washington	150,230	NA	NA	2,560,190	2,868,910	2,764,080	5.87	NA	NA
West Virginia	16,220	17,000	19,900	680,200	717,740	710,540	2.38	2.37	2.80
Wisconsin	93,320	101,680	103,030	2,687,400	2,776,690	2,673,280	3.47	3.66	3.85
Wyoming	6,130	8,850	8,710	240,730	283,980	278,040	2.55	3.12	3.13
Puerto Rico	19,940	22,970	21,750	962,000	999,010	942,080	2.07	2.30	2.31

NA = not available.

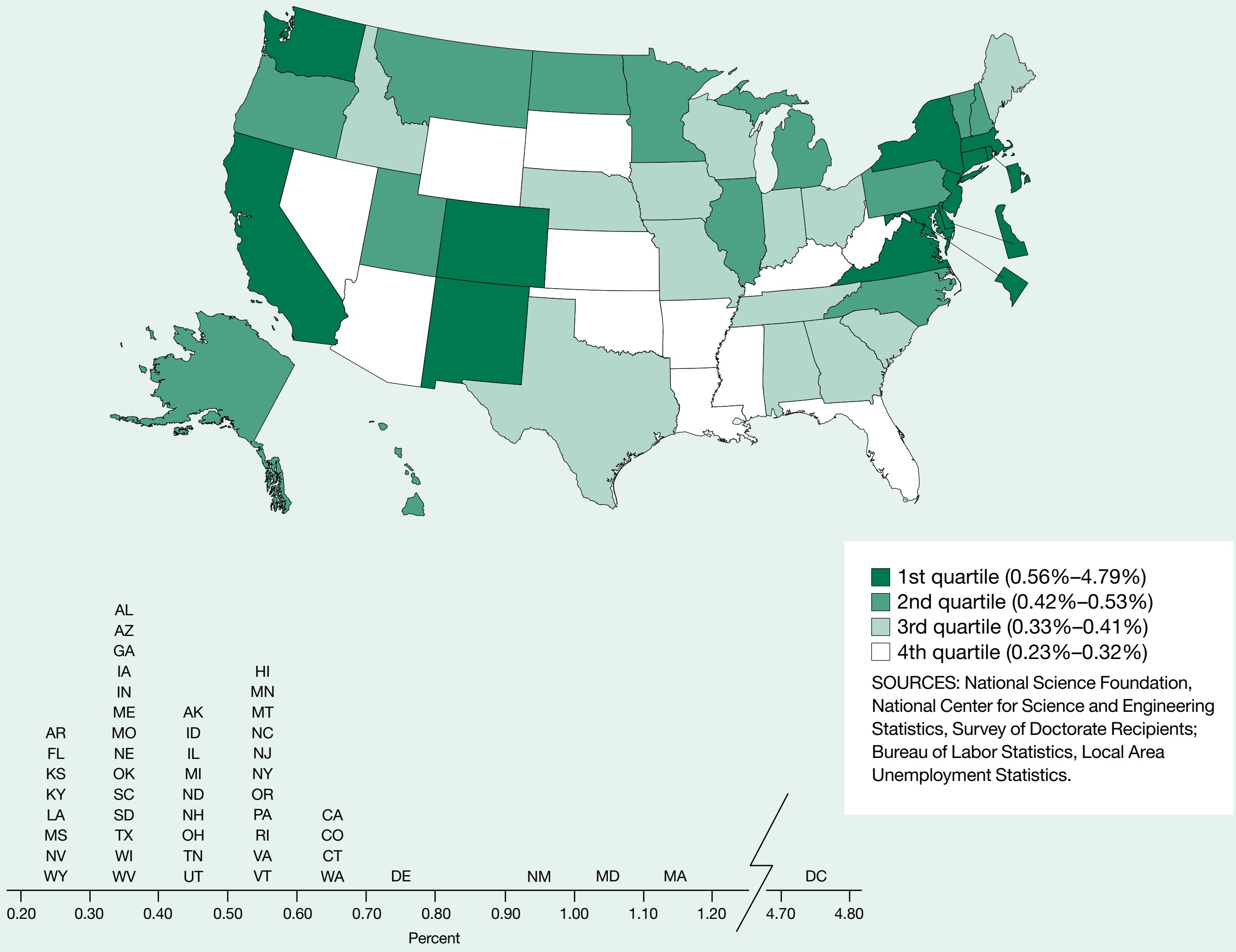
NOTES: United States total includes states with suppressed data. Occupational Employment Statistics survey estimates for 2003 are based on November data; estimates for the remaining years are based on May data.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (various years).

Science and Engineering Indicators 2014

Employed Science and Engineering Doctorate Holders as a Percentage of the Workforce

Figure 8-35
Employed science and engineering doctorate holders as a percentage of the workforce: 2010



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients; Bureau of Labor Statistics, Local Area Unemployment Statistics.

Findings

- The number of employed S&E doctorate holders in the United States rose from almost 573,000 in 2001 to about 688,000 in 2010, an increase of 20%.
- Overall, the value of this indicator rose from 0.42% in 2001 to 0.49% in 2010 because the number of employed S&E doctorate holders nationwide increased more rapidly than the size of the workforce.
- In 2010, the values for this indicator in individual states ranged from 0.23% to 1.16% of a state's workforce.
- States in the top quartile tended to be homes to major research laboratories, research universities, or research-intensive industries.

This indicator represents a state's ability to attract and retain highly trained scientists and engineers. These individuals often conduct R&D, manage R&D activities, or are otherwise engaged in knowledge-intensive activities. A high value for this indicator in a state suggests employment opportunities for individuals with highly advanced training in S&E fields.

Data on employed S&E doctorate holders include those with doctoral degrees in computer and mathematical sciences; the biological, agricultural, or environmental life sciences; physical sciences; social sciences; psychology; engineering; and health fields. S&E doctorate data exclude individuals with doctorates from foreign institutions and those older than the age of 75. S&E doctorate holders are assigned to a state based on where they work.

Employed workforce data are developed by the Bureau of Labor Statistics, which assigns workers to a state based on where they live. Workforce data represent annual estimates of the employed civilian labor force; estimates are not seasonally adjusted.

Small differences in the values of the indicator between states or across time are generally not meaningful.

Table 8-35

Employed science and engineering doctorate holders as a percentage of the workforce, by state: 2001, 2006, and 2010

	Employed S&E doctorate holders			Employed workforce			S&E doctorate holders/all workers (%)		
State	2001	2006	2010	2001	2006	2010	2001	2006	2010
United States	572,800	618,400	688,300	137,107,779	143,729,350	139,395,958	0.42	0.43	0.49
Alabama	5,300	5,900	6,600	2,034,909	2,098,462	1,969,557	0.26	0.28	0.34
Alaska	1,200	1,100	1,400	301,694	326,109	333,538	0.40	0.34	0.42
Arizona	7,100	8,400	9,000	2,453,453	2,836,638	2,780,328	0.29	0.30	0.32
Arkansas	2,600	2,800	2,900	1,194,024	1,286,887	1,242,088	0.22	0.22	0.23
California	80,900	87,400	102,300	16,220,033	16,821,266	16,063,550	0.50	0.52	0.64
Colorado	11,800	13,100	14,800	2,303,494	2,541,828	2,475,831	0.51	0.52	0.60
Connecticut	9,500	10,300	11,300	1,700,046	1,745,993	1,735,059	0.56	0.59	0.65
Delaware	3,500	3,100	3,000	404,135	424,618	402,612	0.87	0.73	0.75
District of Columbia	14,200	13,300	14,900	286,649	303,791	310,842	4.95	4.38	4.79
Florida	15,700	17,600	20,600	7,624,718	8,584,095	8,141,447	0.21	0.21	0.25
Georgia	12,000	13,000	15,200	4,112,868	4,500,150	4,241,718	0.29	0.29	0.36
Hawaii	2,600	2,800	3,000	589,216	617,807	603,894	0.44	0.45	0.50
Idaho	2,200	2,800	2,800	644,816	718,077	694,976	0.34	0.39	0.40
Illinois	22,100	24,100	25,300	6,113,536	6,225,095	5,925,554	0.36	0.39	0.43
Indiana	9,600	9,900	10,900	3,020,985	3,080,047	2,843,268	0.32	0.32	0.38
Iowa	4,400	4,900	5,600	1,568,638	1,595,136	1,566,307	0.28	0.31	0.36
Kansas	4,000	4,300	4,000	1,347,715	1,403,938	1,398,046	0.30	0.31	0.29
Kentucky	4,600	5,000	5,100	1,852,056	1,904,467	1,854,279	0.25	0.26	0.28
Louisiana	5,300	5,500	5,300	1,922,110	1,900,240	1,920,732	0.28	0.29	0.28
Maine	2,000	2,400	2,400	650,699	665,856	643,499	0.31	0.36	0.37
Maryland	22,700	26,200	29,800	2,712,268	2,892,733	2,831,069	0.84	0.91	1.05
Massachusetts	29,100	32,400	36,900	3,275,343	3,255,504	3,187,622	0.89	1.00	1.16
Michigan	17,400	17,900	18,000	4,876,338	4,722,716	4,147,952	0.36	0.38	0.43
Minnesota	11,400	11,800	13,700	2,755,808	2,774,524	2,744,470	0.41	0.43	0.50
Mississippi	3,200	3,300	3,300	1,229,884	1,199,871	1,177,276	0.26	0.28	0.28
Missouri	9,300	9,300	10,700	2,867,853	2,889,461	2,755,946	0.32	0.32	0.39
Montana	1,400	2,000	2,400	447,827	476,412	462,278	0.31	0.42	0.52
Nebraska	2,900	3,000	3,100	925,783	943,176	944,562	0.31	0.32	0.33
Nevada	2,000	2,600	3,000	1,042,182	1,222,277	1,199,517	0.19	0.21	0.25
New Hampshire	2,500	2,500	3,000	680,706	708,748	693,679	0.37	0.35	0.43
New Jersey	22,700	20,800	23,000	4,117,543	4,257,899	4,111,155	0.55	0.49	0.56
New Mexico	7,700	8,300	8,000	821,003	886,708	861,503	0.94	0.94	0.93
New York	44,000	45,900	50,900	8,743,924	9,062,464	8,760,743	0.50	0.51	0.58
North Carolina	16,800	18,900	20,600	3,929,977	4,261,325	4,136,257	0.43	0.44	0.50
North Dakota	1,100	1,400	1,500	336,228	349,368	360,921	0.33	0.40	0.42
Ohio	20,100	20,500	21,700	5,566,735	5,602,764	5,271,394	0.36	0.37	0.41
Oklahoma	4,400	4,400	4,900	1,614,627	1,650,070	1,657,099	0.27	0.27	0.30
Oregon	7,000	8,300	9,100	1,711,041	1,792,039	1,761,867	0.41	0.46	0.52
Pennsylvania	26,100	29,100	31,300	5,874,153	6,021,084	5,854,537	0.44	0.48	0.53
Rhode Island	2,600	3,000	3,000	520,677	543,973	505,131	0.50	0.55	0.59
South Carolina	5,100	5,900	6,400	1,834,871	1,970,912	1,917,747	0.28	0.30	0.33
South Dakota	1,000	1,000	1,300	400,352	421,799	420,171	0.25	0.24	0.31
Tennessee	9,000	10,000	11,500	2,728,523	2,852,509	2,777,213	0.33	0.35	0.41
Texas	32,500	36,000	42,400	9,991,920	10,757,510	11,273,239	0.33	0.33	0.38
Utah	4,800	5,500	5,900	1,108,547	1,285,389	1,252,466	0.43	0.43	0.47
Vermont	1,800	1,700	1,800	330,099	343,149	337,049	0.55	0.50	0.53
Virginia	17,500	19,800	22,000	3,537,719	3,862,508	3,840,619	0.49	0.51	0.57
Washington	14,800	16,900	18,900	2,863,705	3,155,384	3,166,880	0.52	0.54	0.60
West Virginia	1,900	2,000	2,200	758,904	777,210	737,115	0.25	0.26	0.30
Wisconsin	8,700	9,500	10,600	2,897,937	2,932,482	2,820,453	0.30	0.32	0.38
Wyoming	800	700	800	259,508	276,882	280,903	0.31	0.25	0.28
Puerto Rico	1,400	1,700	2,300	1,128,704	1,270,693	1,061,519	0.12	0.13	0.22

NOTE: Employed S&E doctorate holders are classified by employment lcoation; employed workers are classified by residence.

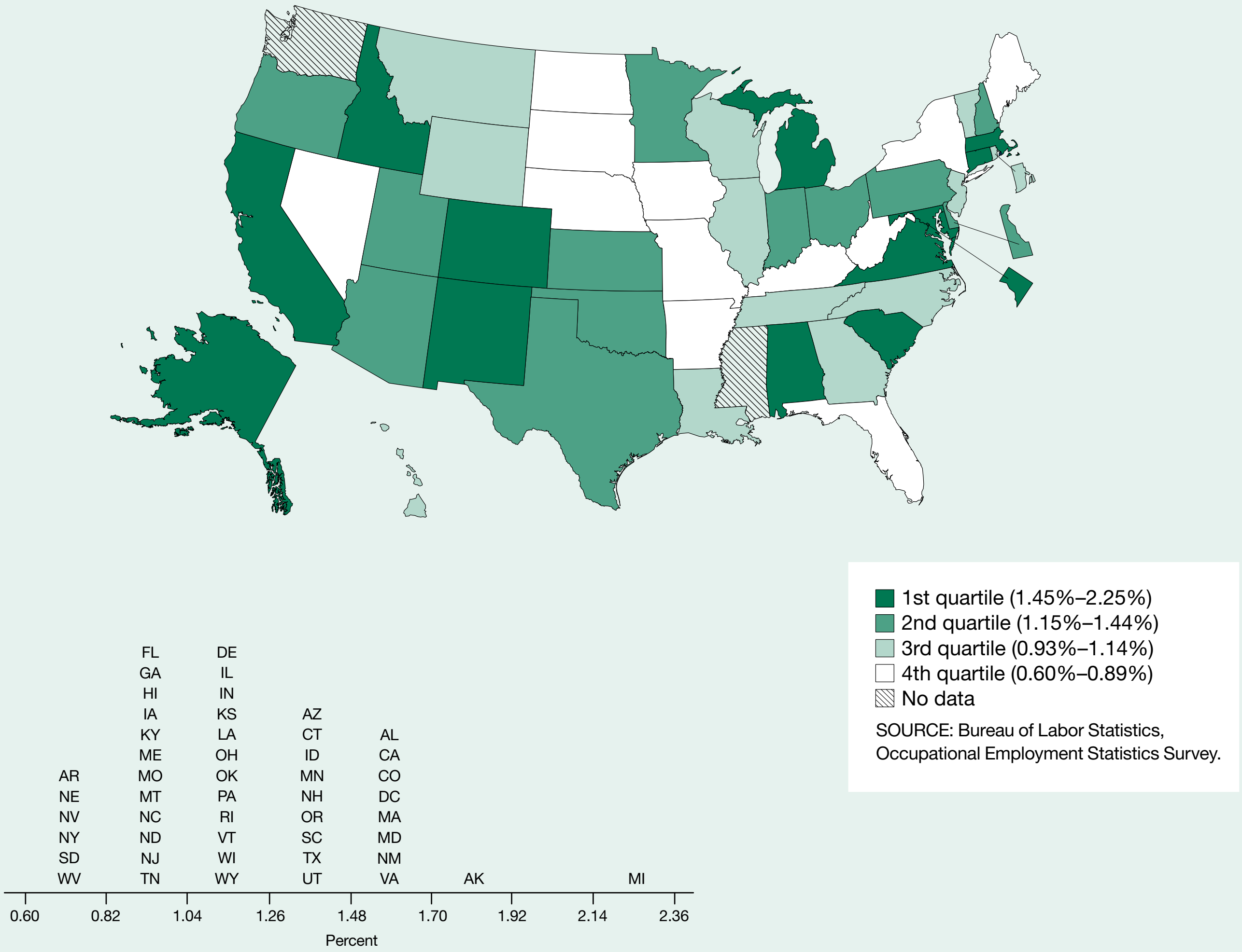
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients, (various years); Bureau of Labor Statistics, Local Area Unemployment Statistics (various years).

Science and Engineering Indicators 2014

Engineers as a Percentage of All Occupations

Figure 8-36

Engineers as a percentage of all occupations: 2012



SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey.

Findings

- In the United States, 1.63 million individuals were employed in engineering occupations in 2012, an increase from the 1.47 million engineers employed in 2003. Between 2003 and 2012, the percentage of the workforce employed in engineering occupations increased from 1.15% to 1.25%.
- The concentration of engineers in individual states ranged from 0.60% to 2.25% in 2012.
- States ranking highest on this indicator also ranked high on employment in high-technology establishments as a share of total employment.

Engineers design and operate production processes and create new products and services. This indicator represents the percentage of trained engineers in a state's workforce. It includes the standard occupational codes for engineering fields: aerospace, agricultural, biomedical, chemical, civil, computer hardware, electrical and electronics, environmental, industrial, marine and naval architectural, materials, mechanical, mining and geological, nuclear, and petroleum.

Data on individuals in engineering occupations and total occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics from data provided by state workforce agencies.

Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-36

Engineers as a percentage of all occupations, by state: 2003, 2008, and 2012

State	Engineers			All occupations			Engineers in all occupations (%)		
	2003	2008	2012	2003	2008	2012	2003	2008	2012
United States	1,465,670	1,626,330	1,629,470	127,420,170	135,185,230	130,287,700	1.15	1.20	1.25
Alabama	21,660	26,430	29,240	1,817,240	1,945,300	1,824,400	1.19	1.36	1.60
Alaska	3,570	4,450	5,540	290,740	307,790	318,700	1.23	1.45	1.74
Arizona	34,500	35,850	32,880	2,275,410	2,637,830	2,414,340	1.52	1.36	1.36
Arkansas	5,610	7,340	6,940	1,118,690	1,176,050	1,155,020	0.50	0.62	0.60
California	212,620	240,860	234,600	14,460,860	15,212,610	14,303,630	1.47	1.58	1.64
Colorado	35,180	41,130	37,050	2,097,650	2,302,340	2,226,160	1.68	1.79	1.66
Connecticut	26,020	23,920	23,480	1,631,610	1,697,810	1,620,620	1.59	1.41	1.45
Delaware	3,440	5,120	4,910	403,650	425,210	405,750	0.85	1.20	1.21
District of Columbia	10,070	8,220	9,840	595,220	635,500	653,760	1.69	1.29	1.51
Florida	58,300	69,040	62,860	7,217,400	7,771,740	7,273,850	0.81	0.89	0.86
Georgia	30,060	36,020	36,360	3,770,430	4,068,270	3,815,530	0.80	0.89	0.95
Hawaii	4,670	5,020	5,800	557,400	612,420	588,210	0.84	0.82	0.99
Idaho	8,530	7,870	8,760	563,200	650,240	598,540	1.51	1.21	1.46
Illinois	58,150	55,840	61,420	5,719,150	5,910,630	5,640,740	1.02	0.94	1.09
Indiana	30,110	30,780	32,230	2,851,210	2,927,620	2,811,920	1.06	1.05	1.15
Iowa	NA	10,270	12,100	1,413,220	1,502,600	1,470,740	NA	0.68	0.82
Kansas	19,870	16,930	15,320	1,292,170	1,374,560	1,320,920	1.54	1.23	1.16
Kentucky	13,090	13,880	14,690	1,719,620	1,817,860	1,764,750	0.76	0.76	0.83
Louisiana	15,940	18,270	19,940	1,851,870	1,887,370	1,868,210	0.86	0.97	1.07
Maine	4,880	4,480	5,070	591,750	604,150	581,110	0.82	0.74	0.87
Maryland	33,610	39,390	41,130	2,448,580	2,561,530	2,510,680	1.37	1.54	1.64
Massachusetts	49,430	54,330	52,610	3,130,720	3,234,860	3,202,080	1.58	1.68	1.64
Michigan	92,190	92,190	87,980	4,310,420	4,142,750	3,918,120	2.14	2.23	2.25
Minnesota	30,650	29,490	33,210	2,591,720	2,704,860	2,641,110	1.18	1.09	1.26
Mississippi	7,770	10,160	NA	1,089,350	1,138,210	1,080,420	0.71	0.89	NA
Missouri	20,090	25,950	23,100	2,623,020	2,740,170	2,605,910	0.77	0.95	0.89
Montana	2,680	3,570	4,020	394,820	444,090	432,380	0.68	0.80	0.93
Nebraska	5,890	6,350	6,330	879,550	928,120	914,830	0.67	0.68	0.69
Nevada	6,660	7,870	7,180	1,086,110	1,278,230	1,127,160	0.61	0.62	0.64
New Hampshire	7,490	7,870	8,290	607,570	634,570	612,710	1.23	1.24	1.35
New Jersey	37,190	40,720	39,140	3,878,020	3,986,310	3,793,720	0.96	1.02	1.03
New Mexico	12,710	11,500	12,350	747,050	819,480	773,860	1.70	1.40	1.60
New York	65,600	74,570	61,980	8,236,200	8,633,580	8,542,280	0.80	0.86	0.73
North Carolina	31,020	33,400	36,710	3,702,170	4,063,420	3,878,800	0.84	0.82	0.95
North Dakota	2,130	2,530	3,520	314,620	350,360	403,290	0.68	0.72	0.87
Ohio	61,960	60,120	60,790	5,308,270	5,323,130	5,054,250	1.17	1.13	1.20
Oklahoma	12,830	14,040	17,740	1,416,640	1,557,750	1,529,900	0.91	0.90	1.16
Oregon	17,970	18,740	21,440	1,537,000	1,706,740	1,609,900	1.17	1.10	1.33
Pennsylvania	NA	63,340	66,970	5,494,430	5,705,170	5,596,480	NA	1.11	1.20
Rhode Island	5,080	5,150	5,110	477,320	478,420	453,020	1.06	1.08	1.13
South Carolina	19,960	22,750	26,470	1,764,170	1,892,690	1,796,550	1.13	1.20	1.47
South Dakota	1,990	2,440	2,770	364,970	395,960	398,680	0.55	0.62	0.69
Tennessee	20,880	23,130	26,420	2,614,830	2,755,800	2,657,280	0.80	0.84	0.99
Texas	116,160	146,520	152,120	9,248,660	10,391,420	10,579,400	1.26	1.41	1.44
Utah	12,120	14,350	15,940	1,043,500	1,230,320	1,200,850	1.16	1.17	1.33
Vermont	3,600	3,790	3,120	291,400	301,130	294,090	1.24	1.26	1.06
Virginia	46,400	54,280	54,050	3,412,070	3,670,980	3,597,100	1.36	1.48	1.50
Washington	45,460	55,490	NA	2,560,190	2,868,910	2,764,080	1.78	1.93	NA
West Virginia	4,890	5,320	4,990	680,200	717,740	710,540	0.72	0.74	0.70
Wisconsin	29,850	32,010	30,570	2,687,400	2,776,690	2,673,280	1.11	1.15	1.14
Wyoming	2,110	3,260	3,050	240,730	283,980	278,040	0.88	1.15	1.10
Puerto Rico	7,200	7,990	7,640	962,000	999,010	942,080	0.75	0.80	0.81

NA = not available.

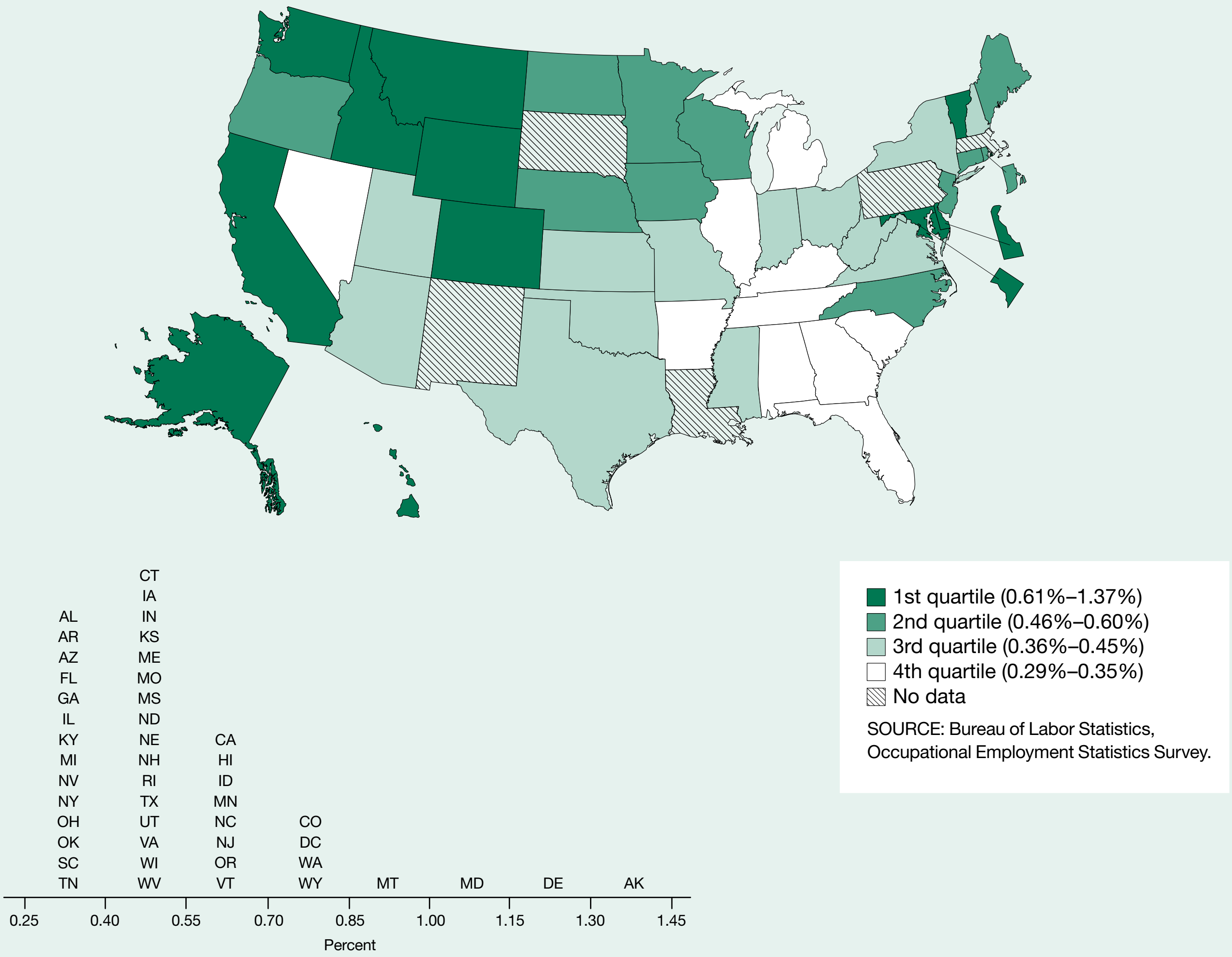
NOTE: United States total includes states with suppressed data.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (various years).

Science and Engineering Indicators 2014

Life and Physical Scientists as a Percentage of All Occupations

Figure 8-37
Life and physical scientists as a percentage of all occupations: 2012



SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey.

Findings

- About 648,000 individuals (0.50% of the workforce) were employed as life and physical scientists in the United States in 2012, an increase from the 544,000 life and physical scientists employed in 2003, which represented 0.43% of the workforce.
- In 2012, individual states had indicator values ranging from 0.27% to 1.37%, which showed major differences in the concentration of jobs in the life and physical sciences.
- States with the highest concentrations of life and physical scientists in their workforces were widely distributed throughout the United States.

This indicator represents the percentage of life and physical scientists in a state's workforce. Life scientists are identified from standard occupational codes and include agricultural and food scientists, biological scientists, conservation scientists and foresters, and medical scientists. Physical scientists are identified from standard occupational codes and include astronomers, physicists, atmospheric and space scientists, chemists, materials scientists, environmental scientists, and geoscientists. A high share of life and physical scientists in a state's workforce could be due to a variety of factors, ranging from a cluster of life sciences companies in the state to the presence of forests or national parks, which require foresters, wildlife specialists, and conservationists to manage the natural assets in these areas.

Data on individuals in life and physical sciences occupations and total occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics from data provided by state workforce agencies.

Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-37

Life and physical scientists as a percentage of all occupations, by state: 2003, 2008, and 2012

	Life and physical scientists			All occupations			Life and physical scientists in all occupations (%)		
State	2003	2008	2012	2003	2008	2012	2003	2008	2012
United States	543,540	621,020	647,850	127,420,170	135,185,230	130,287,700	0.43	0.46	0.50
Alabama	5,720	7,570	6,370	1,817,240	1,945,300	1,824,400	0.31	0.39	0.35
Alaska	3,020	3,720	4,380	290,740	307,790	318,700	1.04	1.21	1.37
Arizona	6,760	7,660	9,210	2,275,410	2,637,830	2,414,340	0.30	0.29	0.38
Arkansas	2,950	3,180	4,020	1,118,690	1,176,050	1,155,020	0.26	0.27	0.35
California	65,400	92,000	99,360	14,460,860	15,212,610	14,303,630	0.45	0.60	0.69
Colorado	NA	15,040	17,220	2,097,650	2,302,340	2,226,160	NA	0.65	0.77
Connecticut	8,210	7,550	8,640	1,631,610	1,697,810	1,620,620	0.50	0.44	0.53
Delaware	3,250	3,420	5,210	403,650	425,210	405,750	0.81	0.80	1.28
District of Columbia	5,650	5,650	5,240	595,220	635,500	653,760	0.95	0.89	0.80
Florida	19,820	22,280	23,140	7,217,400	7,771,740	7,273,850	0.27	0.29	0.32
Georgia	12,290	9,610	11,200	3,770,430	4,068,270	3,815,530	0.33	0.24	0.29
Hawaii	2,450	3,570	3,570	557,400	612,420	588,210	0.44	0.58	0.61
Idaho	3,630	3,100	3,980	563,200	650,240	598,540	0.64	0.48	0.66
Illinois	18,990	20,370	19,240	5,719,150	5,910,630	5,640,740	0.33	0.34	0.34
Indiana	9,100	11,530	11,350	2,851,210	2,927,620	2,811,920	0.32	0.39	0.40
Iowa	4,370	5,900	7,190	1,413,220	1,502,600	1,470,740	0.31	0.39	0.49
Kansas	4,470	6,010	5,520	1,292,170	1,374,560	1,320,920	0.35	0.44	0.42
Kentucky	5,410	NA	5,680	1,719,620	1,817,860	1,764,750	0.31	NA	0.32
Louisiana	6,170	NA	NA	1,851,870	1,887,370	1,868,210	0.33	NA	NA
Maine	2,290	2,750	2,870	591,750	604,150	581,110	0.39	0.46	0.49
Maryland	18,630	22,630	25,880	2,448,580	2,561,530	2,510,680	0.76	0.88	1.03
Massachusetts	20,480	26,930	NA	3,130,720	3,234,860	3,202,080	0.65	0.83	NA
Michigan	10,450	NA	13,300	4,310,420	4,142,750	3,918,120	0.24	NA	0.34
Minnesota	11,530	13,990	15,400	2,591,720	2,704,860	2,641,110	0.44	0.52	0.58
Mississippi	4,430	4,890	4,760	1,089,350	1,138,210	1,080,420	0.41	0.43	0.44
Missouri	9,370	10,620	10,400	2,623,020	2,740,170	2,605,910	0.36	0.39	0.40
Montana	2,870	NA	4,010	394,820	444,090	432,380	0.73	NA	0.93
Nebraska	4,070	3,580	4,280	879,550	928,120	914,830	0.46	0.39	0.47
Nevada	3,130	3,400	3,920	1,086,110	1,278,230	1,127,160	0.29	0.27	0.35
New Hampshire	1,720	2,690	2,720	607,570	634,570	612,710	0.28	0.42	0.44
New Jersey	20,970	25,170	21,380	3,878,020	3,986,310	3,793,720	0.54	0.63	0.56
New Mexico	7,580	6,870	NA	747,050	819,480	773,860	1.01	0.84	NA
New York	30,430	28,460	30,780	8,236,200	8,633,580	8,542,280	0.37	0.33	0.36
North Carolina	18,330	21,860	23,190	3,702,170	4,063,420	3,878,800	0.50	0.54	0.60
North Dakota	1,610	1,650	2,130	314,620	350,360	403,290	0.51	0.47	0.53
Ohio	15,550	19,040	18,140	5,308,270	5,323,130	5,054,250	0.29	0.36	0.36
Oklahoma	6,500	5,720	5,820	1,416,640	1,557,750	1,529,900	0.46	0.37	0.38
Oregon	8,130	9,170	9,610	1,537,000	1,706,740	1,609,900	0.53	0.54	0.60
Pennsylvania	25,470	28,610	NA	5,494,430	5,705,170	5,596,480	0.46	0.50	NA
Rhode Island	2,670	2,080	2,200	477,320	478,420	453,020	0.56	0.43	0.49
South Carolina	4,920	5,220	5,200	1,764,170	1,892,690	1,796,550	0.28	0.28	0.29
South Dakota	1,800	2,350	NA	364,970	395,960	398,680	0.49	0.59	NA
Tennessee	7,240	7,920	8,470	2,614,830	2,755,800	2,657,280	0.28	0.29	0.32
Texas	47,660	46,710	47,770	9,248,660	10,391,420	10,579,400	0.52	0.45	0.45
Utah	5,730	6,520	5,200	1,043,500	1,230,320	1,200,850	0.55	0.53	0.43
Vermont	1,230	1,460	1,860	291,400	301,130	294,090	0.42	0.48	0.63
Virginia	14,750	14,810	15,420	3,412,070	3,670,980	3,597,100	0.43	0.40	0.43
Washington	17,970	NA	21,730	2,560,190	2,868,910	2,764,080	0.70	NA	0.79
West Virginia	2,830	2,890	2,930	680,200	717,740	710,540	0.42	0.40	0.41
Wisconsin	11,600	14,580	12,200	2,687,400	2,776,690	2,673,280	0.43	0.53	0.46
Wyoming	1,670	2,320	2,290	240,730	283,980	278,040	0.69	0.82	0.82
Puerto Rico	4,870	5,380	4,070	962,000	999,010	942,080	0.51	0.54	0.43

NA = not available.

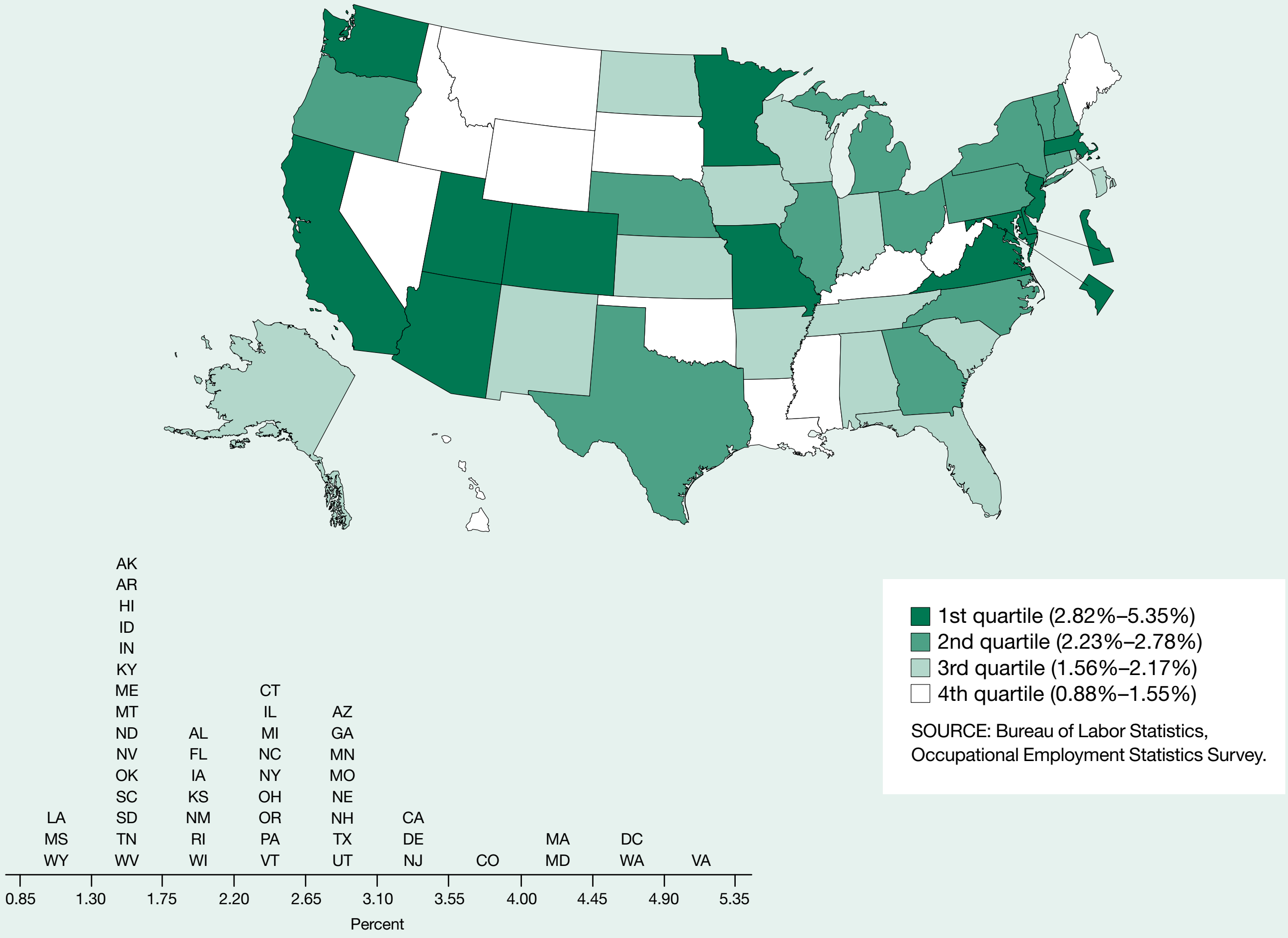
NOTE: United States total includes states with suppressed data.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (various years).

Science and Engineering Indicators 2014

Computer Specialists as a Percentage of All Occupations

Figure 8-38
Computer specialists as a percentage of all occupations: 2012



SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey.

Findings

- In the United States, 3.46 million individuals (2.65% of the workforce) were employed as computer specialists in 2012, an increase from the 2.73 million computer specialists employed in 2003, which accounted for 2.14% of the workforce.
- States showed large differences in the intensity of computer-related operations in their economies, with 0.88% to 5.35% of their workforces employed in computer-related occupations in 2012.
- Computer-intensive occupations were especially concentrated in the District of Columbia and the adjacent states of Maryland and Virginia. This may be due to the presence of many government offices, colleges and universities, and government contractors in the area that employ individuals in computer occupations.
- Experimental Program to Stimulate Competitive Research states tended to have smaller percentages of computer specialists in their workforces and accounted in total for 10% of computer specialists nationally.

This indicator represents the percentage of specialists with advanced computer training in a state's workforce. Computer specialists are identified from standard occupational codes that include computer and information scientists, programmers, software engineers, support specialists, systems analysts, database administrators, and network and computer system administrators. Higher values may indicate a state workforce that is better able to thrive in an information economy or to embrace and use computer technology.

Data on individuals in computer occupations and total occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics from data provided by state workforce agencies.

Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-38

Computer specialists as a percentage of all occupations, by state: 2003, 2008, and 2012

	Computer specialists			All occupations			Computer specialists in all occupations (%)		
State	2003	2008	2012	2003	2008	2012	2003	2008	2012
EPSCoR states	261,450	321,940	337,260	19,688,810	21,058,900	20,239,580	1.33	1.53	1.67
Non-EPSCoR states	2,389,820	2,826,110	3,067,180	106,264,140	112,528,090	108,402,850	2.25	2.51	2.83
Average EPSCoR state value	na	na	na	na	na	na	1.37	1.57	1.74
Average non-EPSCoR state value	na	na	na	na	na	na	2.30	2.55	2.87
United States	2,732,640	3,198,050	3,456,500	127,420,190	135,185,230	130,287,700	2.14	2.37	2.65
Alabama	28,010	33,570	37,140	1,817,240	1,945,300	1,824,400	1.54	1.73	2.04
Alaska	3,170	4,120	5,000	290,740	307,790	318,700	1.09	1.34	1.57
Arizona	45,020	55,840	68,770	2,275,410	2,637,830	2,414,340	1.98	2.12	2.85
Arkansas	11,770*	18,230	18,020*	1,118,690	1,176,050	1,155,020	1.05	1.55	1.56
California	361,640	401,690	458,630	14,460,860	15,212,610	14,303,630	2.50	2.64	3.21
Colorado	73,490	84,680	88,840	2,097,650	2,302,340	2,226,160	3.50	3.68	3.99
Connecticut	42,600	44,470	41,610	1,631,610	1,697,810	1,620,620	2.61	2.62	2.57
Delaware	8,930*	11,800*	13,130	403,650	425,210	405,750	2.21	2.78	3.24
District of Columbia	26,590	32,170	31,340	595,220	635,500	653,760	4.47	5.06	4.79
Florida	132,520	147,920	153,030	7,217,400	7,771,740	7,273,850	1.84	1.90	2.10
Georgia	86,970	91,760	101,120	3,770,430	4,068,270	3,815,530	2.31	2.26	2.65
Hawaii	7,170	8,040	8,950	557,400	612,420	588,210	1.29	1.31	1.52
Idaho	7,720	10,990*	9,010*	563,200	650,240	598,540	1.37	1.69	1.51
Illinois	120,840*	138,900	142,000	5,719,150	5,910,630	5,640,740	2.11	2.35	2.52
Indiana	36,440	43,090	45,450*	2,851,210	2,927,620	2,811,920	1.28	1.47	1.62
Iowa	20,640	26,920	29,300	1,413,220	1,502,600	1,470,740	1.46	1.79	1.99
Kansas	19,980	28,170	27,790	1,292,170	1,374,560	1,320,920	1.55	2.05	2.10
Kentucky	24,370	27,770	27,410	1,719,620	1,817,860	1,764,750	1.42	1.53	1.55
Louisiana	18,190	16,770	19,050	1,851,870	1,887,370	1,868,210	0.98	0.89	1.02
Maine	6,730	7,960	8,550	591,750	604,150	581,110	1.14	1.32	1.47
Maryland	87,350	91,600	101,660	2,448,580	2,561,530	2,510,680	3.57	3.58	4.05
Massachusetts	102,180	117,580	133,370	3,130,720	3,234,860	3,202,080	3.26	3.63	4.17
Michigan	71,830*	88,570	91,460	4,310,420	4,142,750	3,918,120	1.67	2.14	2.33
Minnesota	67,110	79,500	79,410	2,591,720	2,704,860	2,641,110	2.59	2.94	3.01
Mississippi	8,200	9,800	9,490	1,089,350	1,138,210	1,080,420	0.75	0.86	0.88
Missouri	55,730	66,140*	74,530	2,623,020	2,740,170	2,605,910	2.12	2.41	2.86
Montana	4,790*	5,270*	6,250	394,820	444,090	432,380	1.21	1.19	1.45
Nebraska	15,960*	20,110	24,330	879,550	928,120	914,830	1.81	2.17	2.66
Nevada	10,490	13,890	14,780	1,086,110	1,278,230	1,127,160	0.97	1.09	1.31
New Hampshire	12,780	17,560	17,030	607,570	634,570	612,710	2.10	2.77	2.78
New Jersey	109,960	131,090	121,030	3,878,020	3,986,310	3,793,720	2.84	3.29	3.19
New Mexico	11,380*	12,050	13,980	747,050	819,480	773,860	1.52	1.47	1.81
New York	167,790	201,100*	206,960	8,236,200	8,633,580	8,542,280	2.04	2.33	2.42
North Carolina	68,320	87,410	99,940	3,702,170	4,063,420	3,878,800	1.85	2.15	2.58
North Dakota	3,050	4,660*	6,740	314,620	350,360	403,290	0.97	1.33	1.67
Ohio	92,040	116,010	124,070	5,308,270	5,323,130	5,054,250	1.73	2.18	2.45
Oklahoma	21,600*	25,790	22,860	1,416,640	1,557,750	1,529,900	1.52	1.66	1.49
Oregon	31,430	37,010	40,350	1,537,000	1,706,740	1,609,900	2.04	2.17	2.51
Pennsylvania	98,860	118,710	127,390	5,494,430	5,705,170	5,596,480	1.80	2.08	2.28
Rhode Island	9,190*	9,180*	9,770	477,320	478,420	453,020	1.93	1.92	2.16
South Carolina	19,560	28,010	28,940	1,764,170	1,892,690	1,796,550	1.11	1.48	1.61
South Dakota	4,910	5,950	6,120	364,970	395,960	398,680	1.35	1.50	1.54
Tennessee	35,700	38,250	41,480	2,614,830	2,755,800	2,657,280	1.37	1.39	1.56
Texas	197,310	257,960	285,120	9,248,660	10,391,420	10,579,400	2.13	2.48	2.70
Utah	25,930	32,220	33,850	1,043,500	1,230,320	1,200,850	2.48	2.62	2.82
Vermont	5,080	5,460	6,560	291,400	301,130	294,090	1.74	1.81	2.23
Virginia	142,270	172,550	192,490	3,412,070	3,670,980	3,597,100	4.17	4.70	5.35
Washington	79,320	104,850	127,310	2,560,190	2,868,910	2,764,080	3.10	3.65	4.61
West Virginia	6,960	7,360	9,520	680,200	717,740	710,540	1.02	1.03	1.34
Wisconsin	36,530	50,290	58,010	2,687,400	2,776,690	2,673,280	1.36	1.81	2.17
Wyoming	1,680	2,130	2,530	240,730	283,980	278,040	0.70	0.75	0.91
Puerto Rico	7,070	8,750	9,200	962,000	999,010	942,080	0.73	0.88	0.98

* = value may be underreported because one or more codes for computer occupations were suppressed by the state or the Bureau of Labor Statistics and were not reported at the state level; na = not applicable.

EPSCoR = Experimental Program to Stimulate Competitive Research.

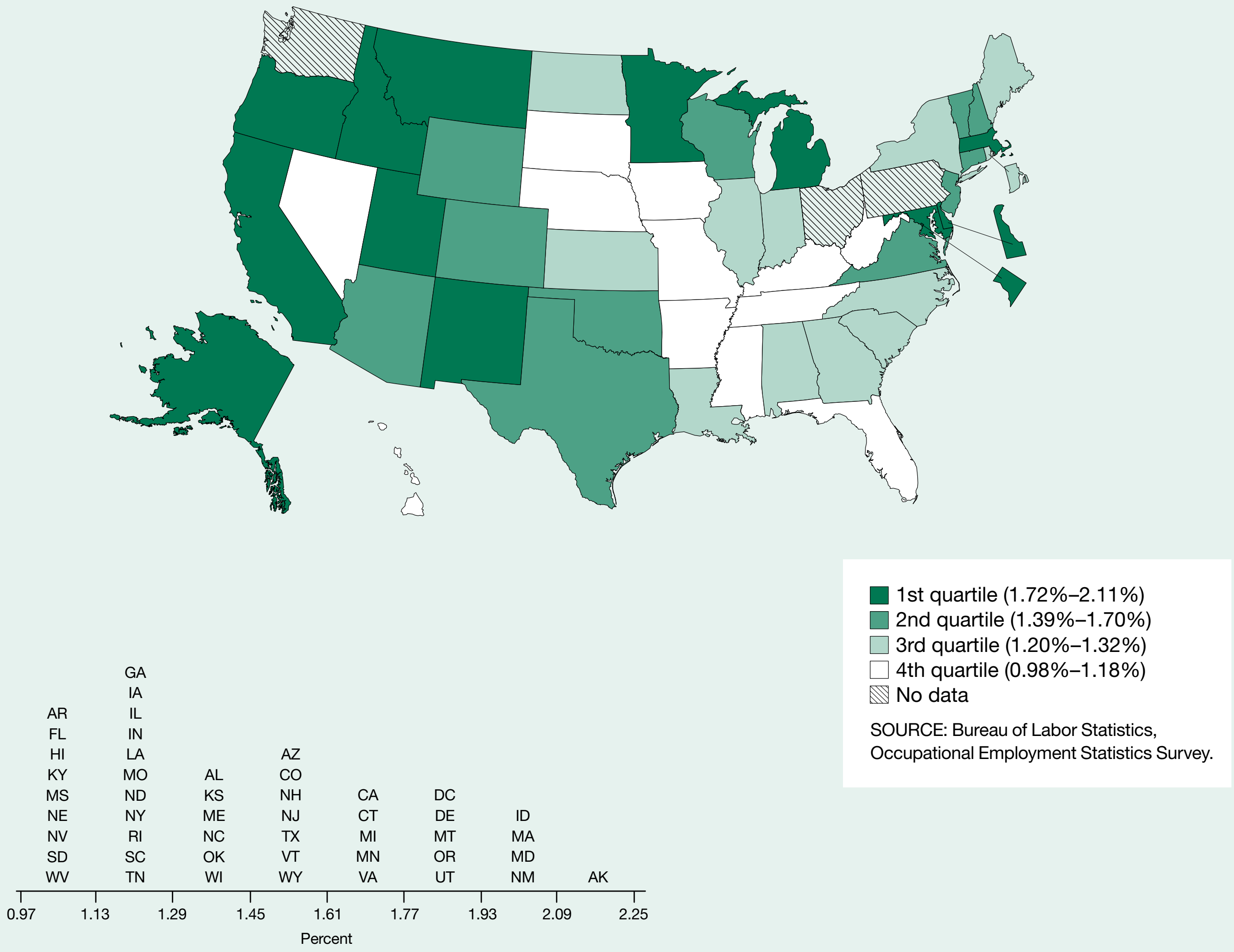
NOTES: United States total includes states with suppressed data. For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (various years).

Science and Engineering Indicators 2014

Technical Workers as a Percentage of All Occupations

Figure 8-39
Technical workers as a percentage of all occupations: 2012



SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey.

Findings

- Only 2 states increased in the use of technical workers between 2003 and 2012. The number of technical workers exceeded the number of doctorate holders, engineers, or life and physical scientists in the workforce during this period.
- Nearly 1.89 million individuals (1.45% of the U.S. workforce) were employed as technical workers in 2012, a decrease from the more than 2 million technical workers employed in 2003, which accounted for 1.61% of the workforce.
- Individual states showed large differences in the percentage of technical workers in their workforce, with 0.98% to 2.11% of their workforce employed as technical workers in 2012.
- Experimental Program to Stimulate Competitive Research states tended to have smaller percentages of technical workers in their workforces and accounted in total for 14% of technical workers nationally.

Technical workers include managers in the areas of computer and information science, engineering, or the natural sciences; computer programmers; drafters working in architecture, civil engineering, electronics, or mechanical engineering; and technicians in a wide variety of technical fields. Individuals who work as scientists and engineers are not included in this indicator.

Data on technical occupations and total occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates are developed by the Bureau of Labor Statistics from data provided by state workforce agencies and do not include self-employed persons.

Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-39
Technical workers as a percentage of all occupations, by state: 2003, 2008, and 2012

	Technical workers			All occupations			Technical workers in all occupations (%)		
State	2003	2008	2012	2003	2008	2012	2003	2008	2012
EPSCoR states	220,020	290,540	264,220	19,688,810	21,058,900	20,239,580	1.12	1.38	1.31
Non-EPSCoR states	1,323,500	1,754,580	1,409,960	106,264,140	112,528,090	108,402,850	1.25	1.56	1.30
Average EPSCoR state value	na	na	na	na	na	na	1.15	1.48	1.40
Average non-EPSCoR state value	na	na	na	na	na	na	1.27	1.58	1.50
United States	1,561,840	2,071,260	1,888,050	127,420,190	135,185,230	130,287,700	1.23	1.53	1.45
Alabama	22,040	25,000	23,770	1,817,240	1,945,300	1,824,400	1.21	1.29	1.30
Alaska	5,140	6,950	6,730	290,740	307,790	318,700	1.77	2.26	2.11
Arizona	30,770	46,960	37,860	2,275,410	2,637,830	2,414,340	1.35	1.78	1.57
Arkansas	10,040	13,470	12,160	1,118,690	1,176,050	1,155,020	0.90	1.15	1.05
California	173,750	248,640	246,680	14,460,860	15,212,610	14,303,630	1.20	1.63	1.72
Colorado	29,940	37,480	33,200	2,097,650	2,302,340	2,226,160	1.43	1.63	1.49
Connecticut	21,800	31,020	26,880	1,631,610	1,697,810	1,620,620	1.34	1.83	1.66
Delaware	5,100	9,170	7,190	403,650	425,210	405,750	1.26	2.16	1.77
District of Columbia	6,840	11,310	11,880	595,220	635,500	653,760	1.15	1.78	1.82
Florida	83,390	94,870	78,110	7,217,400	7,771,740	7,273,850	1.16	1.22	1.07
Georgia	39,760	49,960	48,930	3,770,430	4,068,270	3,815,530	1.05	1.23	1.28
Hawaii	4,580	7,090	6,570	557,400	612,420	588,210	0.82	1.16	1.12
Idaho	7,760	15,520	12,350	563,200	650,240	598,540	1.38	2.39	2.06
Illinois	59,280	78,950	71,670	5,719,150	5,910,630	5,640,740	1.04	1.34	1.27
Indiana	30,740	36,430	35,600	2,851,210	2,927,620	2,811,920	1.08	1.24	1.27
Iowa	13,360	19,560	17,410	1,413,220	1,502,600	1,470,740	0.95	1.30	1.18
Kansas	14,650	20,380	17,460	1,292,170	1,374,560	1,320,920	1.13	1.48	1.32
Kentucky	15,420	18,670	17,330	1,719,620	1,817,860	1,764,750	0.90	1.03	0.98
Louisiana	20,860	25,160	23,430	1,851,870	1,887,370	1,868,210	1.13	1.33	1.25
Maine	6,610	8,450	7,540	591,750	604,150	581,110	1.12	1.40	1.30
Maryland	35,560	47,210	48,880	2,448,580	2,561,530	2,510,680	1.45	1.84	1.95
Massachusetts	43,010	64,150	63,310	3,130,720	3,234,860	3,202,080	1.37	1.98	1.98
Michigan	75,280	72,440	67,450	4,310,420	4,142,750	3,918,120	1.75	1.75	1.72
Minnesota	35,540	47,300	45,380	2,591,720	2,704,860	2,641,110	1.37	1.75	1.72
Mississippi	8,920	14,790	10,630	1,089,350	1,138,210	1,080,420	0.82	1.30	0.98
Missouri	29,980	37,420	30,340	2,623,020	2,740,170	2,605,910	1.14	1.37	1.16
Montana	5,090	6,730	8,050	394,820	444,090	432,380	1.29	1.52	1.86
Nebraska	9,820	10,780	10,290	879,550	928,120	914,830	1.12	1.16	1.12
Nevada	9,420	13,310	11,270	1,086,110	1,278,230	1,127,160	0.87	1.04	1.00
New Hampshire	7,020	10,410	9,280	607,570	634,570	612,710	1.16	1.64	1.51
New Jersey	54,950	68,530	57,440	3,878,020	3,986,310	3,793,720	1.42	1.72	1.51
New Mexico	13,740	16,560	16,120	747,050	819,480	773,860	1.84	2.02	2.08
New York	84,250	126,730	106,730	8,236,200	8,633,580	8,542,280	1.02	1.47	1.25
North Carolina	43,910	62,530	50,890	3,702,170	4,063,420	3,878,800	1.19	1.54	1.31
North Dakota	3,330	4,710	4,870	314,620	350,360	403,290	1.06	1.34	1.21
Ohio	59,130	68,590	NA	5,308,270	5,323,130	5,054,250	1.11	1.29	NA
Oklahoma	15,280	20,040	21,810	1,416,640	1,557,750	1,529,900	1.08	1.29	1.43
Oregon	21,270	31,440	29,410	1,537,000	1,706,740	1,609,900	1.38	1.84	1.83
Pennsylvania	65,160	82,850	NA	5,494,430	5,705,170	5,596,480	1.19	1.45	NA
Rhode Island	5,090	6,600	5,430	477,320	478,420	453,020	1.07	1.38	1.20
South Carolina	21,170	27,370	22,870	1,764,170	1,892,690	1,796,550	1.20	1.45	1.27
South Dakota	3,470	3,990	4,040	364,970	395,960	398,680	0.95	1.01	1.01
Tennessee	27,640	31,230	30,050	2,614,830	2,755,800	2,657,280	1.06	1.13	1.13
Texas	130,250	186,370	163,880	9,248,660	10,391,420	10,579,400	1.41	1.79	1.55
Utah	14,890	23,910	21,620	1,043,500	1,230,320	1,200,850	1.43	1.94	1.80
Vermont	2,570	4,450	4,390	291,400	301,130	294,090	0.88	1.48	1.49
Virginia	50,660	62,770	61,190	3,412,070	3,670,980	3,597,100	1.48	1.71	1.70
Washington	39,510	56,080	NA	2,560,190	2,868,910	2,764,080	1.54	1.95	NA
West Virginia	8,090	8,530	7,910	680,200	717,740	710,540	1.19	1.19	1.11
Wisconsin	29,720	41,160	37,050	2,687,400	2,776,690	2,673,280	1.11	1.48	1.39
Wyoming	2,720	4,210	4,170	240,730	283,980	278,040	1.13	1.48	1.50
Puerto Rico	9,560	10,750	10,640	962,000	999,010	942,080	0.99	1.08	1.13

na = not applicable; NA = not available.

EPSCoR = Experimental Program to Stimulate Competitive Research.

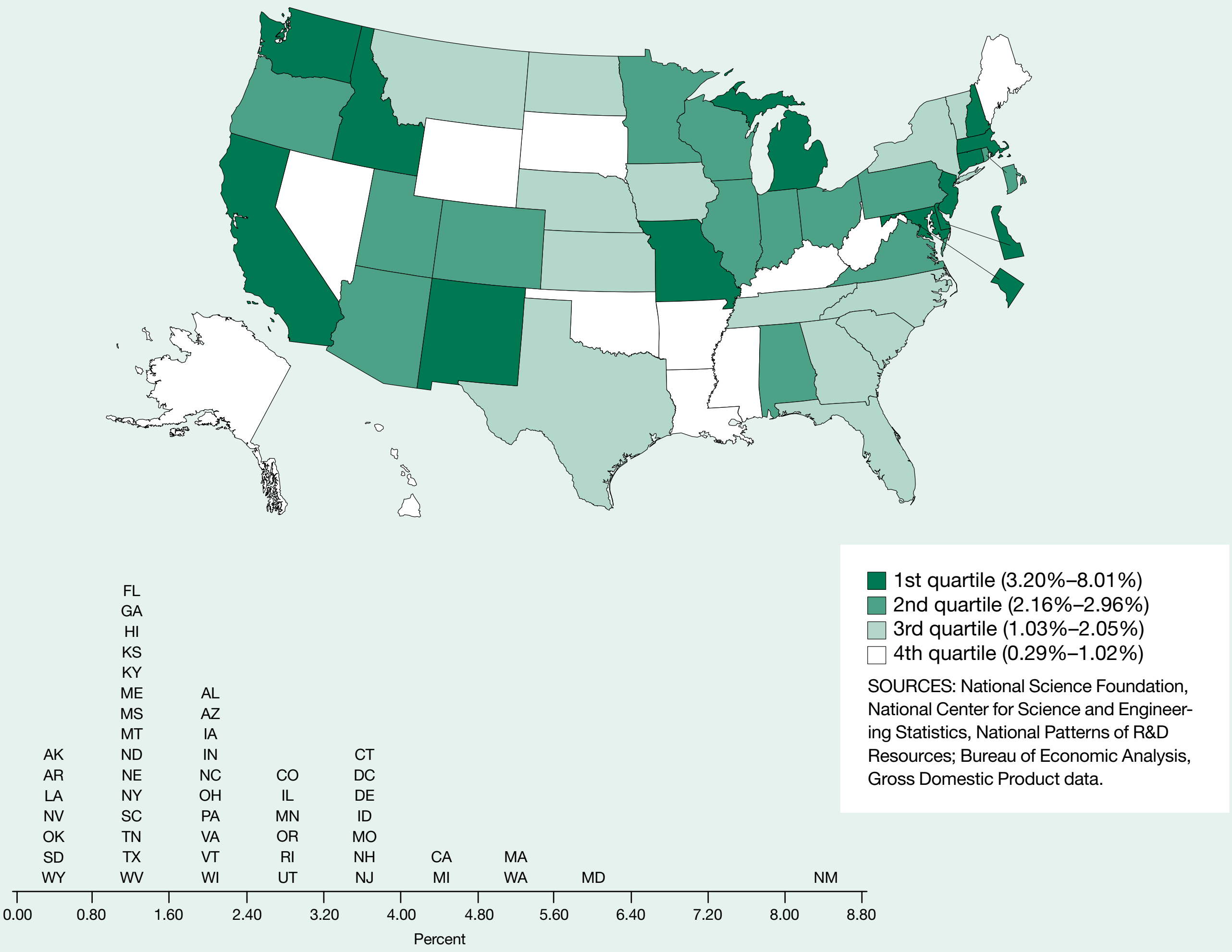
NOTES: United States total includes states with suppressed data. For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (various years).

Science and Engineering Indicators 2014

R&D as a Percentage of Gross Domestic Product

Figure 8-40
R&D as a percentage of gross domestic product: 2010



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The national value of this indicator rose slightly between 2000 and 2010, from 2.48% to 2.61%.
- In 2010, state values for this indicator ranged from 0.29% to 8.01%, indicating large differences in the geographic concentration of R&D activity.
- New Mexico has a large amount of federal R&D activities and a relatively small GDP, giving it the highest value for this indicator.
- States with high rankings on this indicator also tended to rank high on S&E doctorate holders as a share of the workforce.
- The total R&D performed in states in the Experimental Program to Stimulate Competitive Research (EPSCoR) group was approximately 9% of that performed in states in the non-EPSCoR group in 2010.

This indicator represents the extent to which R&D plays a role in a state's economy. A high value indicates that a state has a high intensity of R&D activity, which may support future growth in knowledge-based industries. Industries that have a high percentage of R&D activity include pharmaceuticals, chemicals, computer equipment and services, electronic components, aerospace, and motor vehicles.

"R&D performed" refers to R&D activities conducted or funded by federal and state agencies, businesses, universities, and nonprofit organizations. In 2010, business performed nearly 69% of the total R&D at the national level. The remaining R&D was performed by colleges and universities, government facilities (including federally funded R&D centers), and nonprofit institutions.

The methodology for assigning industry R&D activity at the state level was modified in 2001, and 1998–2000 data were recalculated using the new methodology.

Table 8-40

R&D as a percentage of gross domestic product, by state: 2000, 2005, and 2010

	R&D performed ($millions)			State GDP ($millions)			R&D performed/ state GDP (%)		
State	2000	2005	2010	2000	2005	2010	2000	2005	2010
EPSCoR states	18,292	27,056	31,731	1,309,452	1,725,273	2,017,488	1.40	1.57	1.57
Non-EPSCoR states	223,827	279,001	339,269	8,456,735	10,649,784	12,164,950	2.65	2.62	2.79
Average EPSCoR state value	na	na	na	na	na	na	1.62	1.76	1.75
Average non-EPSCoR state value	na	na	na	na	na	na	2.47	2.65	2.83
United States	244,852	310,197	375,724	9,884,170	12,539,116	14,388,814	2.48	2.47	2.61
Alabama	1,730	2,804	3,738	116,009	150,968	172,842	1.49	1.86	2.16
Alaska	196	266	347	25,911	37,774	47,910	0.76	0.70	0.72
Arizona	3,107	4,139	5,481	161,792	222,569	247,329	1.92	1.86	2.22
Arkansas	454	528	590	68,335	88,501	103,170	0.66	0.60	0.57
California	55,093	63,874	81,005	1,319,472	1,688,949	1,845,249	4.18	3.78	4.39
Colorado	4,230	5,807	6,164	172,037	217,329	254,551	2.46	2.67	2.42
Connecticut	4,888	8,987	7,435	163,455	196,307	221,767	2.99	4.58	3.35
Delaware	1,532	1,635	2,327	40,614	54,422	62,832	3.77	3.00	3.70
District of Columbia	2,296	3,342	3,568	58,267	82,488	103,745	3.94	4.05	3.44
Florida	4,663	6,224	7,952	481,239	681,225	727,972	0.97	0.91	1.09
Georgia	2,796	3,867	5,451	293,966	363,177	402,006	0.95	1.06	1.36
Hawaii	291	513	688	41,450	56,901	67,274	0.70	0.90	1.02
Idaho	1,434	1,030	1,779	36,147	48,683	55,639	3.97	2.12	3.20
Illinois	12,767	12,519	15,820	474,520	568,114	642,769	2.69	2.20	2.46
Indiana	3,252	5,455	6,339	198,238	239,321	270,739	1.64	2.28	2.34
Iowa	1,017	1,669	2,765	93,312	119,998	138,378	1.09	1.39	2.00
Kansas	1,420	2,366	2,002	85,722	104,869	126,640	1.66	2.26	1.58
Kentucky	866	1,136	1,498	113,233	138,772	161,064	0.76	0.82	0.93
Louisiana	627	966	1,200	131,289	196,917	227,373	0.48	0.49	0.53
Maine	319	524	488	36,438	45,520	51,343	0.88	1.15	0.95
Maryland	8,634	14,136	18,429	182,923	247,241	295,981	4.72	5.72	6.23
Massachusetts	13,004	17,757	20,195	273,006	323,314	376,908	4.76	5.49	5.36
Michigan	18,892	18,372	14,702	337,459	375,753	367,107	5.60	4.89	4.00
Minnesota	4,299	7,137	7,393	188,818	237,813	268,578	2.28	3.00	2.75
Mississippi	513	777	852	65,625	81,360	95,763	0.78	0.96	0.89
Missouri	2,583	3,627	9,253	180,967	216,336	243,876	1.43	1.68	3.79
Montana	170	318	390	21,633	30,054	36,521	0.79	1.06	1.07
Nebraska	439	800	935	57,333	72,505	90,910	0.77	1.10	1.03
Nevada	377	614	939	75,895	114,478	124,838	0.50	0.54	0.75
New Hampshire	775	1,776	2,159	44,161	53,693	61,147	1.75	3.31	3.53
New Jersey	13,133	14,900	17,876	350,110	430,246	483,007	3.75	3.46	3.70
New Mexico	3,085	5,265	6,225	50,294	67,763	77,686	6.13	7.77	8.01
New York	13,556	14,103	17,141	769,291	959,867	1,136,417	1.76	1.47	1.51
North Carolina	5,045	7,329	8,746	281,542	354,664	426,875	1.79	2.07	2.05
North Dakota	146	285	468	18,266	24,670	35,357	0.80	1.16	1.32
Ohio	7,662	8,267	10,048	380,895	444,083	465,679	2.01	1.86	2.16
Oklahoma	660	814	1,029	91,273	120,529	147,649	0.72	0.68	0.70
Oregon	2,116	3,920	5,250	113,180	143,429	181,523	1.87	2.73	2.89
Pennsylvania	9,842	11,916	13,074	395,602	482,200	558,818	2.49	2.47	2.34
Rhode Island	1,501	1,990	1,439	33,584	44,189	48,572	4.47	4.50	2.96
South Carolina	1,126	2,108	2,384	115,443	141,877	162,292	0.98	1.49	1.47
South Dakota	85	157	270	24,038	31,549	38,297	0.35	0.50	0.71
Tennessee	2,057	3,009	3,955	177,540	224,288	253,602	1.16	1.34	1.56
Texas	11,552	15,867	19,504	731,064	968,553	1,226,714	1.58	1.64	1.59
Utah	1,361	1,886	3,197	69,489	90,616	118,225	1.96	2.08	2.70
Vermont	465	493	452	18,039	22,743	25,809	2.58	2.17	1.75
Virginia	5,069	8,568	10,063	261,759	356,370	422,763	1.94	2.40	2.38
Washington	10,516	11,864	16,685	227,704	279,333	342,702	4.62	4.25	4.87
West Virginia	457	567	584	41,386	51,857	62,732	1.10	1.09	0.93
Wisconsin	2,693	3,802	5,346	177,355	218,689	245,415	1.52	1.74	2.18
Wyoming	61	122	104	17,050	26,250	36,459	0.36	0.46	0.29
Puerto Rico	NA	NA	NA	69,208	86,158	NA	NA	NA	NA

na = not applicable; NA = not available.

EPSCoR = Experimental Program to Stimulate Competitive Research; GDP = gross domestic product.

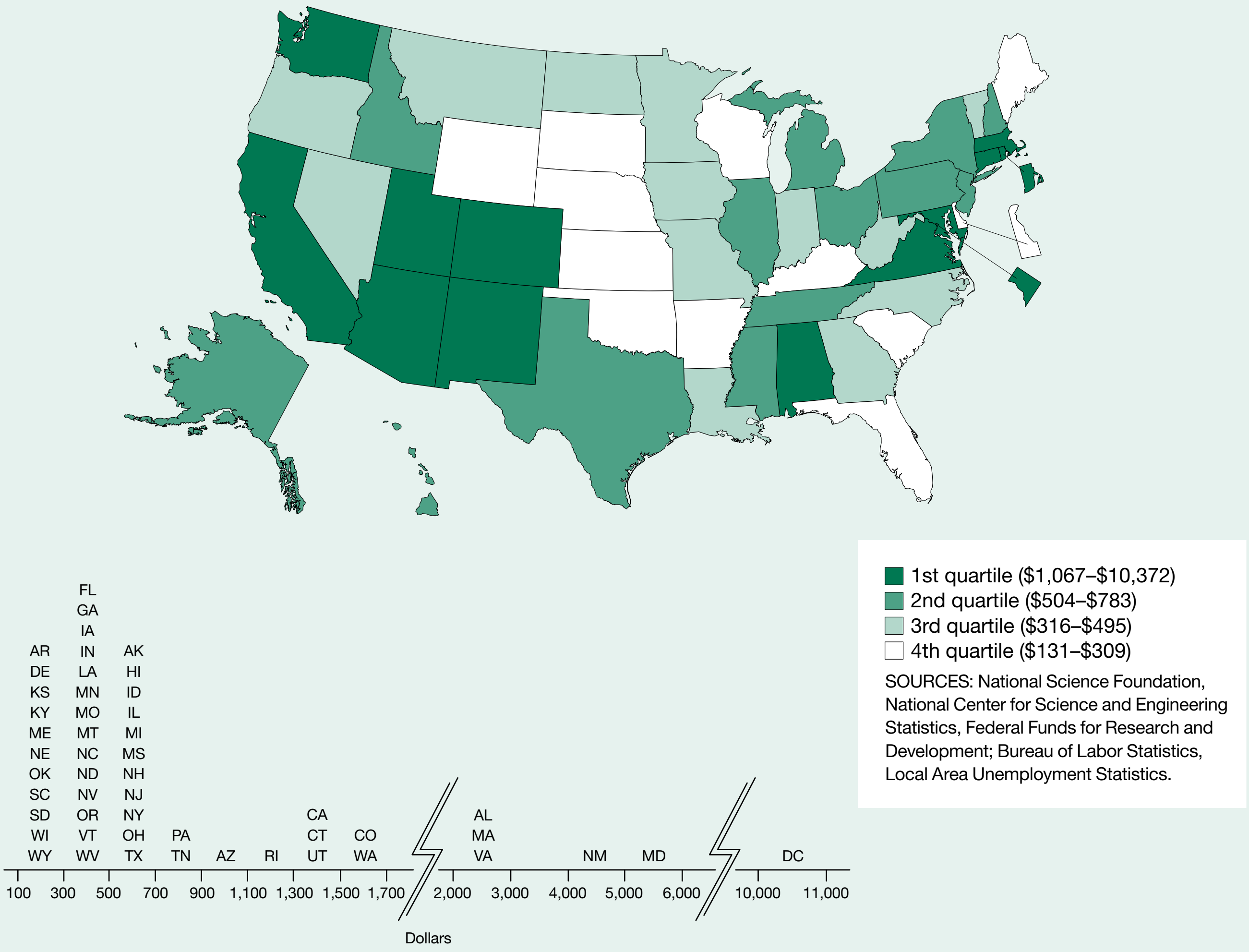
NOTES: R&D includes R&D performed by federal agencies, businesses, universities, other nonprofit organizations, and state agencies. For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (various years); Bureau of Economic Analysis, Gross Domestic Product data (June 2013).

Science and Engineering Indicators 2014

Federal R&D Obligations per Employed Worker

Figure 8-41
Federal R&D obligations per employed worker: 2011



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development; Bureau of Labor Statistics, Local Area Unemployment Statistics.

Findings

- Federal R&D obligations have increased from about $82 billion in 2001 to about $132 billion in 2011, an increase of 60%.
- In 2011, federal R&D obligations per civilian worker were concentrated in a few states; only 12 states and the District of Columbia exceeded the national average of $940 per worker.
- Federal R&D obligations in 2011 varied greatly among the states, ranging from $131 to $5,633 per civilian worker. Higher values were found in the states surrounding the District of Columbia and in sparsely populated states with national laboratories or federal facilities.

This indicator represents how federal R&D obligations are disbursed geographically relative to the size of a state's employed civilian workforce. Federal R&D dollars are attributed to the states in which the recipients are located.

Data on federal obligations for R&D come from the National Center for Science and Engineering Statistics, which aggregates reports from 11 federal agencies. The Department of Defense (DoD) disburses the most federal R&D funding, approximately 50% of the total. The geographic distribution of DoD R&D funding for development to industry reflects the location of prime contractors only, not the subcontractors who perform much of the R&D. A high value may indicate the existence of a number of large prime contractors or major federally funded R&D facilities in a state.

The estimate of a state's workforce is provided by the Bureau of Labor Statistics (BLS). It represents the employed component of the civilian labor force and is not seasonally adjusted. BLS assigns workers to a location based on residence. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-41

Federal R&D obligations per employed worker, by state: 2001, 2006, and 2011

	Federal R&D obligations ($thousands)			Employed workers			Federal R&D obligations/ employed worker ($)		
State	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	82,445,122	107,446,145	132,214,369	137,107,779	143,729,350	140,695,662	601	748	940
Alabama	2,456,769	2,161,708	5,295,260	2,034,909	2,098,462	1,992,522	1,207	1,030	2,658
Alaska	254,444	209,038	202,715	301,694	326,109	337,796	843	641	600
Arizona	1,881,000	2,056,284	2,947,365	2,453,453	2,836,638	2,761,984	767	725	1,067
Arkansas	183,867	156,164	185,011	1,194,024	1,286,887	1,251,877	154	121	148
California	13,001,687	21,156,522	23,766,358	16,220,033	16,821,266	16,237,286	802	1,258	1,464
Colorado	1,450,603	2,029,641	3,956,160	2,303,494	2,541,828	2,490,004	630	798	1,589
Connecticut	1,377,388	1,591,960	2,519,649	1,700,046	1,745,993	1,732,807	810	912	1,454
Delaware	83,546	108,657	115,097	404,135	424,618	407,772	207	256	282
District of Columbia	2,775,973	4,091,852	3,244,864	286,649	303,791	312,859	9,684	13,469	10,372
Florida	2,774,006	2,319,079	2,572,256	7,624,718	8,584,095	8,322,237	364	270	309
Georgia	3,438,270	1,251,445	1,467,224	4,112,868	4,500,150	4,295,113	836	278	342
Hawaii	435,685	340,094	426,895	589,216	617,807	614,824	739	550	694
Idaho	209,344	297,094	461,143	644,816	718,077	702,920	325	414	656
Illinois	1,825,057	1,975,552	2,993,498	6,113,536	6,225,095	5,942,809	299	317	504
Indiana	568,761	559,860	909,639	3,020,985	3,080,047	2,874,722	188	182	316
Iowa	361,455	497,173	702,407	1,568,638	1,595,136	1,562,156	230	312	450
Kansas	306,656	212,152	372,210	1,347,715	1,403,938	1,401,055	228	151	266
Kentucky	370,384	239,141	246,577	1,852,056	1,904,467	1,875,447	200	126	131
Louisiana	275,788	321,096	612,183	1,922,110	1,900,240	1,919,021	143	169	319
Maine	450,735	226,468	181,441	650,699	665,856	649,312	693	340	279
Maryland	9,473,728	12,499,496	16,155,528	2,712,268	2,892,733	2,868,191	3,493	4,321	5,633
Massachusetts	4,499,835	6,104,611	7,789,148	3,275,343	3,255,504	3,216,160	1,374	1,875	2,422
Michigan	1,196,424	1,680,908	2,156,949	4,876,338	4,722,716	4,189,792	245	356	515
Minnesota	900,936	1,237,266	973,293	2,755,808	2,774,524	2,777,285	327	446	350
Mississippi	415,671	544,029	610,041	1,229,884	1,199,871	1,197,641	338	453	509
Missouri	927,045	1,225,269	1,197,459	2,867,853	2,889,461	2,767,043	323	424	433
Montana	136,825	149,876	182,103	447,827	476,412	466,372	306	315	390
Nebraska	145,189	159,986	262,929	925,783	943,176	961,786	157	170	273
Nevada	360,215	422,449	482,238	1,042,182	1,222,277	1,207,799	346	346	399
New Hampshire	474,423	371,808	407,597	680,706	708,748	697,383	697	525	584
New Jersey	1,673,959	2,110,673	2,622,723	4,117,543	4,257,899	4,120,017	407	496	637
New Mexico	2,890,565	3,100,110	3,553,015	821,003	886,708	862,043	3,521	3,496	4,122
New York	3,528,344	5,225,241	5,252,630	8,743,924	9,062,464	8,740,642	404	577	601
North Carolina	1,400,937	1,765,859	2,069,117	3,929,977	4,261,325	4,183,052	356	414	495
North Dakota	77,903	112,067	118,061	336,228	349,368	368,677	232	321	320
Ohio	3,051,142	2,420,136	3,609,891	5,566,735	5,602,764	5,303,655	548	432	681
Oklahoma	324,002	262,336	475,596	1,614,627	1,650,070	1,678,953	201	159	283
Oregon	522,640	505,321	729,170	1,711,041	1,792,039	1,785,400	305	282	408
Pennsylvania	2,772,116	3,227,533	4,528,148	5,874,153	6,021,084	5,892,519	472	536	768
Rhode Island	437,455	615,902	612,766	520,677	543,973	499,481	840	1,132	1,227
South Carolina	314,287	370,562	515,713	1,834,871	1,970,912	1,941,654	171	188	266
South Dakota	54,941	75,926	61,931	400,352	421,799	422,696	137	180	147
Tennessee	1,039,488	1,455,622	2,213,857	2,728,523	2,852,509	2,828,617	381	510	783
Texas	3,189,399	5,263,822	5,904,027	9,991,920	10,757,510	11,493,519	319	489	514
Utah	421,569	737,850	1,757,902	1,108,547	1,285,389	1,254,151	380	574	1,402
Vermont	112,704	105,544	125,857	330,099	343,149	338,632	341	308	372
Virginia	4,995,665	8,882,441	8,637,382	3,537,719	3,862,508	3,928,267	1,412	2,300	2,199
Washington	1,725,258	4,039,292	4,980,150	2,863,705	3,155,384	3,161,818	602	1,280	1,575
West Virginia	376,105	301,416	261,253	758,904	777,210	740,175	496	388	353
Wisconsin	487,948	635,645	752,236	2,897,937	2,932,482	2,832,826	168	217	266
Wyoming	36,986	36,169	37,709	259,508	276,882	284,893	143	131	132
Puerto Rico	90,790	98,790	98,891	1,133,988	1,260,703	1,032,765	80	78	96

NOTES: Only 11 agencies are required to report federal R&D obligations: Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Homeland Security (established in 2002), Interior, and Transportation; Environmental Protection Agency; National Aeronautics and Space Administration; and National Science Foundation. These obligations represent approximately 98% of total federal R&D obligations. Civilian workers represent the employed component of the civilian labor force and are reported as annual data not seasonally adjusted. Federal R&D obligations are reported in current dollars.

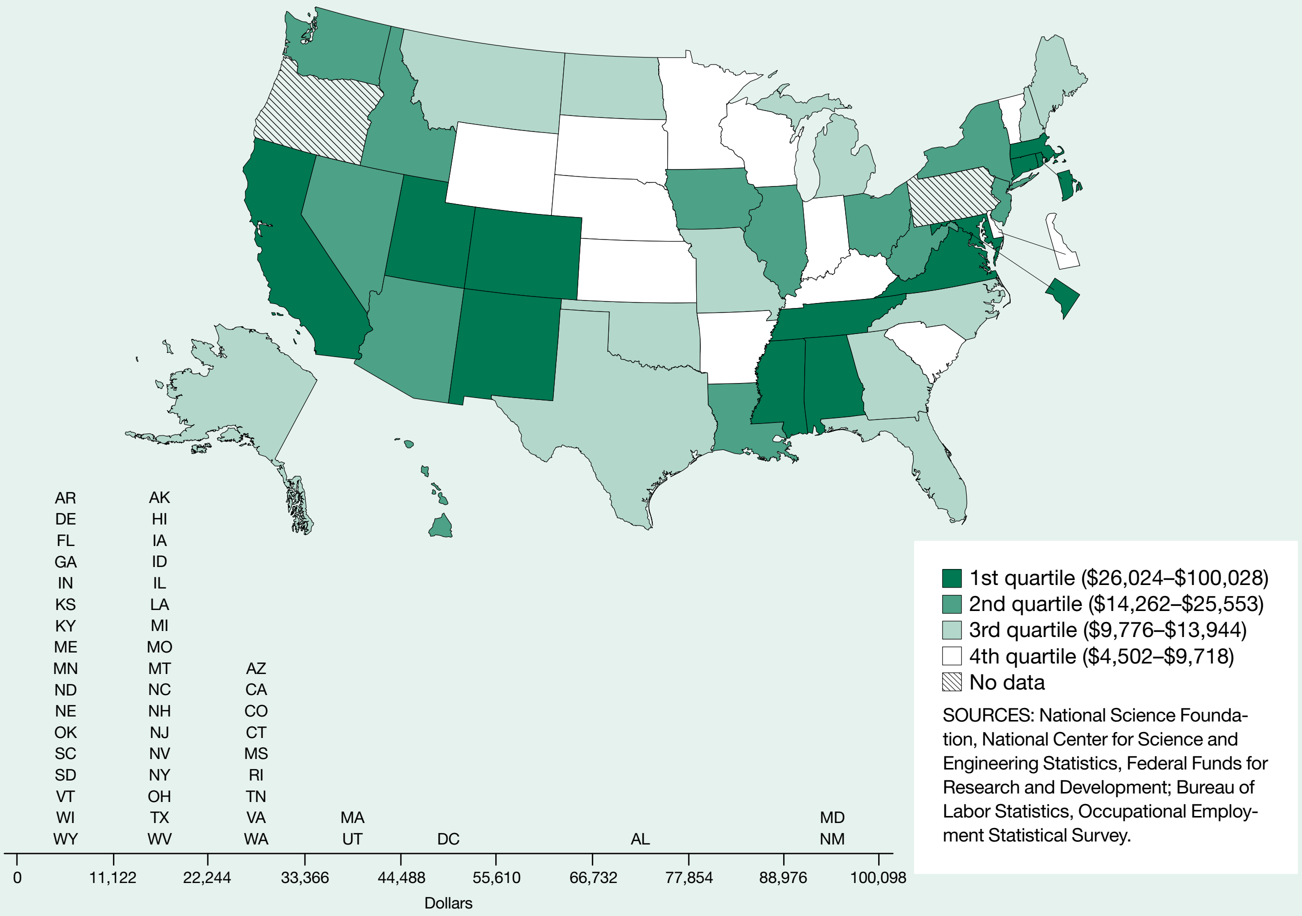
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (various years); Bureau of Labor Statistics, Local Area Unemployment Statistics (various years).

Science and Engineering Indicators 2014

Federal R&D Obligations per Individual in Science and Engineering Occupation

Figure 8-42

Federal R&D obligations per individual in science and engineering occupation: 2011



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development; Bureau of Labor Statistics, Occupational Employment Statistical Survey.

Findings

- The federal government obligated approximately $132 billion for R&D in 2011—nearly $23,000 for each person employed in an S&E occupation.
- Federal R&D obligations per person employed in an S&E occupation ranged across the states from $4,502 to $100,028 in 2011.
- The distribution for this indicator was highly skewed in 2011, with only 14 states and the District of Columbia above the national average. High values were reported in the District of Columbia and adjoining states and also in states where federal facilities or major defense contractors are located.
- The majority of states in the lowest quartile for this indicator in 2011 were Experimental Program to Stimulate Competitive Research states.

This indicator represents the relationship between federal R&D spending in a state and the number of employees in the state who work in S&E occupations. Federal R&D dollars are attributed to the states in which the recipients of federal obligations are located.

Data on federal obligations for R&D come from the National Center for Science and Engineering Statistics, which aggregates reports from 11 federal agencies. The Department of Defense (DoD) disburses the most funding, approximately 50% of the total. The geographic distribution of DoD R&D funding to industry, mostly for development, reflects the location of prime contractors only, not the numerous subcontractors who perform much of the R&D.

S&E occupations are defined by standard occupational codes. They include engineers and computer, mathematical, life, physical, and social scientists. Managers, technicians, elementary and secondary schoolteachers, and medical personnel are not included.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics from data provided by state workforce agencies. Data on people in S&E occupations are sample based.

Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-42

Federal R&D obligations per individual in science and engineering occupation, by state: 2003, 2007, and 2011

State	Federal R&D obligations ($millions)			Individuals in S&E occupations			Federal R&D obligations/individual in S&E occupation ($)		
	2003	2007	2011	2003	2007	2011	2003	2007	2011
United States	100,982	124,684	132,213	4,961,550	5,591,990	5,794,980	20,353	22,297	22,815
Alabama	3,212	2,248	5,295	56,380	69,650	70,290	56,971	32,276	75,331
Alaska	399	264	203	10,600	11,990	15,680	37,642	22,018	12,946
Arizona	2,385	2,422	2,947	92,120	102,380	115,330	25,890	23,657	25,553
Arkansas	145	178	185	21,340	28,460	29,350	6,795	6,254	6,303
California	20,170	26,987	23,766	676,180	753,570	800,430	29,829	35,812	29,692
Colorado	1,735	2,798	3,956	124,140	138,990	144,750	13,976	20,131	27,330
Connecticut	2,068	2,117	2,520	81,380	80,280	76,550	25,412	26,370	32,920
Delaware	95	131	115	17,370	22,140	22,430	5,469	5,917	5,127
District of Columbia	2,986	4,278	3,245	54,890	63,150	62,660	54,400	67,743	51,787
Florida	2,854	4,078	2,572	221,070	244,140	244,970	12,910	16,704	10,499
Georgia	2,133	1,686	1,467	144,170	136,880	147,820	14,795	12,317	9,924
Hawaii	414	379	427	16,090	18,740	20,100	25,730	20,224	21,244
Idaho	218	288	461	22,150	24,330	25,950	9,842	11,837	17,765
Illinois	1,935	2,145	2,993	211,230	225,180	204,420	9,161	9,526	14,641
Indiana	574	597	910	78,410	83,080	93,640	7,320	7,186	9,718
Iowa	500	662	702	37,320	45,430	48,930	13,398	14,572	14,347
Kansas	269	318	372	51,970	50,040	51,530	5,176	6,355	7,219
Kentucky	247	222	247	45,230	49,030	51,990	5,461	4,528	4,751
Louisiana	453	419	612	41,900	38,450	42,760	10,811	10,897	14,312
Maine	167	379	181	15,020	15,960	17,490	11,119	23,747	10,349
Maryland	8,027	11,906	16,156	149,250	162,540	173,020	53,782	73,250	93,376
Massachusetts	5,492	7,529	7,789	184,690	205,610	220,670	29,736	36,618	35,297
Michigan	1,693	1,726	2,157	182,940	212,040	188,380	9,254	8,140	11,450
Minnesota	866	1,387	973	117,120	129,840	130,340	7,394	10,682	7,465
Mississippi	1,181	434	610	22,190	25,520	23,440	53,222	17,006	26,024
Missouri	1,350	1,221	1,197	84,150	102,170	106,930	16,043	11,951	11,194
Montana	131	654	182	11,450	13,240	14,960	11,441	49,396	12,166
Nebraska	168	230	263	30,710	31,420	33,800	5,471	7,320	7,781
Nevada	419	321	482	22,330	26,920	28,370	18,764	11,924	16,990
New Hampshire	512	340	408	23,430	28,450	29,260	21,852	11,951	13,944
New Jersey	2,088	2,192	2,623	161,420	186,120	182,210	12,935	11,777	14,395
New Mexico	3,090	3,478	3,553	33,600	33,440	35,520	91,964	104,007	100,028
New York	4,383	5,368	5,253	272,440	322,520	310,510	16,088	16,644	16,917
North Carolina	1,617	1,828	2,069	132,440	142,970	161,880	12,209	12,786	12,781
North Dakota	107	116	118	8,430	9,660	12,070	12,693	12,008	9,776
Ohio	2,967	3,661	3,610	177,100	196,390	208,140	16,753	18,641	17,344
Oklahoma	570	253	476	44,360	51,430	47,090	12,849	4,919	10,108
Oregon	514	506	729	61,230	67,890	NA	8,395	7,453	NA
Pennsylvania	3,989	3,360	4,528	185,560	218,890	NA	21,497	15,350	NA
Rhode Island	566	628	613	18,740	18,400	19,450	30,203	34,130	31,517
South Carolina	454	422	516	48,740	54,120	61,020	9,315	7,797	8,456
South Dakota	55	62	62	9,150	11,550	11,790	6,011	5,368	5,259
Tennessee	1,131	1,908	2,214	63,680	70,820	77,630	17,761	26,942	28,520
Texas	5,414	6,693	5,904	365,270	441,410	469,080	14,822	15,163	12,586
Utah	803	991	1,758	45,570	51,340	51,350	17,621	19,303	34,236
Vermont	201	108	126	11,420	12,760	13,100	17,601	8,464	9,618
Virginia	6,709	9,088	8,637	209,280	254,710	267,620	32,058	35,680	32,273
Washington	2,442	4,751	4,980	150,230	183,900	196,760	16,255	25,835	25,310
West Virginia	383	219	261	16,220	16,560	18,300	23,613	13,225	14,262
Wisconsin	658	671	752	93,320	99,380	102,320	7,051	6,752	7,349
Wyoming	43	37	38	6,130	8,110	8,440	7,015	4,562	4,502
Puerto Rico	112	86	99	19,940	23,630	20,990	5,617	3,639	4,717

NA = not available.

NOTES: Only 11 agencies are required to report federal R&D obligations: Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Homeland Security (established in 2002), Interior, and Transportation; Environmental Protection Agency; National Aeronautics and Space Administration; and National Science Foundation. These obligations represent approximately 98% of total federal R&D obligations. Federal R&D obligations are reported in current dollars. Occupational Employment Statistics estimates for 2003 are based on November data; estimates for the remaining years are based on May data.

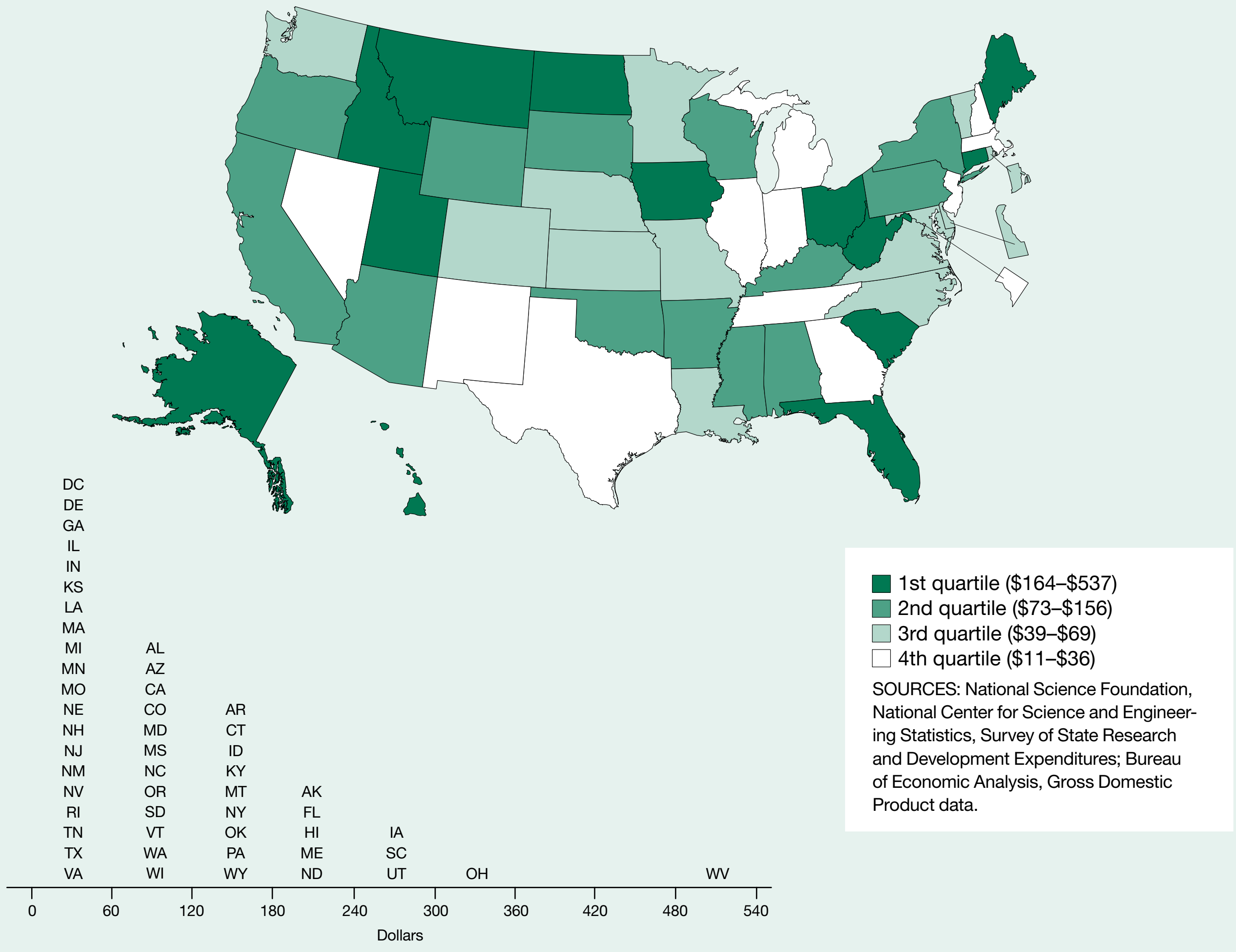
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (various years); Bureau of Labor Statistics, Occupational Employment Statistics Survey (various years).

Science and Engineering Indicators 2014

State Agency R&D Expenditures per $1 Million of Gross Domestic Product

Figure 8-43

State agency R&D expenditures per $1 million of gross domestic product: 2011



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- Nationally, state government agencies spent a total of $1.4 billion on R&D in 2011. This represented $94 for each $1 million of a state's gross domestic product (GDP).
- National, state agency R&D expenditures accounted for less than one-half of 1% of total R&D expenditures in 2001, 2006, and 2011; most R&D was funded by nonstate sources.
- In 2011, the state values for this indicator ranged from $13 to $537 per $1 million of state GDP.
- Five Experimental Program to Stimulate Competitive Research (EPSCoR) states are among those with the highest values for this indicator, suggesting that there is a state-level effort to improve R&D infrastructure in these states, not just a federal effort. The average value of this indicator for EPSCoR states exceeded that of non-EPSCoR states from 2006 to 2011.

This indicator represents the ratio of state agency R&D funding to the size of a state's economy. State R&D expenditures include state-administered funds from all sources that support R&D performed by either a state agency or an external performer.

Data on state R&D funding cover funding administered by state government departments, agencies, independent commissions, and other state-run entities. They exclude state-run colleges and universities as well as laboratories or experiment stations controlled by state universities; funding administered by these institutions is classified as academic R&D. The data also exclude state legislatures' direct appropriations to nonstate agencies. Some data may include expenditures for non-R&D activities such as commercialization, environmental testing, and routine survey work.

Because of differences in the survey populations, definition of covered R&D activities, and collection methods, the results of National Science Foundation surveys on state government R&D prior to 2006 are not comparable.

Table 8-43

State agency R&D expenditures per $1 million of gross domestic product, by state: 2006, 2009, and 2011

State	State agency R&D expenditures ($)			State GDP ($millions)			State agency R&D ($)/ $1 million GDP		
	2006	2009	2011	2006	2009	2011	2006	2009	2011
EPSCoR states	162,703,455	170,308,360	243,823,609	1,827,039	1,928,030	2,102,177	89	88	116
Non-EPSCoR states	824,010,424	1,012,336,215	1,137,595,278	11,288,411	11,746,303	12,640,405	73	86	90
Average EPSCoR state value	na	na	na	na	na	na	107	94	123
Average non-EPSCoR state value	na	na	na	na	na	na	73	93	95
United States	1,021,016,894	1,213,524,157	1,403,816,235	13,289,242	13,869,679	14,959,781	77	87	94
Alabama	7,269,319	12,929,167	19,684,063	159,059	166,315	178,533	46	78	110
Alaska	10,019,060	7,741,467	11,349,400	41,782	45,149	51,237	240	171	222
Arizona	37,151,471	9,363,943	18,626,577	246,099	245,216	255,989	151	38	73
Arkansas	4,869,648	11,465,214	14,705,327	93,792	99,530	106,557	52	115	138
California	107,793,045	146,793,247	149,810,643	1,798,197	1,818,627	1,908,985	60	81	78
Colorado	8,997,236	15,563,581	18,141,931	230,236	245,362	264,733	39	63	69
Connecticut	19,209,064	28,559,052	39,192,091	209,487	217,103	225,409	92	132	174
Delaware	2,812,102	1,683,562	2,609,902	56,262	60,201	64,377	50	28	41
District of Columbia	1,173,076	487,411	1,221,108	86,736	98,355	107,201	14	5	11
Florida	42,329,624	66,513,756	150,764,438	731,467	721,175	746,439	58	92	202
Georgia	10,620,188	6,662,887	11,690,663	380,530	393,964	417,438	28	17	28
Hawaii	12,067,849	13,976,364	13,103,983	60,993	64,787	70,006	198	216	187
Idaho	2,280,873	8,552,058	9,366,052	50,509	54,285	57,096	45	158	164
Illinois	37,184,281	9,570,893	17,207,125	600,668	625,423	670,247	62	15	26
Indiana	6,220,575	47,549,928	6,983,364	248,630	252,488	284,344	25	188	25
Iowa	13,564,062	37,976,643	36,992,222	124,057	134,659	146,057	109	282	253
Kansas	14,348,384	12,305,385	6,635,626	111,658	121,967	134,767	129	101	49
Kentucky	17,558,997	13,938,134	20,498,849	146,409	152,040	168,019	120	92	122
Louisiana	11,216,568	8,285,478	9,203,635	204,437	204,370	237,389	55	41	39
Maine	17,509,051	6,400,019	9,918,765	47,594	50,048	52,489	368	128	189
Maryland	24,945,119	21,093,331	20,084,540	259,792	284,724	305,175	96	74	66
Massachusetts	10,729,419	3,290,198	4,878,927	337,483	360,675	388,575	32	9	13
Michigan	75,016,589	8,630,209	9,802,873	376,208	349,195	385,123	199	25	25
Minnesota	6,219,201	16,655,913	11,653,327	245,026	257,596	279,987	25	65	42
Mississippi	2,744,882	3,623,953	7,420,851	85,854	92,614	97,533	32	39	76
Missouri	18,465,303	15,797,247	13,658,961	223,721	237,774	249,546	83	66	55
Montana	8,606,319	7,200,442	6,474,190	32,232	35,027	38,933	267	206	166
Nebraska	5,602,163	4,415,644	4,061,651	76,549	86,323	96,230	73	51	42
Nevada	1,397,463	1,510,607	1,868,869	123,754	123,115	129,421	11	12	14
New Hampshire	2,040,544	1,860,269	1,921,421	56,103	58,951	63,333	36	32	30
New Jersey	25,900,482	15,146,838	17,068,781	454,701	471,957	493,175	57	32	35
New Mexico	3,105,000	1,655,529	1,821,583	71,426	75,308	79,555	43	22	23
New York	103,597,135	151,467,015	182,736,305	1,030,373	1,080,441	1,169,436	101	140	156
North Carolina	14,344,310	40,404,202	29,611,785	378,241	412,912	436,144	38	98	68
North Dakota	21,062,090	16,415,807	8,072,257	26,063	32,204	39,992	808	510	202
Ohio	55,068,629	121,394,963	159,322,228	452,884	451,574	490,265	122	269	325
Oklahoma	8,922,036	15,930,878	20,304,740	132,176	142,078	156,058	68	112	130
Oregon	7,382,722	11,120,140	20,001,272	159,899	171,535	188,981	46	65	106
Pennsylvania	117,320,158	102,958,404	71,098,139	506,362	540,231	581,256	232	191	122
Rhode Island	150,000	1,877,724	1,947,727	46,450	47,443	49,423	3	40	39
South Carolina	22,427,746	28,599,885	47,795,394	149,104	157,825	168,716	150	181	283
South Dakota	5,791,586	4,430,602	3,629,155	32,304	37,040	41,667	179	120	87
Tennessee	5,355,000	3,752,587	3,606,726	236,313	246,617	263,626	23	15	14
Texas	28,019,645	49,381,346	47,372,367	1,054,414	1,140,218	1,321,005	27	43	36
Utah	3,214,170	26,442,711	34,418,764	100,221	112,995	124,454	32	234	277
Vermont	1,680,533	738,707	1,711,673	23,613	24,394	26,545	71	30	64
Virginia	11,579,623	17,412,519	17,241,804	374,566	404,005	433,611	31	43	40
Washington	22,834,218	13,892,247	24,500,489	300,145	332,600	357,056	76	42	69
West Virginia	6,024,577	10,357,006	35,475,338	55,205	59,575	66,109	109	174	537
Wisconsin	10,949,155	24,942,415	21,128,936	228,691	237,237	253,349	48	105	83
Wyoming	6,326,604	4,806,630	5,419,398	30,767	34,432	38,190	206	140	142
Puerto Rico	1,458,790	NA	537,869	88,902	NA	NA	16	NA	NA

na = not applicable; NA = not available.

EPSCoR = Experimental Program to Stimulate Competitive Research; GDP = gross domestic product.

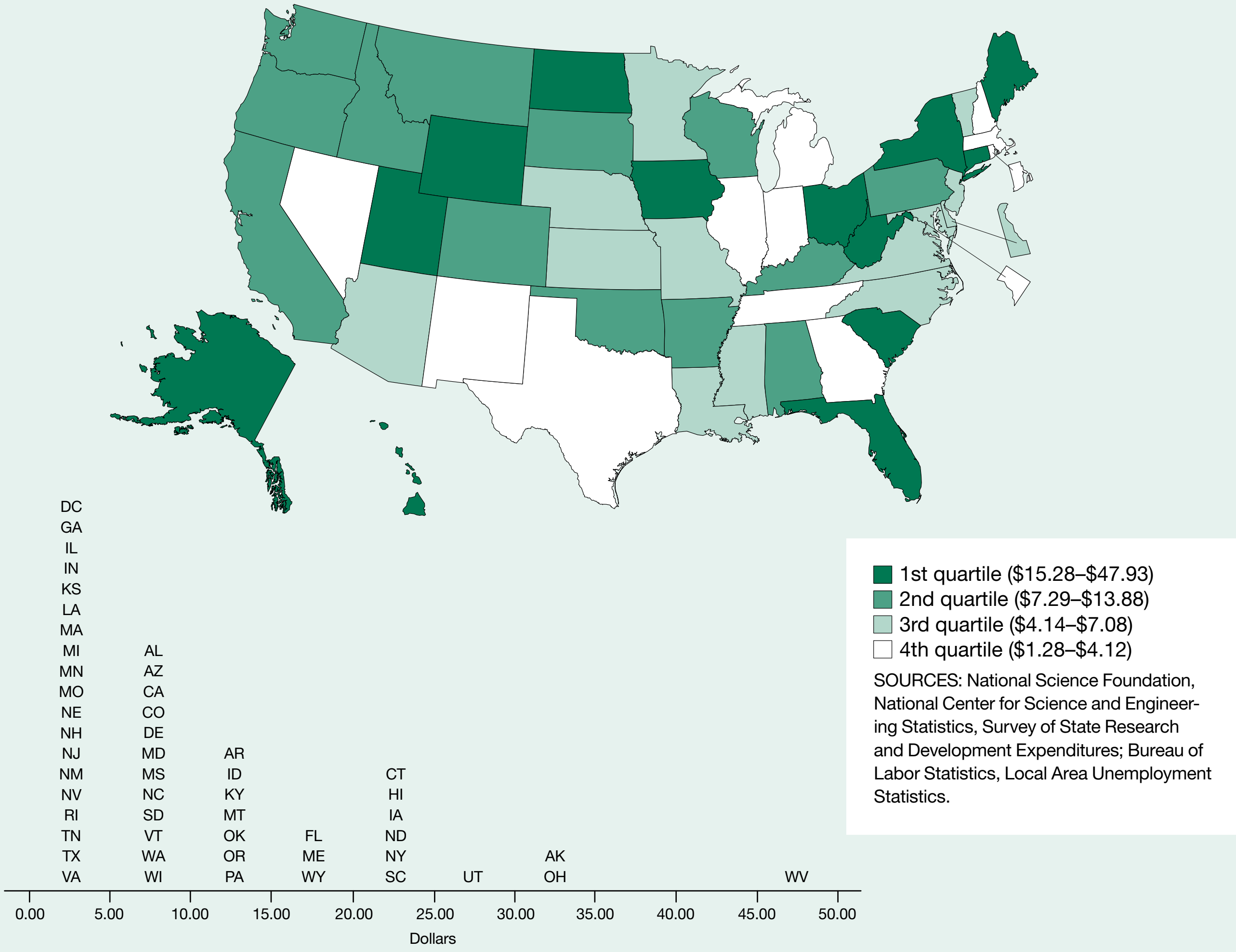
NOTE: For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures (various years); Bureau of Economic Analysis, Gross Domestic Product data (June 2013).

Science and Engineering Indicators 2014

State Agency R&D Expenditures per Employed Worker

Figure 8-44
State agency R&D expenditures per employed worker: 2011



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures; Bureau of Labor Statistics, Local Area Unemployment Statistics.

Findings

- In 2011, state government agency R&D expenditures averaged $9.98 per employed civilian worker nationwide.
- State agency R&D funding per civilian worker across the United States was approximately 1% of the $940 in federal R&D obligations per worker in 2011.
- State agency R&D spending per civilian worker varied greatly among the states in 2011, ranging from a low of $1.28 to a high of $47.93.
- Seven Experimental Program to Stimulate Competitive Research states are among those with the highest values for this indicator.

This indicator represents the extent of R&D activity funded by state government agencies relative to the size of the state's employed civilian workforce. State R&D expenditures include state-administered funds from all sources that support R&D performed by either a state agency or an external performer.

Data on state R&D cover funding administered by state government departments, agencies, independent commissions, and other state-run entities. They exclude state-run colleges and universities as well as laboratories or experiment stations controlled by state universities; funding administered by these institutions is classified as academic R&D. The data also exclude state legislatures' direct appropriations to nonstate agencies. Some data may include expenditures for non-R&D activities such as commercialization, environmental testing, and routine survey work.

Estimates of the size of a state's workforce are provided by the Bureau of Labor Statistics and represent the employed component of the civilian labor force. The data are not seasonally adjusted and workers are assigned to a location based on residence. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-44

State agency R&D expenditures per employed worker, by state: 2006, 2009, and 2011

State	State agency R&D expenditures ($)			Employed workers			State agency R&D expenditures/ employed worker ($)		
	2006	2009	2011	2006	2009	2011	2006	2009	2011
United States	1,021,016,894	1,213,524,157	1,403,816,235	143,729,350	139,594,700	140,695,662	7.10	8.69	9.98
Alabama	7,269,319	12,929,167	19,684,063	2,098,462	1,930,230	1,992,522	3.46	6.70	9.88
Alaska	10,019,060	7,741,467	11,349,400	326,109	331,099	337,796	30.72	23.38	33.60
Arizona	37,151,471	9,363,943	18,626,577	2,836,638	2,820,086	2,761,984	13.10	3.32	6.74
Arkansas	4,869,648	11,465,214	14,705,327	1,286,887	1,250,526	1,251,877	3.78	9.17	11.75
California	107,793,045	146,793,247	149,810,643	16,821,266	16,151,063	16,237,286	6.41	9.09	9.23
Colorado	8,997,236	15,563,581	18,141,931	2,541,828	2,511,189	2,490,004	3.54	6.20	7.29
Connecticut	19,209,064	28,559,052	39,192,091	1,745,993	1,740,974	1,732,807	11.00	16.40	22.62
Delaware	2,812,102	1,683,562	2,609,902	424,618	405,553	407,772	6.62	4.15	6.40
District of Columbia	1,173,076	487,411	1,221,108	303,791	302,687	312,859	3.86	1.61	3.90
Florida	42,329,624	66,513,756	150,764,438	8,584,095	8,152,332	8,322,237	4.93	8.16	18.12
Georgia	10,620,188	6,662,887	11,690,663	4,500,150	4,289,819	4,295,113	2.36	1.55	2.72
Hawaii	12,067,849	13,976,364	13,103,983	617,807	593,514	614,824	19.53	23.55	21.31
Idaho	2,280,873	8,552,058	9,366,052	718,077	695,476	702,920	3.18	12.30	13.32
Illinois	37,184,281	9,570,893	17,207,125	6,225,095	5,937,296	5,942,809	5.97	1.61	2.90
Indiana	6,220,575	47,549,928	6,983,364	3,080,047	2,869,556	2,874,722	2.02	16.57	2.43
Iowa	13,564,062	37,976,643	36,992,222	1,595,136	1,573,085	1,562,156	8.50	24.14	23.68
Kansas	14,348,384	12,305,385	6,635,626	1,403,938	1,400,319	1,401,055	10.22	8.79	4.74
Kentucky	17,558,997	13,938,134	20,498,849	1,904,467	1,848,505	1,875,447	9.22	7.54	10.93
Louisiana	11,216,568	8,285,478	9,203,635	1,900,240	1,916,952	1,919,021	5.90	4.32	4.80
Maine	17,509,051	6,400,019	9,918,765	665,856	642,434	649,312	26.30	9.96	15.28
Maryland	24,945,119	21,093,331	20,084,540	2,892,733	2,814,180	2,868,191	8.62	7.50	7.00
Massachusetts	10,729,419	3,290,198	4,878,927	3,255,504	3,187,538	3,216,160	3.30	1.03	1.52
Michigan	75,016,589	8,630,209	9,802,873	4,722,716	4,201,763	4,189,792	15.88	2.05	2.34
Minnesota	6,219,201	16,655,913	11,653,327	2,774,524	2,713,601	2,777,285	2.24	6.14	4.20
Mississippi	2,744,882	3,623,953	7,420,851	1,199,871	1,168,581	1,197,641	2.29	3.10	6.20
Missouri	18,465,303	15,797,247	13,658,961	2,889,461	2,778,671	2,767,043	6.39	5.69	4.94
Montana	8,606,319	7,200,442	6,474,190	476,412	465,005	466,372	18.06	15.48	13.88
Nebraska	5,602,163	4,415,644	4,061,651	943,176	939,290	961,786	5.94	4.70	4.22
Nevada	1,397,463	1,510,607	1,868,869	1,222,277	1,209,252	1,207,799	1.14	1.25	1.55
New Hampshire	2,040,544	1,860,269	1,921,421	708,748	696,145	697,383	2.88	2.67	2.76
New Jersey	25,900,482	15,146,838	17,068,781	4,257,899	4,135,921	4,120,017	6.08	3.66	4.14
New Mexico	3,105,000	1,655,529	1,821,583	886,708	873,960	862,043	3.50	1.89	2.11
New York	103,597,135	151,467,015	182,736,305	9,062,464	8,832,592	8,740,642	11.43	17.15	20.91
North Carolina	14,344,310	40,404,202	29,611,785	4,261,325	4,104,049	4,183,052	3.37	9.84	7.08
North Dakota	21,062,090	16,415,807	8,072,257	349,368	355,641	368,677	60.29	46.16	21.90
Ohio	55,068,629	121,394,963	159,322,228	5,602,764	5,320,715	5,303,655	9.83	22.82	30.04
Oklahoma	8,922,036	15,930,878	20,304,740	1,650,070	1,648,556	1,678,953	5.41	9.66	12.09
Oregon	7,382,722	11,120,140	20,001,272	1,792,039	1,753,853	1,785,400	4.12	6.34	11.20
Pennsylvania	117,320,158	102,958,404	71,098,139	6,021,084	5,898,301	5,892,519	19.48	17.46	12.07
Rhode Island	150,000	1,877,724	1,947,727	543,973	504,616	499,481	0.28	3.72	3.90
South Carolina	22,427,746	28,599,885	47,795,394	1,970,912	1,908,839	1,941,654	11.38	14.98	24.62
South Dakota	5,791,586	4,430,602	3,629,155	421,799	420,278	422,696	13.73	10.54	8.59
Tennessee	5,355,000	3,752,587	3,606,726	2,852,509	2,713,058	2,828,617	1.88	1.38	1.28
Texas	28,019,645	49,381,346	47,372,367	10,757,510	11,070,143	11,493,519	2.60	4.46	4.12
Utah	3,214,170	26,442,711	34,418,764	1,285,389	1,275,514	1,254,151	2.50	20.73	27.44
Vermont	1,680,533	738,707	1,711,673	343,149	335,132	338,632	4.90	2.20	5.05
Virginia	11,579,623	17,412,519	17,241,804	3,862,508	3,842,447	3,928,267	3.00	4.53	4.39
Washington	22,834,218	13,892,247	24,500,489	3,155,384	3,194,251	3,161,818	7.24	4.35	7.75
West Virginia	6,024,577	10,357,006	35,475,338	777,210	745,150	740,175	7.75	13.90	47.93
Wisconsin	10,949,155	24,942,415	21,128,936	2,932,482	2,843,857	2,832,826	3.73	8.77	7.46
Wyoming	6,326,604	4,806,630	5,419,398	276,882	281,106	284,893	22.85	17.10	19.02
Puerto Rico	1,458,790	NA	537,869	1,260,703	1,101,862	1,032,765	1.16	NA	0.52

NA = not available.

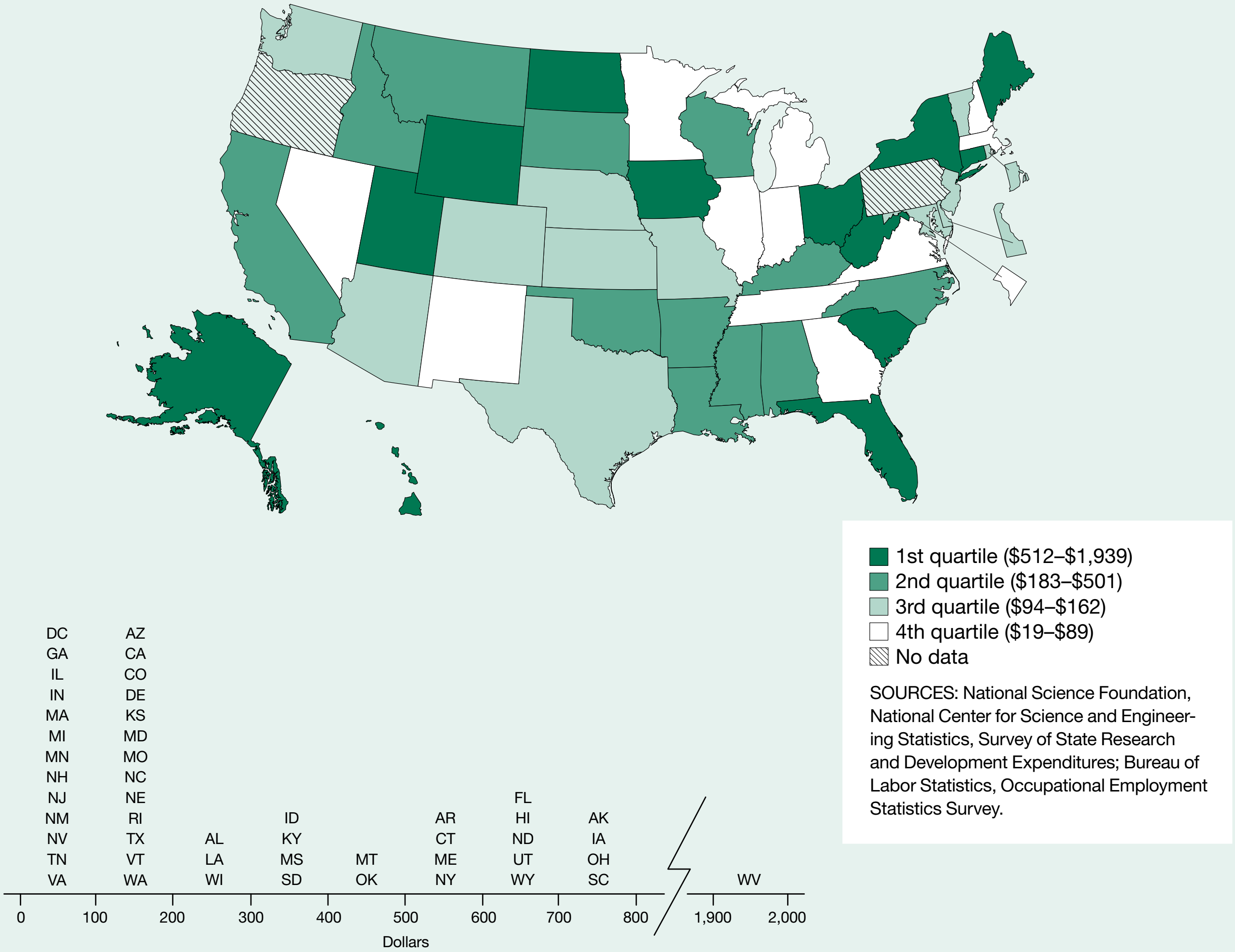
NOTE: Civilian workers represent the employed component of the civilian labor force and are reported as annual data not seasonally adjusted.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures (various years); Bureau of Labor Statistics, Local Area Unemployment Statistics (various years).

Science and Engineering Indicators 2014

State Agency R&D Expenditures per Individual in Science and Engineering Occupation

Figure 8-45
State agency R&D expenditures per individual in science and engineering occupation: 2011



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures; Bureau of Labor Statistics, Occupational Employment Statistics Survey.

Findings

- Nationally, state government agencies spent about $1.4 billion for R&D in 2011. By comparison, the federal government obligated more than $132 billion for R&D in 2011.
- In 2011, the average state agency R&D expenditure per person employed in an S&E occupation was $242, compared to about $23,000 the federal government averaged for each person employed in an S&E occupation.
- State agency R&D funding per person employed in an S&E occupation ranged from $22 to $1,939 per state in 2011.
- Several Experimental Program to Stimulate Competitive Research states had the highest state agency R&D spending per S&E worker.

This indicator represents the ratio of state agency R&D funding to the number of individuals who work in S&E occupations in the state.

Data on state agency R&D cover funding administered by state government departments, agencies, independent commissions, and other state-run entities. They exclude state-run colleges and universities as well as laboratories or experiment stations controlled by state universities; funding administered by these institutions is classified as academic R&D. The data also exclude state legislatures' direct appropriations to nonstate agencies. Some data may include expenditures for non-R&D activities such as commercialization, environmental testing, and routine survey work.

S&E occupations are defined by standard occupational codes. They include engineers and computer, mathematical, life, physical, and social scientists. Managers, technicians, elementary and secondary schoolteachers, and medical personnel are not included.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics from data provided by state workforce agencies. Because of the way data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations. Data on people in S&E occupations are sample based.

Table 8-45

State agency R&D expenditures per individual in science and engineering occupation, by state: 2006, 2009, and 2011

State	State agency R&D expenditures ($)			Individuals in S&E occupations			State agency R&D expenditures/ individual in S&E occupation ($)		
	2006	2009	2011	2006	2009	2011	2006	2009	2011
United States	1,021,016,894	1,213,524,157	1,403,816,235	5,407,710	5,785,710	5,794,980	189	210	242
Alabama	7,269,319	12,929,167	19,684,063	66,100	68,670	70,290	110	188	280
Alaska	10,019,060	7,741,467	11,349,400	10,720	14,780	15,680	935	524	724
Arizona	37,151,471	9,363,943	18,626,577	98,110	102,820	115,330	379	91	162
Arkansas	4,869,648	11,465,214	14,705,327	24,860	31,420	29,350	196	365	501
California	107,793,045	146,793,247	149,810,643	730,010	795,240	800,430	148	185	187
Colorado	8,997,236	15,563,581	18,141,931	133,730	148,090	144,750	67	105	125
Connecticut	19,209,064	28,559,052	39,192,091	79,380	79,160	76,550	242	361	512
Delaware	2,812,102	1,683,562	2,609,902	21,550	22,200	22,430	130	76	116
District of Columbia	1,173,076	487,411	1,221,108	64,120	61,430	62,660	18	8	19
Florida	42,329,624	66,513,756	150,764,438	246,190	247,070	244,970	172	269	615
Georgia	10,620,188	6,662,887	11,690,663	136,470	NA	147,820	78	NA	79
Hawaii	12,067,849	13,976,364	13,103,983	18,940	19,020	20,100	637	735	652
Idaho	2,280,873	8,552,058	9,366,052	NA	23,520	25,950	NA	364	361
Illinois	37,184,281	9,570,893	17,207,125	222,470	221,170	204,420	167	43	84
Indiana	6,220,575	47,549,928	6,983,364	80,110	90,750	93,640	78	524	75
Iowa	13,564,062	37,976,643	36,992,222	43,670	47,080	48,930	311	807	756
Kansas	14,348,384	12,305,385	6,635,626	48,620	56,200	51,530	295	219	129
Kentucky	17,558,997	13,938,134	20,498,849	44,680	51,200	51,990	393	272	394
Louisiana	11,216,568	8,285,478	9,203,635	40,180	43,630	42,760	279	190	215
Maine	17,509,051	6,400,019	9,918,765	15,950	17,910	17,490	1,098	357	567
Maryland	24,945,119	21,093,331	20,084,540	159,470	169,540	173,020	156	124	116
Massachusetts	10,729,419	3,290,198	4,878,927	198,670	217,690	220,670	54	15	22
Michigan	75,016,589	8,630,209	9,802,873	208,520	187,760	188,380	360	46	52
Minnesota	6,219,201	16,655,913	11,653,327	125,930	134,060	130,340	49	124	89
Mississippi	2,744,882	3,623,953	7,420,851	24,910	25,940	23,440	110	140	317
Missouri	18,465,303	15,797,247	13,658,961	96,420	104,310	106,930	192	151	128
Montana	8,606,319	7,200,442	6,474,190	13,010	14,210	14,960	662	507	433
Nebraska	5,602,163	4,415,644	4,061,651	32,500	31,790	33,800	172	139	120
Nevada	1,397,463	1,510,607	1,868,869	26,930	27,560	28,370	52	55	66
New Hampshire	2,040,544	1,860,269	1,921,421	27,680	30,550	29,260	74	61	66
New Jersey	25,900,482	15,146,838	17,068,781	176,460	195,690	182,210	147	77	94
New Mexico	3,105,000	1,655,529	1,821,583	30,800	36,950	35,520	101	45	51
New York	103,597,135	151,467,015	182,736,305	306,810	315,480	310,510	338	480	589
North Carolina	14,344,310	40,404,202	29,611,785	138,790	158,920	161,880	103	254	183
North Dakota	21,062,090	16,415,807	8,072,257	9,360	9,930	12,070	2,250	1,653	669
Ohio	55,068,629	121,394,963	159,322,228	185,190	207,930	208,140	297	584	765
Oklahoma	8,922,036	15,930,878	20,304,740	50,770	45,730	47,090	176	348	431
Oregon	7,382,722	11,120,140	20,001,272	64,520	69,630	NA	114	160	NA
Pennsylvania	117,320,158	102,958,404	71,098,139	214,910	NA	NA	546	NA	NA
Rhode Island	150,000	1,877,724	1,947,727	18,060	18,120	19,450	8	104	100
South Carolina	22,427,746	28,599,885	47,795,394	53,230	57,370	61,020	421	499	783
South Dakota	5,791,586	4,430,602	3,629,155	10,120	11,570	11,790	572	383	308
Tennessee	5,355,000	3,752,587	3,606,726	67,040	68,970	77,630	80	54	46
Texas	28,019,645	49,381,346	47,372,367	408,710	470,010	469,080	69	105	101
Utah	3,214,170	26,442,711	34,418,764	49,690	51,270	51,350	65	516	670
Vermont	1,680,533	738,707	1,711,673	12,780	12,780	13,100	131	58	131
Virginia	11,579,623	17,412,519	17,241,804	251,720	264,090	267,620	46	66	64
Washington	22,834,218	13,892,247	24,500,489	171,780	196,850	196,760	133	71	125
West Virginia	6,024,577	10,357,006	35,475,338	17,150	16,350	18,300	351	633	1,939
Wisconsin	10,949,155	24,942,415	21,128,936	96,860	100,850	102,320	113	247	206
Wyoming	6,326,604	4,806,630	5,419,398	7,640	8,920	8,440	828	539	642
Puerto Rico	1,458,790	NA	537,869	23,850	22,760	20,990	61	NA	26

NA = not available.

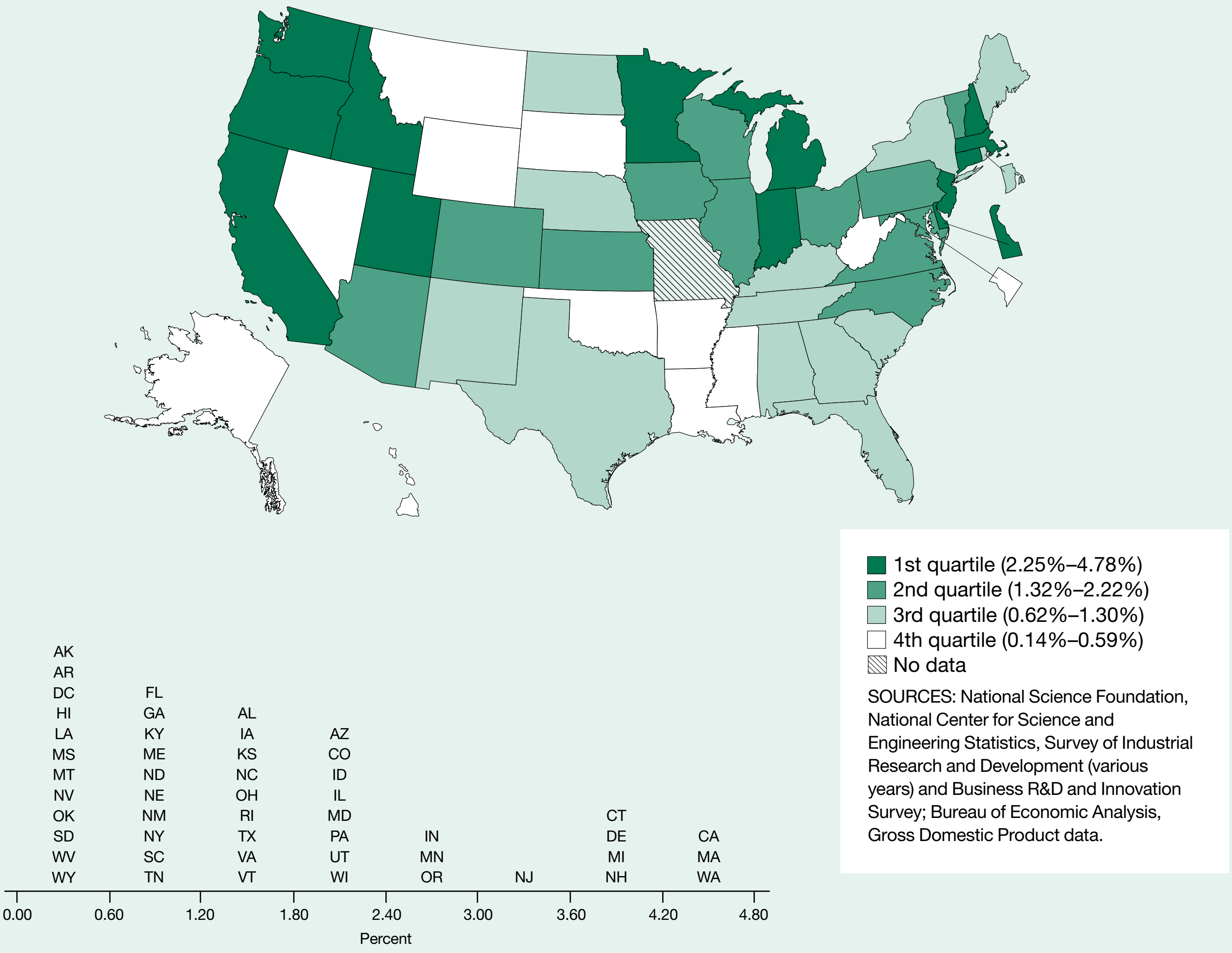
NOTES: The national total for S&E occupations includes states with suppressed data. Occupational Employment Statistics estimates for S&E occupations are based on May data.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures (various years); Bureau of Labor Statistics, Occupational Employment Statistics Survey (various years).

Science and Engineering Indicators 2014

Business-Performed R&D as a Percentage of Private-Industry Output

Figure 8-46
Business-performed domestic R&D as a percentage of private-industry output: 2011



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Industrial Research and Development (various years) and Business R&D and Innovation Survey; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The amount of R&D performed by business rose from more than $202 billion in 2001 to about $294 billion in 2011, an increase of 46%.
- The value of this indicator for the United States remained virtually unchanged between 2001 and 2011.
- Business-performed R&D as a share of private industry output varied greatly among states in 2011, ranging from 0.14 to 4.78.
- Business R&D was concentrated in a few states—only 12 states had indicator values that exceeded the national average in 2011.

This indicator represents the role of R&D in a state's business activity. The business sector is the largest performer of U.S. R&D. It accounts for more than half of all U.S. applied research funding and a significant portion, over 80%, of all development funding. A high value for this indicator means that the businesses within a state are making a large investment in their R&D activities.

The methodology for data collection, assignment to individual states, and developing estimates of R&D spending has changed during the last decade as the transition was made from the Survey of Industrial R&D to the Business R&D and Innovation Survey. Estimates from the two surveys are consistent. Estimates for states with smaller economies are generally less precise than those for states with larger economies.

Private-industry output is the portion of state gross domestic product contributed by state businesses.

Table 8-46

Business-performed domestic R&D as a percentage of private-industry output, by state: 2001, 2006, and 2011

State	Business-performed domestic R&D ($millions)			Private-industry output ($millions)			Business-performed domestic R&D/ private-industry output (%)		
	2001	2006	2011	2001	2006	2011	2001	2006	2011
United States	202,017	247,669	294,093	9,010,778	11,709,405	13,081,829	2.24	2.12	2.25
Alabama	905	1,835	1,879	101,748	134,131	148,510	0.89	1.37	1.27
Alaska	68	49e	84e	22,208	34,059	41,756	0.31	0.14	0.20
Arizona	2,707	3,590	4,931	148,971	215,927	222,442	1.82	1.66	2.22
Arkansas	254e	285	344	62,027	80,964	91,227	0.41	0.35	0.38
California	44,628	58,424	75,035	1,190,581	1,603,109	1,687,543	3.75	3.64	4.45
Colorado	3,082	4,657	4,310	160,347	202,993	230,650	1.92	2.29	1.87
Connecticut	4,686	8,273	7,504	152,898	190,578	204,211	3.06	4.34	3.67
Delaware	1,232	1,446	2,097	40,005	51,333	58,313	3.08	2.82	3.60
District of Columbia	242	276	415	41,378	57,397	69,787	0.58	0.48	0.59
Florida	3,755	4,139	5,988	445,856	654,411	650,652	0.84	0.63	0.92
Georgia	1,912	2,786	3,839	267,990	330,692	358,180	0.71	0.84	1.07
Hawaii	93	155	252	33,397	47,688	52,975	0.28	0.33	0.48
Idaho	884	625	1,171	31,084	43,450	49,304	2.84	1.44	2.38
Illinois	8,232	10,765	12,038	440,581	544,055	601,979	1.87	1.98	2.00
Indiana	3,583	4,858	6,158	180,282	220,584	256,124	1.99	2.20	2.40
Iowa	817	1,055	2,314	83,002	109,971	129,407	0.98	0.96	1.79
Kansas	1,299 i	2,064 i	1,509	77,240	95,821	114,751	1.68	2.15	1.32
Kentucky	636	839	1,278	100,203	124,402	140,036	0.63	0.67	0.91
Louisiana	316e	367	459	120,435	182,648	211,357	0.26	0.20	0.22
Maine	249	253	295	32,916	41,042	45,163	0.76	0.62	0.65
Maryland	3,682	3,421	5,101	162,500	215,095	248,615	2.27	1.59	2.05
Massachusetts	11,756	15,562	15,722	257,702	307,528	352,398	4.56	5.06	4.46
Michigan	14,283	16,477	13,660	301,664	333,606	339,886	4.73	4.94	4.02
Minnesota	4,355	6,296	6,174	173,971	219,748	251,930	2.50	2.87	2.45
Mississippi	219e	231	235	56,068	71,207	79,490	0.39	0.32	0.30
Missouri	1,792	2,675	NA	163,803	196,615	217,573	1.09	1.36	NA
Montana	70e	103 i	136	19,184	27,064	32,709	0.36	0.38	0.42
Nebraska	306	447	636	51,532	66,099	83,460	0.59	0.68	0.76
Nevada	290	535	638	71,072	112,123	115,577	0.41	0.48	0.55
New Hampshire	1,339	1,774 i	2,069	40,680	50,826	56,693	3.29	3.49	3.65
New Jersey	10,164	14,606	13,930	329,143	408,330	439,353	3.09	3.58	3.17
New Mexico	231	676	472	41,609	57,760	64,097	0.56	1.17	0.74
New York	10,884	9,518	12,072	726,643	923,574	1,045,302	1.50	1.03	1.15
North Carolina	4,437	5,486	6,193	256,039	328,722	371,955	1.73	1.67	1.66
North Dakota	347	120	261	16,005	21,956	34,991	2.17	0.55	0.75
Ohio	6,694	6,852	6,993	341,402	403,379	434,407	1.96	1.70	1.61
Oklahoma	543e	474	604	80,579	109,859	129,709	0.67	0.43	0.47
Oregon	2,677	3,419	4,631	97,526	141,073	166,817	2.74	2.42	2.78
Pennsylvania	8,967	9,819	9,718	367,480	457,197	524,349	2.44	2.15	1.85
Rhode Island	1,134 i	1,330 i	542	31,263	40,777	42,800	3.63	3.26	1.27
South Carolina	921	1,396	1,399	101,790	124,815	139,836	0.90	1.12	1.00
South Dakota	87e	95	136	21,906	28,132	36,560	0.40	0.34	0.37
Tennessee	1,503	1,428	1,434	163,834	208,571	232,226	0.92	0.68	0.62
Texas	9,839	13,334	15,309	677,945	940,631	1,174,548	1.45	1.42	1.30
Utah	1,173	1,274	2,438	62,231	86,675	108,306	1.88	1.47	2.25
Vermont	339	360	374 i	16,466	20,432	22,821	2.06	1.76	1.64
Virginia	2,957	4,816	5,562	232,954	308,886	353,751	1.27	1.56	1.57
Washington	8,933 i	11,320	14,558	199,011	257,173	304,420	4.49	4.40	4.78
West Virginia	211	221	247	35,755	44,991	54,212	0.59	0.49	0.46
Wisconsin	2,469 i	3,020	4,053	163,999	204,541	225,709	1.51	1.48	1.80
Wyoming	28e	27e	46e	15,873	26,765	32,962	0.18	0.10	0.14
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

e = estimated; more than 50% of value is imputed due to raking of state data. i = more than 50% of value is imputed. NA = not available.

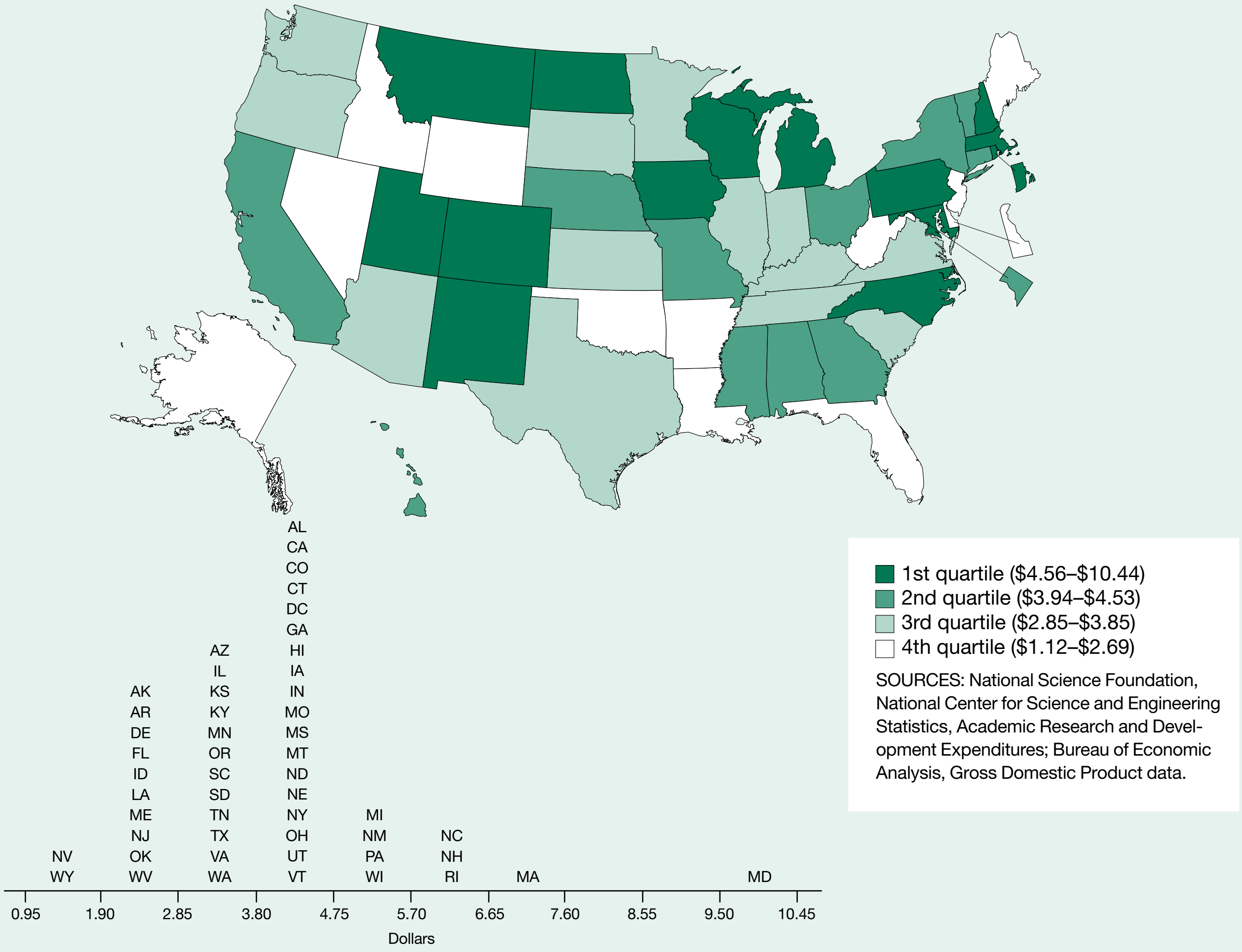
NOTE: The national totals for business-performed R&D in the United States, from the National Science Foundation/National Center for Science and Engineering Statistics, and Census Bureau Business R&D and Innovation Survey, include undistributed business performed R&D and states with suppressed data.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Industrial Research and Development (various years) and Business R&D and Innovation Survey; Bureau of Economic Analysis, Gross Domestic Product data (June 2013).

Science and Engineering Indicators 2014

Academic Science and Engineering R&D per $1,000 of Gross Domestic Product

Figure 8-47
Academic science and engineering R&D per $1,000 of gross domestic product: 2012



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Academic Research and Development Expenditures; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- Expenditures for research performed in academic institutions have increased by 71% between 2002 and 2012, rising from $36.3 billion to $62.1 billion.
- In the United States, growth in academic research increased more rapidly than gross domestic product (GDP), causing the value of this indicator to increase by 16% between 2002 and 2012.
- In 2012, the value of this indicator ranged from $1.12 to $10.44 across states.
- The amount of spending for academic S&E R&D declined as a share of GDP in 15 states between 2002 and 2012. Ten of these states were Experimental Program to Stimulate Competitive Research (EPSCoR) states.
- Although non-EPSCoR states had 7.6 times the amount of spending for academic S&E R&D as EPSCoR states in 2012, the average indicator value for both groups increased between 2002 and 2012.

This indicator represents the ratio of S&E R&D expenditures at a state's colleges and universities to the size of the state's economy. Academic R&D performers account for slightly more than half of U.S. basic research, about one-third of total research (basic plus applied), and roughly 10% of all R&D conducted in the United States. Academic R&D can be a valuable basis for future economic development.

Data on academic R&D are provided by the National Center for Science and Engineering Statistics and represent S&E R&D at U.S. colleges and universities with more than $150,000 in R&D expenditures.

Table 8-47

Academic science and engineering R&D per $1,000 of gross domestic product, by state: 2002, 2007, and 2012

	Academic S&E R&D ($thousands)			State GDP ($millions)			Academic S&E R&D ($)/ $1,000 GDP		
State	2002	2007	2012	2002	2007	2012	2002	2007	2012
EPSCoR states	4,575,040	6,292,689	7,120,907	1,412,084	1,918,622	2,164,567	3.24	3.28	3.29
Non-EPSCoR states	31,201,781	42,290,351	53,976,573	9,027,189	11,833,059	13,173,276	3.46	3.57	4.10
Average EPSCoR state value	na	na	na	na	na	na	3.29	3.41	3.42
Average non-EPSCoR state value	na	na	na	na	na	na	3.65	3.76	4.31
United States	36,316,382	49,363,499	62,094,377	10,572,388	13,936,196	15,566,076	3.44	3.54	3.99
Alabama	503,470	655,245	808,194	125,168	165,665	183,547	4.02	3.96	4.40
Alaska	128,875	130,637	135,751	28,894	44,540	51,859	4.46	2.93	2.62
Arizona	531,106	782,671	987,123	177,068	259,157	266,891	3.00	3.02	3.70
Arkansas	140,813	240,321	275,503	74,167	97,470	109,557	1.90	2.47	2.51
California	4,887,918	6,733,546	8,092,820	1,387,213	1,870,916	2,003,479	3.52	3.60	4.04
Colorado	645,291	872,576	1,249,413	186,529	242,633	274,048	3.46	3.60	4.56
Connecticut	538,488	691,408	925,024	168,865	221,133	229,317	3.19	3.13	4.03
Delaware	88,319	125,663	176,743	43,672	59,592	65,984	2.02	2.11	2.68
District of Columbia	260,819	336,618	455,063	67,924	91,896	109,793	3.84	3.66	4.14
Florida	1,085,764	1,557,504	1,934,951	536,061	760,936	777,164	2.03	2.05	2.49
Georgia	1,076,706	1,388,976	1,708,803	313,952	399,579	433,569	3.43	3.48	3.94
Hawaii	172,664	274,373	328,168	44,752	64,070	72,424	3.86	4.28	4.53
Idaho	93,323	114,224	142,976	37,729	54,273	58,243	2.47	2.10	2.45
Illinois	1,441,156	1,867,003	2,270,759	497,802	626,611	695,238	2.90	2.98	3.27
Indiana	650,718	893,808	1,150,327	208,674	261,755	298,625	3.12	3.41	3.85
Iowa	485,756	586,786	695,465	98,584	134,053	152,436	4.93	4.38	4.56
Kansas	299,806	375,960	479,721	91,671	120,599	138,953	3.27	3.12	3.45
Kentucky	334,208	503,293	547,025	121,436	150,487	173,466	2.75	3.34	3.15
Louisiana	476,785	604,007	653,885	139,202	207,312	243,264	3.43	2.91	2.69
Maine	75,063	137,425	118,589	39,989	49,065	53,656	1.88	2.80	2.21
Maryland	1,895,382	2,542,336	3,316,156	206,624	271,985	317,678	9.17	9.35	10.44
Massachusetts	1,697,182	2,171,596	3,009,019	288,352	352,378	403,823	5.89	6.16	7.45
Michigan	1,233,887	1,509,953	2,091,921	351,832	386,591	400,504	3.51	3.91	5.22
Minnesota	504,398	636,920	840,731	201,559	253,374	294,729	2.50	2.51	2.85
Mississippi	289,412	410,637	437,775	69,527	92,107	101,490	4.16	4.46	4.31
Missouri	705,593	941,445	1,057,351	192,189	232,959	258,832	3.67	4.04	4.09
Montana	122,375	179,137	184,754	23,781	35,085	40,422	5.15	5.11	4.57
Nebraska	266,930	364,842	419,163	61,384	82,135	99,557	4.35	4.44	4.21
Nevada	126,713	192,081	149,323	82,764	133,185	133,584	1.53	1.44	1.12
New Hampshire	220,061	307,074	397,916	46,730	57,868	64,697	4.71	5.31	6.15
New Jersey	690,642	864,737	1,061,201	376,922	471,372	508,003	1.83	1.83	2.09
New Mexico	292,691	410,375	390,548	53,662	74,356	80,600	5.45	5.52	4.85
New York	2,765,484	3,971,652	5,166,092	822,408	1,076,255	1,205,930	3.36	3.69	4.28
North Carolina	1,279,377	1,884,244	2,619,095	302,201	396,740	455,973	4.23	4.75	5.74
North Dakota	106,078	169,468	213,666	20,439	28,549	46,016	5.19	5.94	4.64
Ohio	1,116,116	1,767,903	2,017,681	397,966	467,138	509,393	2.80	3.78	3.96
Oklahoma	282,062	298,663	412,978	98,778	140,378	160,953	2.86	2.13	2.57
Oregon	386,666	574,521	680,956	119,571	167,088	198,702	3.23	3.44	3.43
Pennsylvania	1,913,687	2,438,312	3,120,745	424,103	531,098	600,897	4.51	4.59	5.19
Rhode Island	163,052	230,281	335,957	38,135	47,293	50,956	4.28	4.87	6.59
South Carolina	399,982	569,347	563,599	124,391	157,712	176,217	3.22	3.61	3.20
South Dakota	38,449	81,544	123,383	27,610	34,885	42,464	1.39	2.34	2.91
Tennessee	491,274	761,388	968,317	193,069	242,220	277,036	2.54	3.14	3.50
Texas	2,535,237	3,417,082	4,413,601	782,780	1,147,404	1,397,369	3.24	2.98	3.16
Utah	359,556	414,690	608,199	74,603	108,474	130,486	4.82	3.82	4.66
Vermont	90,189	115,025	119,802	19,599	24,043	27,296	4.60	4.78	4.39
Virginia	693,668	971,377	1,283,852	290,904	389,570	445,876	2.38	2.49	2.88
Washington	784,186	981,229	1,376,467	237,117	325,118	375,730	3.31	3.02	3.66
West Virginia	100,830	167,208	183,510	44,533	56,864	69,380	2.26	2.94	2.64
Wisconsin	806,543	1,066,688	1,330,504	190,241	236,522	261,548	4.24	4.51	5.09
Wyoming	41,632	79,700	63,812	19,262	33,708	38,422	2.16	2.36	1.66
Puerto Rico	NA	NA	NA	74,827	93,263	NA	NA	NA	NA

na = not applicable; NA = not available.

EPSCoR = Experimental Program to Stimulate Competitive Research; GDP = gross domestic product.

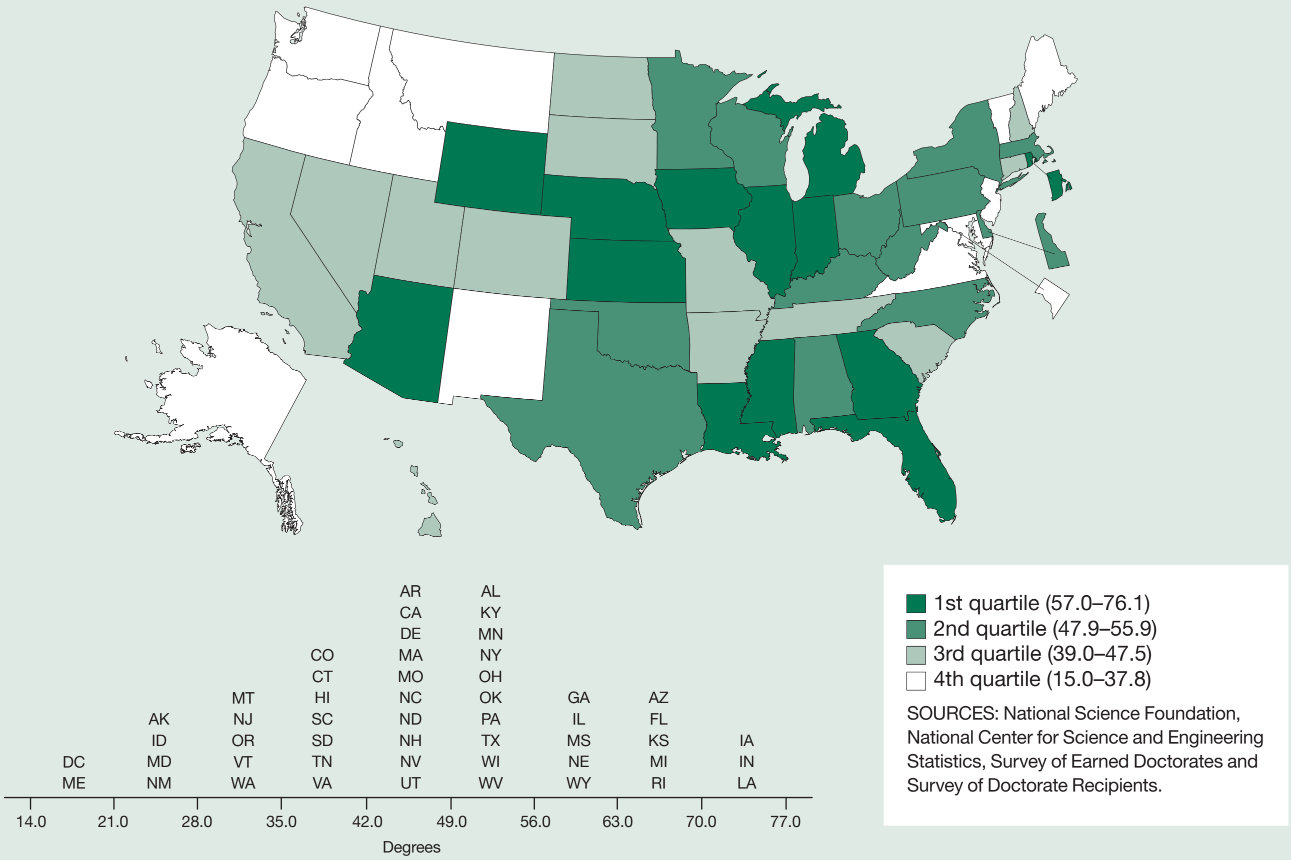
NOTES: Academic R&D is reported for institutions with R&D over $150,000. For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Academic Research and Development Expenditures (various years); Bureau of Economic Analysis, Gross Domestic Product data (June 2013).

Science and Engineering Indicators 2014

Science and Engineering Doctorates Conferred per 1,000 Employed S&E Doctorate Holders

Figure 8-48
Science and engineering doctorates conferred per 1,000 employed S&E doctorate holders: 2010



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Earned Doctorates and Survey of Doctorate Recipients.

Findings

- In 2010, nearly 33,000 S&E doctorates were awarded by U.S. academic institutions, approximately 28% more than in 2001.
- The national value for this indicator rose from 44.3 S&E doctorates conferred per 1,000 employed S&E doctorate holders in 2001 to 47.2 in 2010.
- State values for S&E doctorates conferred per 1,000 S&E doctorate holders employed ranged from 15.0 to 76.1 in 2010.
- Low state values on this indicator may indicate either a small S&E graduate-level educational program or a concentration of S&E doctorate-level employment opportunities that attract significant numbers of S&E doctorate holders who were educated elsewhere. Low-ranking Experimental Program to Stimulate Competitive Research states tend to fall into the former category.

This indicator represents the rate at which the states are training new S&E doctorate recipients for entry into the workforce. High values indicate relatively large production of new doctorate holders compared with the existing stock of employed doctorate holders. States with relatively low values may need to attract S&E doctorate holders from elsewhere to meet the needs of local employers.

Data on doctorates conferred and on employed doctorate holders include those with doctoral degrees in computer and mathematical sciences; the biological, agricultural, or environmental life sciences; physical sciences; social sciences; psychology; engineering; and health fields. Both sets of data exclude individuals with doctorates from foreign institutions. The employed doctorate data also exclude those older than the age of 75. Data for doctorates conferred are presented by the location where the doctorate was earned; employment data for S&E doctorate holders are presented by employment location regardless of residence. Estimates for states with smaller populations of employed doctorate holders are generally less precise than estimates for states with larger populations.

The indicator does not take into account any postgraduation mobility of recent S&E doctorate recipients to their place of employment. Doctorate recipients with temporary visas may decide to return home after graduation to begin their careers. The indicator also does not cover individuals with non-U.S. S&E doctorates who are working in the United States.

Table 8-48

Science and engineering doctorates conferred per 1,000 employed S&E doctorate holders, by state: 2001, 2006, and 2010

State	S&E doctorates conferred			Employed S&E doctorate holders			S&E doctorates conferred/1,000 employed S&E doctorate holders		
	2001	2006	2010	2001	2006	2010	2001	2006	2010
United States	25,352	30,291	32,509	572,800	618,400	688,300	44.3	49.0	47.2
Alabama	268	309	357	5,300	5,900	6,600	50.6	52.4	54.1
Alaska	22	18	38	1,200	1,100	1,400	18.3	16.4	27.1
Arizona	392	514	567	7,100	8,400	9,000	55.2	61.2	63.0
Arkansas	61	106	126	2,600	2,800	2,900	23.5	37.9	43.4
California	3,664	4,365	4,589	80,900	87,400	102,300	45.3	49.9	44.9
Colorado	511	546	611	11,800	13,100	14,800	43.3	41.7	41.3
Connecticut	370	453	470	9,500	10,300	11,300	38.9	44.0	41.6
Delaware	108	135	145	3,500	3,100	3,000	30.9	43.5	48.3
District of Columbia	306	363	263	14,200	13,300	14,900	21.5	27.3	17.7
Florida	838	1,211	1,389	15,700	17,600	20,600	53.4	68.8	67.4
Georgia	607	819	867	12,000	13,000	15,200	50.6	63.0	57.0
Hawaii	141	110	122	2,600	2,800	3,000	54.2	39.3	40.7
Idaho	50	72	63	2,200	2,800	2,800	22.7	25.7	22.5
Illinois	1,528	1,603	1,518	22,100	24,100	25,300	69.1	66.5	60.0
Indiana	621	700	818	9,600	9,900	10,900	64.7	70.7	75.0
Iowa	322	373	426	4,400	4,900	5,600	73.2	76.1	76.1
Kansas	236	247	259	4,000	4,300	4,000	59.0	57.4	64.8
Kentucky	174	254	263	4,600	5,000	5,100	37.8	50.8	51.6
Louisiana	317	289	377	5,300	5,500	5,300	59.8	52.5	71.1
Maine	30	27	36	2,000	2,400	2,400	15.0	11.3	15.0
Maryland	604	791	817	22,700	26,200	29,800	26.6	30.2	27.4
Massachusetts	1,436	1,689	1,788	29,100	32,400	36,900	49.3	52.1	48.5
Michigan	868	1,060	1,153	17,400	17,900	18,000	49.9	59.2	64.1
Minnesota	531	705	713	11,400	11,800	13,700	46.6	59.7	52.0
Mississippi	115	142	200	3,200	3,300	3,300	35.9	43.0	60.6
Missouri	412	512	495	9,300	9,300	10,700	44.3	55.1	46.3
Montana	39	66	70	1,400	2,000	2,400	27.9	33.0	29.2
Nebraska	131	136	191	2,900	3,000	3,100	45.2	45.3	61.6
Nevada	50	93	126	2,000	2,600	3,000	25.0	35.8	42.0
New Hampshire	111	129	133	2,500	2,500	3,000	44.4	51.6	44.3
New Jersey	652	708	775	22,700	20,800	23,000	28.7	34.0	33.7
New Mexico	134	181	168	7,700	8,300	8,000	17.4	21.8	21.0
New York	2,157	2,495	2,576	44,000	45,900	50,900	49.0	54.4	50.6
North Carolina	665	805	987	16,800	18,900	20,600	39.6	42.6	47.9
North Dakota	43	45	69	1,100	1,400	1,500	39.1	32.1	46.0
Ohio	1,023	1,138	1,175	20,100	20,500	21,700	50.9	55.5	54.1
Oklahoma	198	195	271	4,400	4,400	4,900	45.0	44.3	55.3
Oregon	298	320	295	7,000	8,300	9,100	42.6	38.6	32.4
Pennsylvania	1,143	1,551	1,571	26,100	29,100	31,300	43.8	53.3	50.2
Rhode Island	168	223	209	2,600	3,000	3,000	64.6	74.3	69.7
South Carolina	205	231	264	5,100	5,900	6,400	40.2	39.2	41.3
South Dakota	31	38	51	1,000	1,000	1,300	31.0	38.0	39.2
Tennessee	351	395	448	9,000	10,000	11,500	39.0	39.5	39.0
Texas	1,500	1,845	2,192	32,500	36,000	42,400	46.2	51.3	51.7
Utah	197	225	280	4,800	5,500	5,900	41.0	40.9	47.5
Vermont	52	49	58	1,800	1,700	1,800	28.9	28.8	32.2
Virginia	667	787	832	17,500	19,800	22,000	38.1	39.7	37.8
Washington	422	525	540	14,800	16,900	18,900	28.5	31.1	28.6
West Virginia	56	102	115	1,900	2,000	2,200	29.5	51.0	52.3
Wisconsin	494	559	593	8,700	9,500	10,600	56.8	58.8	55.9
Wyoming	33	37	50	800	700	800	41.3	52.9	62.5
Puerto Rico	101	161	140	1,400	1,700	2,300	72.1	94.7	60.9

NOTE: Data on U.S. S&E doctorate holders are classified by employment location.

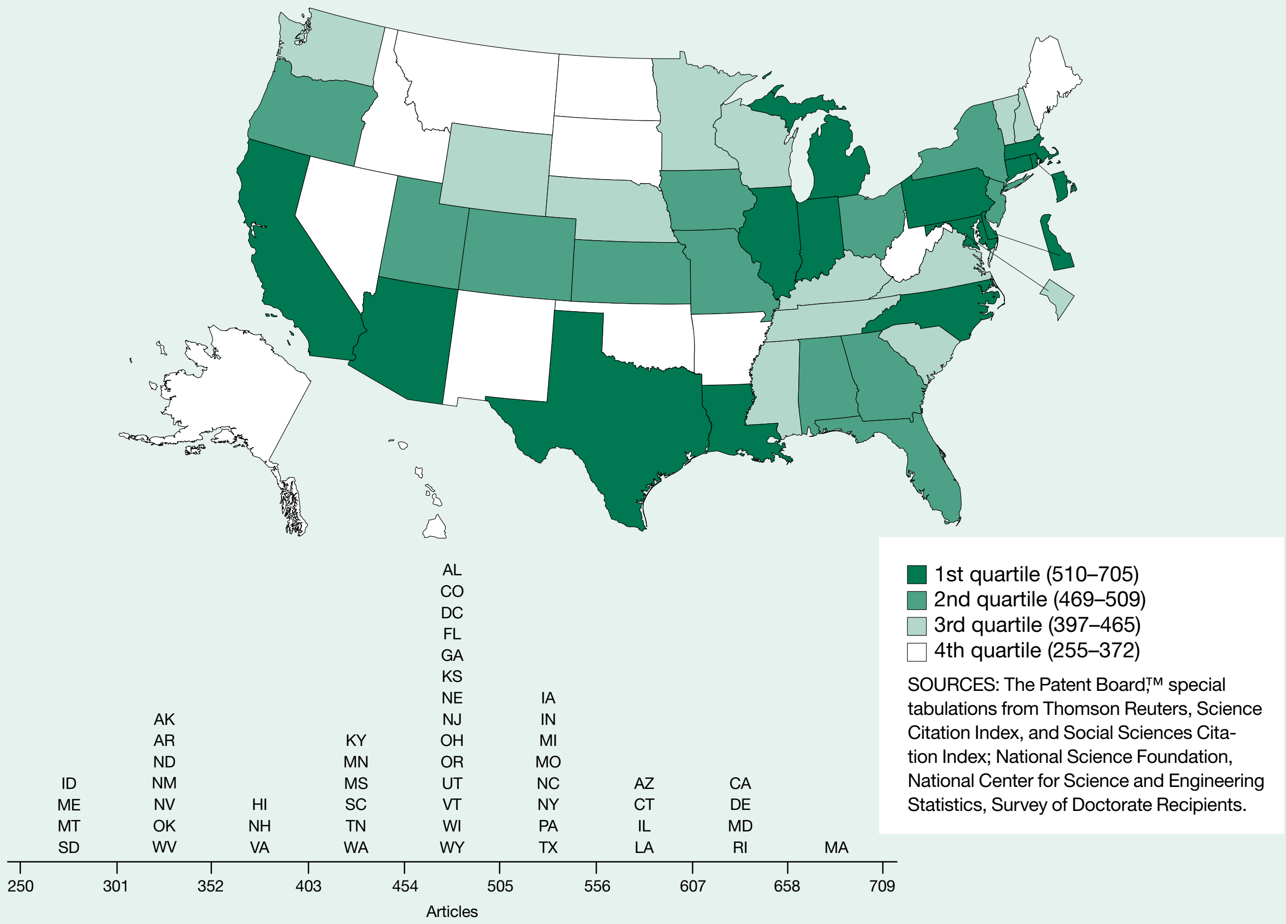
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Earned Doctorates, and Survey of Doctorate Recipients (various years).

Science and Engineering Indicators 2014

Academic Science and Engineering Article Output per 1,000 S&E Doctorate Holders in Academia

Figure 8-49

Academic science and engineering article output per 1,000 S&E doctorate holders in academia: 2010



SOURCES: The Patent Board,™ special tabulations from Thomson Reuters, Science Citation Index, and Social Sciences Citation Index; National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients.

Findings

- Between 2001 and 2010, the number of scientific and engineering articles published by academia increased from 141,000 to 154,000 and the number of S&E doctorate holders in academia increased from 251,000 to 300,000.
- In 2010, the value of this indicator across the states ranged from 255 to 705 S&E articles per 1,000 S&E doctorate holders in academia.
- The publication rate for academic S&E doctorate holders in states in the top quartile of this indicator was nearly twice as high as for states in the bottom quartile. The average indicator value for Experimental Program to Stimulate Competitive Research (EPSCoR) states was considerably lower than the average indicator value for non-EPSCoR states.

The volume of peer-reviewed articles per 1,000 academic S&E doctorate holders is an approximate measure of their contribution to scientific knowledge. Publications are only one measure of academic productivity, which includes trained personnel, patents, trademarks, copyrights, and other outputs. A high value on this indicator shows that the S&E faculty in a state's academic institutions are generating a high volume of publications relative to other states. Academic institutions include 2-year colleges, 4-year colleges and universities, medical schools, and university-affiliated research centers.

Publication counts are based on the number of articles that appear in a set of journals tracked by Thomson Reuters in the Science Citation Index and Social Sciences Citation Index. Academic article output is based on the most recent journal set; data for earlier years may differ slightly from previous publications due to changes in the journal set. Articles with authors from different institutions were counted fractionally. For instance, for a publication with authors at *N* institutions, each institution would be credited with 1/*N* of the article.

S&E doctorates include those in the biological, agricultural, or environmental life sciences; computer, physical, and social sciences; mathematics; psychology; engineering; and health fields. S&E doctorate data are estimates and exclude those with doctorates from foreign institutions and those older than the age of 75. Estimates for states with smaller populations of S&E doctorate holders are generally less precise than estimates for states with larger populations. Data for S&E doctorate holders in academia are presented by employment location.

Table 8-49

Academic science and engineering article output per 1,000 S&E doctorate holders in academia, by state: 2001, 2006, and 2010

	Academic S&E article output			S&E doctorate holders in academia			Academic S&E articles/ 1,000 S&E doctorate holders in academia		
State	2001	2006	2010	2001	2006	2010	2001	2006	2010
EPSCoR states	15,686	17,489	16,921	37,300	40,500	41,000	421	432	413
Non-EPSCoR states	123,090	136,312	135,402	208,500	233,600	254,000	590	584	533
Average EPSCoR state value	na	na	na	na	na	na	402	423	403
Average non-EPSCoR state value	na	na	na	na	na	na	570	563	515
United States	140,601	155,818	154,331	250,600	278,900	300,400	561	559	514
Alabama	1,851	1,868	1,688	3,000	3,300	3,600	617	566	469
Alaska	184	215	245	500	600	700	368	358	350
Arizona	2,082	2,333	2,342	3,200	3,800	3,900	651	614	601
Arkansas	585	713	616	1,600	1,900	2,000	366	375	308
California	17,440	19,566	19,781	25,100	27,600	31,800	695	709	622
Colorado	2,536	2,694	2,673	4,800	5,300	5,600	528	508	477
Connecticut	2,632	2,949	2,910	4,200	4,500	5,200	627	655	560
Delaware	535	604	572	800	800	900	669	755	636
District of Columbia	1,047	1,077	1,044	2,500	2,300	2,300	419	468	454
Florida	4,043	5,029	5,152	7,800	9,000	10,700	518	559	481
Georgia	3,372	3,862	4,084	6,300	7,400	8,400	535	522	486
Hawaii	515	569	595	1,500	1,600	1,600	343	356	372
Idaho	300	356	321	900	1,400	1,200	333	254	268
Illinois	6,598	7,153	7,089	10,600	11,400	12,200	622	627	581
Indiana	2,891	3,291	3,415	5,600	6,100	6,700	516	540	510
Iowa	2,068	2,099	1,980	3,200	3,500	3,900	646	600	508
Kansas	1,194	1,172	1,241	2,200	2,600	2,500	543	451	496
Kentucky	1,291	1,509	1,415	3,200	3,600	3,500	403	419	404
Louisiana	1,733	1,782	1,770	3,300	3,400	3,000	525	524	590
Maine	221	301	280	1,100	1,200	1,100	201	251	255
Maryland	4,786	5,158	4,922	5,800	7,200	7,900	825	716	623
Massachusetts	9,167	10,073	9,945	12,900	14,300	14,100	711	704	705
Michigan	4,833	5,328	5,549	8,700	9,300	10,200	556	573	544
Minnesota	2,289	2,410	2,483	5,300	5,600	6,000	432	430	414
Mississippi	669	816	805	2,000	2,000	1,900	335	408	424
Missouri	3,111	3,165	3,202	5,600	5,600	6,300	556	565	508
Montana	317	412	348	800	1,200	1,300	396	343	268
Nebraska	972	1,076	977	1,900	1,800	2,100	512	598	465
Nevada	414	521	491	1,300	1,600	1,400	318	326	351
New Hampshire	582	715	638	1,200	1,200	1,600	485	596	399
New Jersey	2,896	3,201	2,977	5,400	6,000	6,300	536	534	473
New Mexico	754	839	753	2,800	2,100	2,300	269	400	327
New York	11,722	12,468	12,075	20,200	21,800	23,700	580	572	509
North Carolina	4,932	5,590	5,740	8,600	9,900	10,400	573	565	552
North Dakota	263	371	369	700	1,000	1,100	376	371	335
Ohio	4,857	5,339	4,969	9,800	10,100	10,100	496	529	492
Oklahoma	862	973	1,020	2,800	2,800	3,300	308	348	309
Oregon	1,497	1,835	1,648	3,100	3,500	3,500	483	524	471
Pennsylvania	7,941	8,756	8,723	13,300	15,800	16,000	597	554	545
Rhode Island	840	894	971	1,700	2,000	1,600	494	447	607
South Carolina	1,299	1,453	1,509	2,900	3,500	3,600	448	415	419
South Dakota	124	154	196	600	700	700	207	220	280
Tennessee	2,178	2,574	2,555	4,700	5,500	6,000	463	468	426
Texas	8,709	9,884	9,842	13,600	16,600	19,300	640	595	510
Utah	1,509	1,734	1,692	3,000	3,500	3,500	503	495	483
Vermont	400	451	410	1,000	1,000	900	400	451	456
Virginia	2,896	3,161	3,332	6,500	7,600	8,400	446	416	397
Washington	3,217	3,381	3,216	6,200	7,000	7,200	519	483	447
West Virginia	375	428	425	1,100	1,300	1,300	341	329	327
Wisconsin	2,888	3,279	3,106	5,000	5,700	6,700	578	575	464
Wyoming	184	237	230	600	500	500	307	474	460
Puerto Rico	185	254	271	1,000	1,300	1,500	185	195	181

na = not applicable.

EPSCoR = Experimental Program to Stimulate Competitive Research.

NOTE: For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

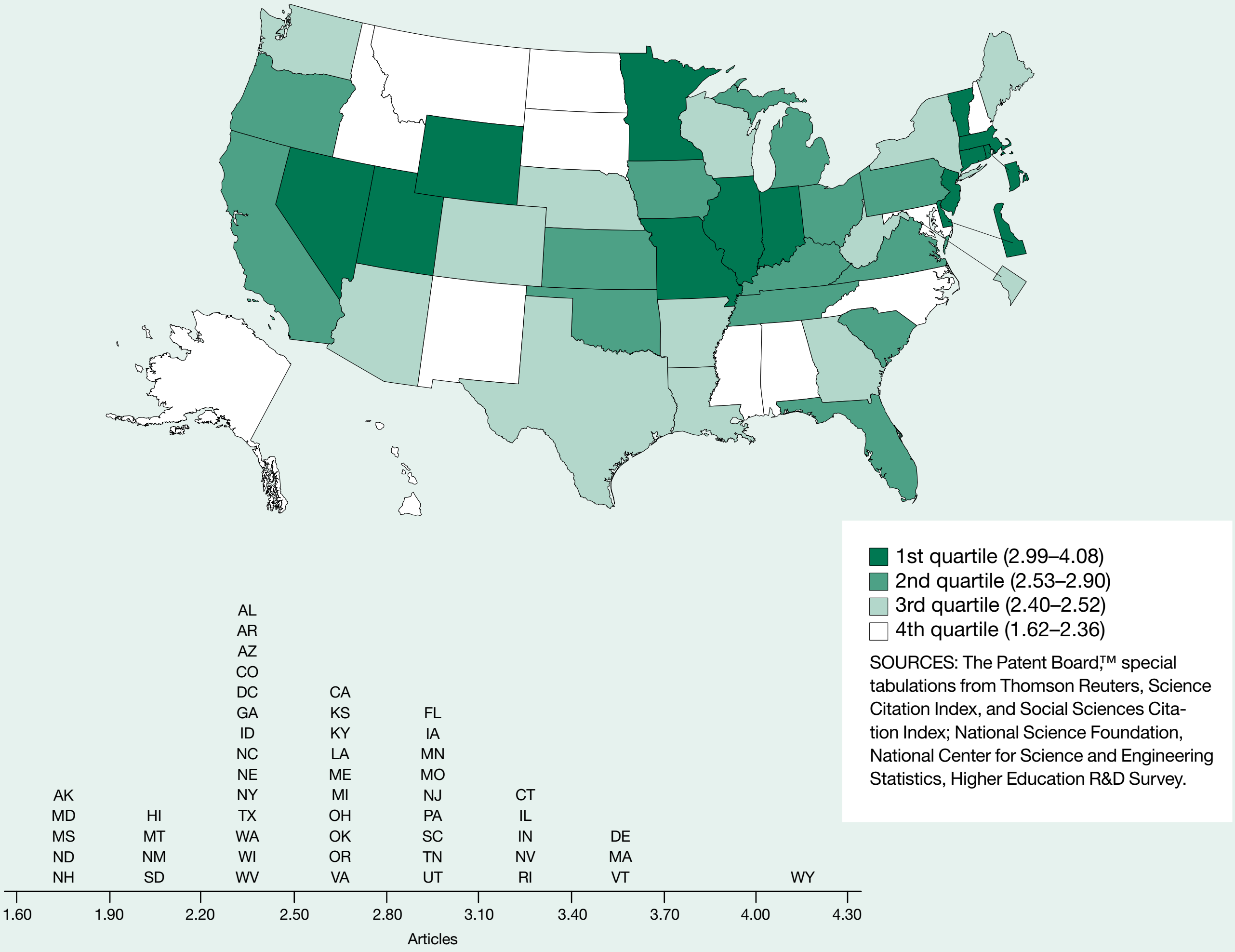
SOURCES: The Patent Board,™ special tabulations (2013) from Thomson Reuters, Science Citation Index and Social Sciences Citation Index http://thomsonreuters.com/products_services/science/; National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (various years).

Science and Engineering Indicators 2014

Academic Science and Engineering Article Output per $1 Million of Academic S&E R&D

Figure 8-50

Academic science and engineering article output per $1 million of academic S&E R&D: 2012



SOURCES: The Patent Board,™ special tabulations from Thomson Reuters, Science Citation Index, and Social Sciences Citation Index; National Science Foundation, National Center for Science and Engineering Statistics, Higher Education R&D Survey.

Findings

- From 2003 to 2012, the number of academic S&E publications rose from about 148,000 to about 163,000—an increase of 10% that may reflect both an increase in publications and an increase in the number of journals in the Thomson Reuters database.
- In 2012, academic researchers produced an average of 2.62 publications per $1 million of academic R&D, compared with 3.71 in 2003. This partly reflects the effect of general price inflation but may also indicate rising academic research costs.
- The value of this indicator ranged from 1.62 to 4.08 across the states in 2012.
- Between 2003 and 2012, the value for this indicator decreased 29% nationwide and in all states but Wyoming, Alaska, Nevada, and Vermont.

This indicator represents the relationship between the number of academic S&E publications and the amount of money expended for academic R&D. Academic institutions include 2-year colleges, 4-year colleges or universities, medical schools, and university-affiliated research centers. This indicator is not an efficiency measure; it is affected by the highly variable costs of R&D and by publishing conventions in different fields and institutions. It may also reflect variations in field emphasis among states and institutions.

Publication counts are based on the number of articles that appear in a set of journals tracked by Thomson Reuters in the Science Citation Index and Social Sciences Citation Index. Academic article output is based on the most recent journal set; data for earlier years may differ slightly from previous publications due to changes in the journal set. Articles with authors from different institutions were counted fractionally. For instance, for a publication with authors at *N* institutions, each institution would be credited with 1/*N* of the article.

Table 8-50

Academic science and engineering article output per $1 million of academic S&E R&D, by state: 2003, 2008, and 2012

	Academic S&E article output			Academic S&E R&D ($millions)			Academic S&E articles/ $1 million academic S&E R&D		
State	2003	2008	2012	2003	2008	2012	2003	2008	2012
United States	148,487	167,518	162,877	40,002	51,736	62,097	3.71	3.24	2.62
Alabama	1,851	1,976	1,824	551	708	808	3.36	2.79	2.26
Alaska	195	285	238	142	128	136	1.37	2.23	1.75
Arizona	2,152	2,455	2,388	618	831	987	3.48	2.95	2.42
Arkansas	664	716	683	184	247	276	3.61	2.90	2.47
California	18,756	21,003	20,485	5,358	7,026	8,093	3.50	2.99	2.53
Colorado	2,615	2,854	3,044	695	924	1,249	3.76	3.09	2.44
Connecticut	2,748	3,070	3,108	595	732	925	4.62	4.19	3.36
Delaware	581	650	627	105	133	177	5.53	4.89	3.54
District of Columbia	1,060	1,106	1,096	281	375	455	3.77	2.95	2.41
Florida	4,549	5,678	5,543	1,205	1,592	1,935	3.78	3.57	2.86
Georgia	3,641	4,300	4,187	1,177	1,521	1,709	3.09	2.83	2.45
Hawaii	572	696	622	185	279	328	3.09	2.49	1.90
Idaho	305	360	322	105	113	143	2.90	3.19	2.25
Illinois	6,958	7,655	7,393	1,614	1,973	2,271	4.31	3.88	3.26
Indiana	3,022	3,645	3,681	726	955	1,150	4.16	3.82	3.20
Iowa	2,212	2,215	2,015	499	528	695	4.43	4.20	2.90
Kansas	1,235	1,292	1,327	310	404	480	3.98	3.20	2.76
Kentucky	1,434	1,604	1,471	378	499	547	3.79	3.21	2.69
Louisiana	1,759	1,753	1,645	514	660	654	3.42	2.66	2.52
Maine	267	285	300	84	128	119	3.18	2.23	2.52
Maryland	4,947	5,453	5,381	2,041	2,747	3,316	2.42	1.99	1.62
Massachusetts	9,451	10,846	10,649	1,822	2,272	3,009	5.19	4.77	3.54
Michigan	5,071	5,804	5,829	1,390	1,594	2,092	3.65	3.64	2.79
Minnesota	2,287	2,633	2,515	518	699	841	4.42	3.77	2.99
Mississippi	710	840	764	324	406	438	2.19	2.07	1.74
Missouri	3,122	3,443	3,215	807	960	1,057	3.87	3.59	3.04
Montana	363	396	376	141	186	185	2.57	2.13	2.03
Nebraska	991	1,115	1,023	301	376	419	3.29	2.97	2.44
Nevada	458	571	471	155	191	149	2.95	2.99	3.16
New Hampshire	627	681	657	252	302	398	2.49	2.25	1.65
New Jersey	3,150	3,327	3,186	754	878	1,061	4.18	3.79	3.00
New Mexico	792	835	763	307	417	391	2.58	2.00	1.95
New York	12,140	13,317	12,816	3,078	3,982	5,166	3.94	3.34	2.48
North Carolina	5,321	6,170	6,182	1,398	1,979	2,619	3.81	3.12	2.36
North Dakota	315	411	363	134	181	214	2.35	2.27	1.70
Ohio	5,090	5,635	5,302	1,268	1,827	2,018	4.01	3.08	2.63
Oklahoma	933	1,081	1,131	295	333	413	3.16	3.25	2.74
Oregon	1,650	1,974	1,853	437	595	681	3.78	3.32	2.72
Pennsylvania	8,263	9,421	8,944	2,015	2,604	3,121	4.10	3.62	2.87
Rhode Island	871	1,020	1,102	187	237	336	4.66	4.30	3.28
South Carolina	1,428	1,587	1,584	435	576	564	3.28	2.76	2.81
South Dakota	165	202	259	50	92	123	3.30	2.20	2.11
Tennessee	2,310	2,826	2,810	600	787	968	3.85	3.59	2.90
Texas	9,423	10,756	10,584	2,765	3,744	4,414	3.41	2.87	2.40
Utah	1,539	1,786	1,851	385	426	608	4.00	4.19	3.04
Vermont	383	475	434	107	117	120	3.58	4.06	3.62
Virginia	2,991	3,593	3,551	776	1,053	1,284	3.85	3.41	2.77
Washington	3,412	3,605	3,334	871	1,058	1,376	3.92	3.41	2.42
West Virginia	375	417	451	125	169	184	3.00	2.47	2.45
Wisconsin	3,129	3,445	3,237	878	1,117	1,331	3.56	3.08	2.43
Wyoming	204	255	261	60	75	64	3.40	3.40	4.08
Puerto Rico	212	265	243	78	NA	NA	2.72	NA	NA

NA = not available.

NOTE: Academic R&D expenditures are reported in current dollars.

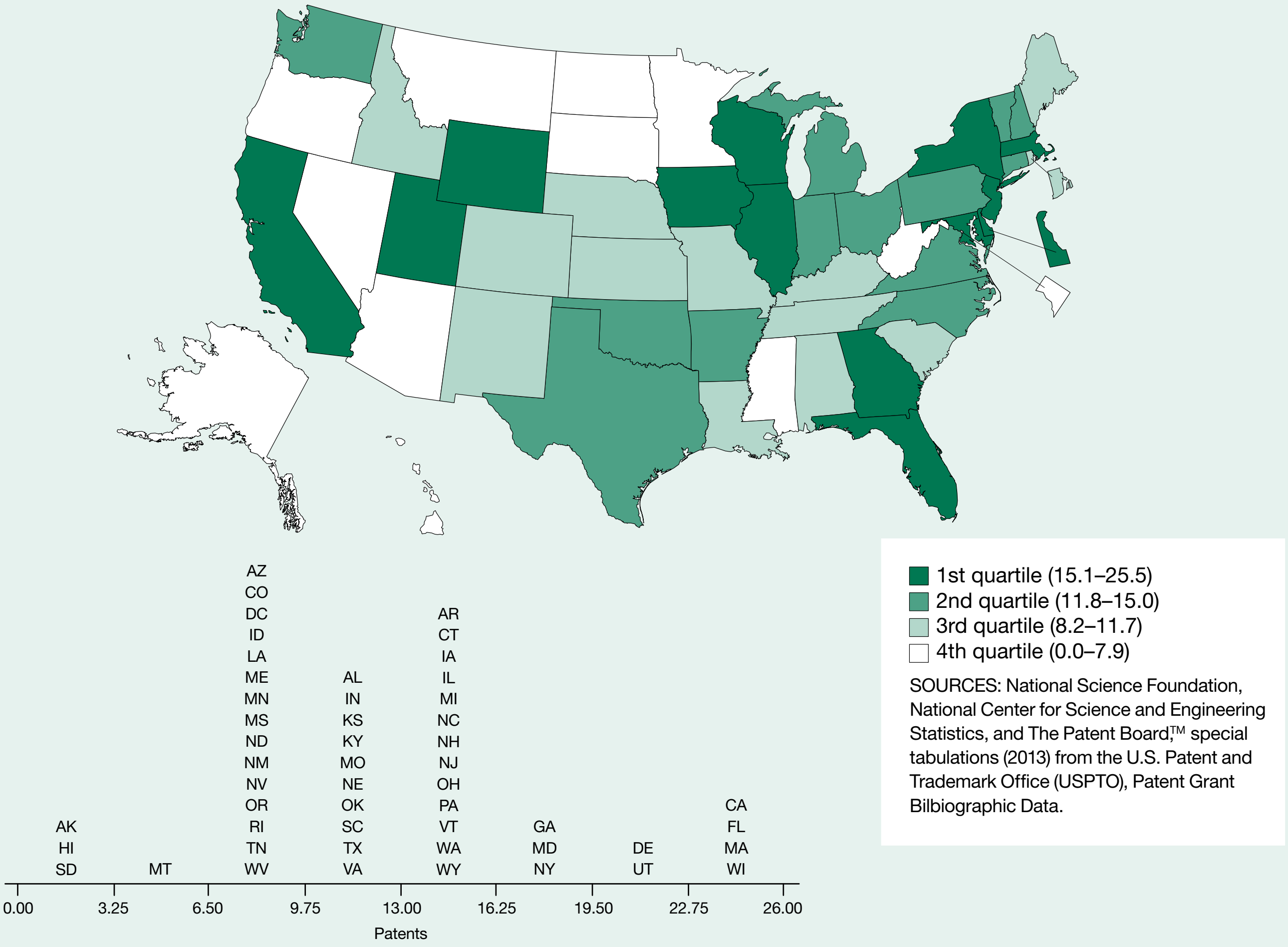
SOURCES: The Patent Board,™ special tabulations (2013) from Thomson Reuters, Science Citation Index and Social Sciences Citation Index http://thomsonreuters.com/products_services/science/; National Science Foundation, National Center for Science and Engineering Statistics, Academic R&D Expenditure Survey, Higher Education R&D Survey (various years).

Science and Engineering Indicators 2014

Academic Patents Awarded per 1,000 Science and Engineering Doctorate Holders in Academia

Figure 8-51

Academic patents awarded per 1,000 science and engineering doctorate holders in academia: 2010



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from the U.S. Patent and Trademark Office (USPTO), Patent Grant Bilbiographic Data.

Findings

- Throughout the United States, the number of new patents assigned to academic institutions increased 28% from 2001 to 2010; the number of academic S&E doctorate holders rose by 20% during the same period.
- In 2010, states varied widely on this indicator, with values ranging from 0 to 25.5 patents per 1,000 S&E doctorate holders employed in academia.
- California showed the highest level of both academic patenting and venture capital investment.
- The value of this indicator fluctuates over time and across states.

Since the early 1980s, academic institutions have increasingly been viewed as engines of economic growth. Growing attention has been paid to the role of academic R&D in creating new products, processes, and services. One indicator of such R&D results is the volume of patents assigned to academic institutions. Academic patenting is highly concentrated and partly reflects the resources devoted to institutional patenting offices.

This indicator relates the number of academic-owned utility patents to the size of the doctoral S&E workforce in academia and is one approximate measure of the degree to which results with perceived economic value are generated by the doctoral academic workforce. Academia includes 2-year colleges, 4-year colleges and universities, medical schools, and university-affiliated research centers. Utility patents, commonly known as patents for inventions, include any new, useful, or improved method, process, machine, device, manufactured item, or chemical compound and represent a key measure of intellectual property. Patent assignments are made on the basis of the address of their original assignee(s). For patents with multiple U.S. university assignees from different U.S. states, the database credits each participating U.S. state as owning one patent.

S&E doctorates include those in computer sciences; mathematics; biological, agricultural, or environmental life sciences; physical sciences; social sciences; psychology; engineering; and health fields. S&E doctorate data exclude those with doctorates from foreign institutions and those older than the age of 75. For states with smaller populations, estimates of doctorate holders in academia are generally less precise than estimates for states with larger populations. Data for S&E doctorate holders are presented by employment location regardless of residence.

Table 8-51

Academic patents awarded per 1,000 science and engineering doctorate holders in academia, by state: 2001, 2006, and 2010

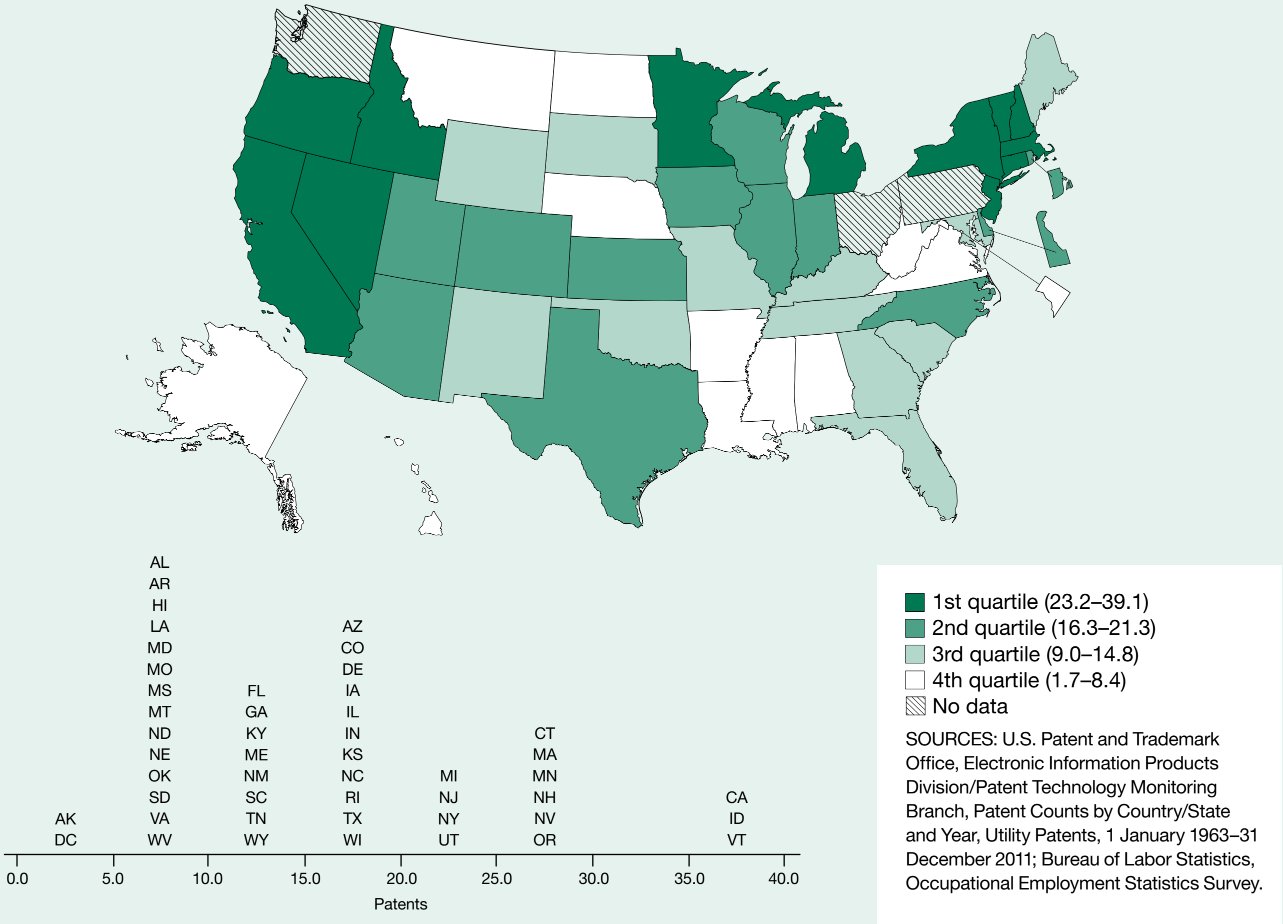
State	Patents awarded to academic institutions			S&E doctorate holders in academia			Academic patents/1,000 academic S&E doctorate holders		
	2001	2006	2010	2001	2006	2010	2001	2006	2010
United States	3,680	3,646	4,699	250,600	278,900	300,400	14.7	13.1	15.6
Alabama	43	31	37	3,000	3,300	3,600	14.3	9.4	10.3
Alaska	0	0	2	500	600	700	0.0	0.0	2.9
Arizona	24	38	31	3,200	3,800	3,900	7.5	10.0	7.9
Arkansas	30	27	27	1,600	1,900	2,000	18.8	14.2	13.5
California	703	728	787	25,100	27,600	31,800	28.0	26.4	24.7
Colorado	35	32	46	4,800	5,300	5,600	7.3	6.0	8.2
Connecticut	44	53	68	4,200	4,500	5,200	10.5	11.8	13.1
Delaware	5	5	20	800	800	900	6.3	6.3	22.2
District of Columbia	14	13	15	2,500	2,300	2,300	5.6	5.7	6.5
Florida	118	178	258	7,800	9,000	10,700	15.1	19.8	24.1
Georgia	87	87	139	6,300	7,400	8,400	13.8	11.8	16.5
Hawaii	8	10	5	1,500	1,600	1,600	5.3	6.3	3.1
Idaho	6	11	11	900	1,400	1,200	6.7	7.9	9.2
Illinois	151	132	191	10,600	11,400	12,200	14.2	11.6	15.7
Indiana	41	42	79	5,600	6,100	6,700	7.3	6.9	11.8
Iowa	70	57	62	3,200	3,500	3,900	21.9	16.3	15.9
Kansas	19	6	25	2,200	2,600	2,500	8.6	2.3	10.0
Kentucky	23	30	41	3,200	3,600	3,500	7.2	8.3	11.7
Louisiana	49	29	29	3,300	3,400	3,000	14.8	8.5	9.7
Maine	2	5	10	1,100	1,200	1,100	1.8	4.2	9.1
Maryland	133	148	148	5,800	7,200	7,900	22.9	20.6	18.7
Massachusetts	257	255	359	12,900	14,300	14,100	19.9	17.8	25.5
Michigan	121	136	147	8,700	9,300	10,200	13.9	14.6	14.4
Minnesota	42	39	42	5,300	5,600	6,000	7.9	7.0	7.0
Mississippi	15	14	15	2,000	2,000	1,900	7.5	7.0	7.9
Missouri	65	48	62	5,600	5,600	6,300	11.6	8.6	9.8
Montana	5	6	7	800	1,200	1,300	6.3	5.0	5.4
Nebraska	21	21	22	1,900	1,800	2,100	11.1	11.7	10.5
Nevada	4	5	10	1,300	1,600	1,400	3.1	3.1	7.1
New Hampshire	11	20	21	1,200	1,200	1,600	9.2	16.7	13.1
New Jersey	92	92	95	5,400	6,000	6,300	17.0	15.3	15.1
New Mexico	22	11	21	2,800	2,100	2,300	7.9	5.2	9.1
New York	317	317	444	20,200	21,800	23,700	15.7	14.5	18.7
North Carolina	159	137	152	8,600	9,900	10,400	18.5	13.8	14.6
North Dakota	4	4	8	700	1,000	1,100	5.7	4.0	7.3
Ohio	104	104	139	9,800	10,100	10,100	10.6	10.3	13.8
Oklahoma	23	27	40	2,800	2,800	3,300	8.2	9.6	12.1
Oregon	26	24	24	3,100	3,500	3,500	8.4	6.9	6.9
Pennsylvania	243	165	240	13,300	15,800	16,000	18.3	10.4	15.0
Rhode Island	30	14	15	1,700	2,000	1,600	17.6	7.0	9.4
South Carolina	15	23	42	2,900	3,500	3,600	5.2	6.6	11.7
South Dakota	1	0	0	600	700	700	1.7	0.0	0.0
Tennessee	53	40	53	4,700	5,500	6,000	11.3	7.3	8.8
Texas	179	217	244	13,600	16,600	19,300	13.2	13.1	12.6
Utah	51	40	79	3,000	3,500	3,500	17.0	11.4	22.6
Vermont	5	5	12	1,000	1,000	900	5.0	5.0	13.3
Virginia	51	56	107	6,500	7,600	8,400	7.8	7.4	12.7
Washington	67	50	94	6,200	7,000	7,200	10.8	7.1	13.1
West Virginia	6	2	9	1,100	1,300	1,300	5.5	1.5	6.9
Wisconsin	83	108	157	5,000	5,700	6,700	16.6	18.9	23.4
Wyoming	3	4	8	600	500	500	5.0	8.0	16.0
Puerto Rico	6	3	2	1,000	1,300	1,500	6.0	2.3	1.3

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from U.S. Patent and Trademark Office, Patent Grant Bibliographic Data.

Science and Engineering Indicators 2014

Patents Awarded per 1,000 Individuals in Science and Engineering Occupations

Figure 8-52
Patents awarded per 1,000 individuals in science and engineering occupations: 2012



SOURCES: U.S. Patent and Trademark Office, Electronic Information Products Division/Patent Technology Monitoring Branch, Patent Counts by Country/State and Year, Utility Patents, 1 January 1963–31 December 2011; Bureau of Labor Statistics, Occupational Employment Statistics Survey.

Findings

- About 121,000 utility patents were awarded to inventors residing in the United States in 2012, an increase from the 88,000 utility patents awarded in 2003.
- In 2012, the national average for this indicator was 20.3 patents per 1,000 individuals in an S&E occupation, higher than the average of 17.7 in 2003.
- Values for individual states varied widely, ranging from 1.7 to 39.1 patents per 1,000 individuals in S&E occupations in 2012.
- Almost 27% of all 2012 U.S. utility patents were awarded to residents of California. Texas and New York were each awarded approximately 8,000 utility patents in 2012, together representing more than 13% of the national total.

This indicator represents state patent activity normalized to the size of its S&E workforce, specifically employees in S&E occupations. People in S&E occupations include engineers and computer, mathematical, life, physical, and social scientists. Managers, technicians, elementary and secondary schoolteachers, and medical personnel are not included.

Although the U.S. Patent and Trademark Office (USPTO) grants several types of patents, this indicator covers only utility patents, commonly known as patents for inventions. Utility patents can be granted for any new, useful, or improved method, process, machine, device, manufactured item, or chemical compound and represent a key measure of intellectual property. USPTO classifies patents geographically according to the residence of the first-named inventor. Only U.S.-origin patents are included.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics.

Situations in which workers live in one state and work in another introduce some imprecision into the calculation of this indicator. The treatment of postsecondary teachers is another source of imprecision. Due to the way the data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-52

Patents awarded per 1,000 individuals in science and engineering occupations, by state: 2003, 2008, and 2012

	Patents awarded			Individuals in S&E occupations			Patents/1,000 individuals in S&E occupations		
State	2003	2008	2012	2003	2008	2012	2003	2008	2012
United States	87,864	77,480	120,989	4,961,550	5,781,460	5,968,240	17.7	13.4	20.3
Alabama	397	279	413	56,380	68,580	72,880	7.0	4.1	5.7
Alaska	37	20	28	10,600	13,260	16,260	3.5	1.5	1.7
Arizona	1,584	1,584	2,210	92,120	102,100	116,930	17.2	15.5	18.9
Arkansas	152	108	178	21,340	29,310	29,530	7.1	3.7	6.0
California	19,688	19,182	32,107	676,180	791,750	821,780	29.1	24.2	39.1
Colorado	2,069	1,621	2,442	124,140	147,000	149,020	16.7	11.0	16.4
Connecticut	1,667	1,357	2,108	81,380	80,290	78,450	20.5	16.9	26.9
Delaware	346	325	445	17,370	22,330	23,440	19.9	14.6	19.0
District of Columbia	49	68	131	54,890	63,360	63,600	0.9	1.1	2.1
Florida	2,563	2,046	3,686	221,070	248,200	248,300	11.6	8.2	14.8
Georgia	1,333	1,344	2,128	144,170	147,380	148,830	9.2	9.1	14.3
Hawaii	75	77	108	16,090	18,830	20,930	4.7	4.1	5.2
Idaho	1,803	1,162	930	22,150	23,310	25,260	81.4	49.8	36.8
Illinois	3,296	2,741	4,345	211,230	224,370	220,170	15.6	12.2	19.7
Indiana	1,385	985	1,741	78,410	90,840	94,620	17.7	10.8	18.4
Iowa	665	561	854	37,320	46,180	50,950	17.8	12.1	16.8
Kansas	428	425	1,004	51,970	54,260	50,930	8.2	7.8	19.7
Kentucky	439	413	543	45,230	NA	51,830	9.7	NA	10.5
Louisiana	390	260	364	41,900	41,790	45,920	9.3	6.2	7.9
Maine	150	113	211	15,020	17,000	17,910	10.0	6.6	11.8
Maryland	1,453	1,232	1,609	149,250	167,070	179,550	9.7	7.4	9.0
Massachusetts	3,908	3,516	5,734	184,690	217,310	229,160	21.2	16.2	25.0
Michigan	3,857	2,996	4,598	182,940	204,290	198,610	21.1	14.7	23.2
Minnesota	2,953	2,535	3,902	117,120	134,440	131,690	25.2	18.9	29.6
Mississippi	162	102	140	22,190	27,270	23,640	7.3	3.7	5.9
Missouri	823	615	1,015	84,150	105,390	109,650	9.8	5.8	9.3
Montana	121	91	119	11,450	NA	15,360	10.6	NA	7.7
Nebraska	185	191	292	30,710	31,820	34,720	6.0	6.0	8.4
Nevada	389	375	752	22,330	27,300	27,000	17.4	13.7	27.9
New Hampshire	677	477	734	23,430	29,150	28,950	28.9	16.4	25.4
New Jersey	3,522	2,722	4,224	161,420	198,060	181,480	21.8	13.7	23.3
New Mexico	390	280	417	33,600	34,560	35,310	11.6	8.1	11.8
New York	6,234	4,885	7,640	272,440	326,510	321,480	22.9	15.0	23.8
North Carolina	1,871	1,841	2,977	132,440	153,680	167,900	14.1	12.0	17.7
North Dakota	55	63	96	8,430	9,450	13,120	6.5	6.7	7.3
Ohio	3,183	2,227	3,387	177,100	206,320	NA	18.0	10.8	NA
Oklahoma	516	417	471	44,360	48,900	50,420	11.6	8.5	9.3
Oregon	1,665	1,781	2,059	61,230	70,070	75,780	27.2	25.4	27.2
Pennsylvania	3,182	2,414	3,483	185,560	227,170	NA	17.1	10.6	NA
Rhode Island	266	218	329	18,740	18,090	20,180	14.2	12.1	16.3
South Carolina	571	395	850	48,740	57,770	63,170	11.7	6.8	13.5
South Dakota	80	54	113	9,150	11,870	12,000	8.7	4.5	9.4
Tennessee	797	586	930	63,680	72,760	79,830	12.5	8.1	11.6
Texas	6,029	5,712	8,367	365,270	463,850	493,980	16.5	12.3	16.9
Utah	638	642	1,167	45,570	52,570	54,720	14.0	12.2	21.3
Vermont	429	437	487	11,420	12,360	12,870	37.6	35.4	37.8
Virginia	1,110	1,030	1,691	209,280	259,280	274,280	5.3	4.0	6.2
Washington	2,285	3,517	5,390	150,230	NA	NA	15.2	NA	NA
West Virginia	139	74	135	16,220	17,000	19,900	8.6	4.4	6.8
Wisconsin	1,787	1,349	1,785	93,320	101,680	103,030	19.1	13.3	17.3
Wyoming	71	35	120	6,130	8,850	8,710	11.6	4.0	13.8
Puerto Rico	27	14	34	19,940	22,970	21,750	1.4	0.6	1.6

NA = not available.

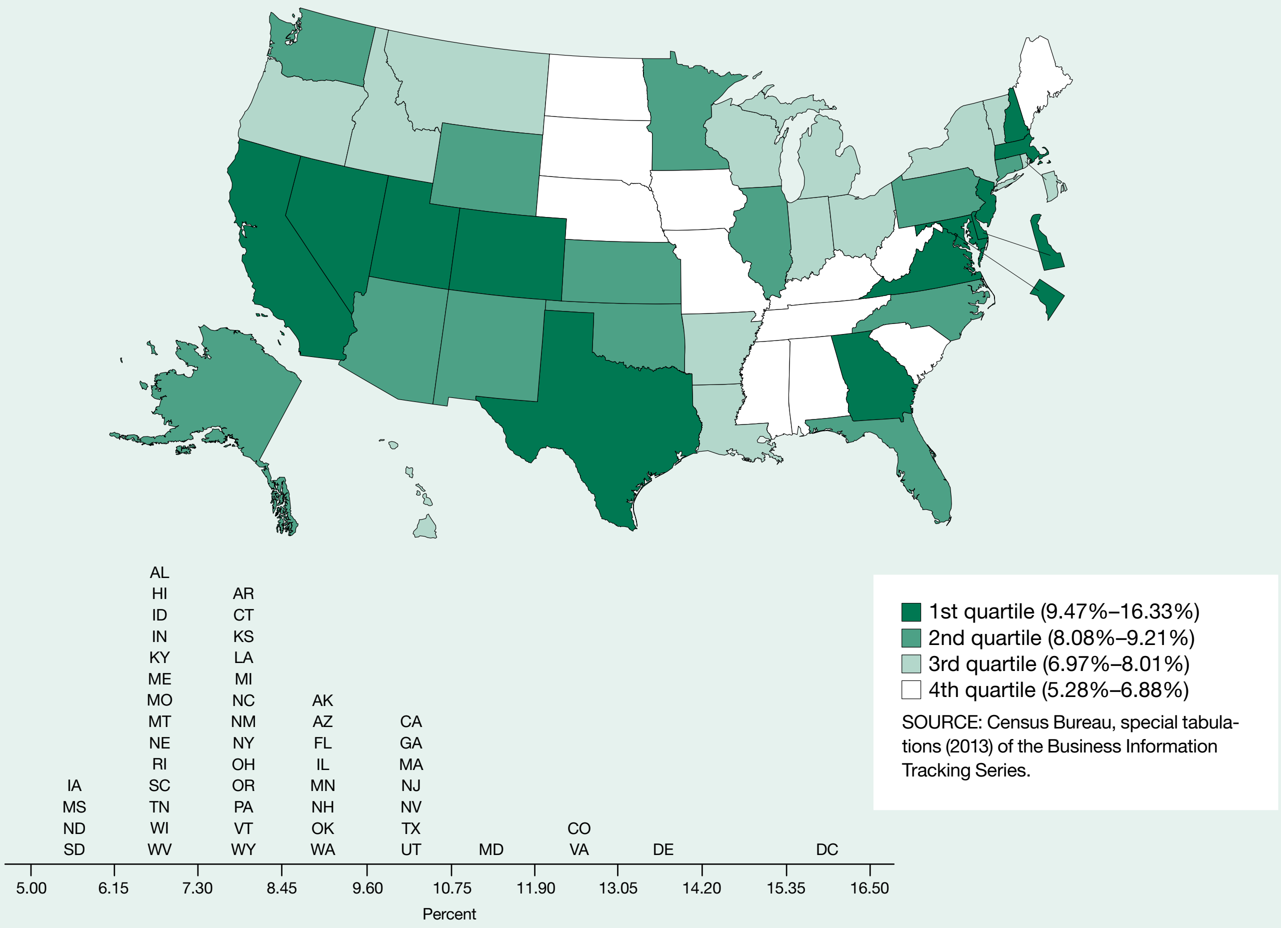
NOTES: Origin of utility patent is determined by the residence of the first-named inventor. National totals for S&E occupations include states with suppressed data. Occupational Employment Statistics estimates for 2003 are based on November data; estimates for the remaining years are based on May data.

SOURCES: U.S. Patent and Trademark Office, Electronic Information Products Division/Patent Technology Monitoring Branch, Patent Counts by Country/State and Year, Utility Patents, 1 January 1963–31 December 2011; Bureau of Labor Statistics, Occupational Employment Statistics Survey (various years).

Science and Engineering Indicators 2014

High-Technology Establishments as a Percentage of All Business Establishments

Figure 8-53
High-technology establishments as a percentage of all business establishments: 2010



SOURCE: Census Bureau, special tabulations (2013) of the Business Information Tracking Series.

Findings

- The number of establishments in high-technology industries rose from about 590,000 in 2003 to nearly 649,000 in 2010, an increase of 10%.
- The percentage of U.S. establishments in high-technology industries went from 8.17% to 8.79% of the total business establishments during the 2003–10 period, and most states showed an upward trend in the percentage of their establishments in high-technology industries.
- Between 2003 and 2010, the largest growth in the number of establishments in high-technology industries occurred in California and Florida, which added approximately 8,200 and 6,500 establishments, respectively.
- The state distribution of this indicator is similar to that of three other indicators: bachelor's degree holders, S&E doctoral degree holders, and workers in S&E occupations, all expressed as a share of the workforce.
- Experimental Program to Stimulate Competitive Research (EPSCoR) states have a lower average value on this indicator than non-EPSCoR states.

This indicator represents the portion of a state's business establishments that are classified as being part of high-technology industries. High-technology industries are defined as those in which the proportion of employees in technology-oriented occupations is at least twice the average proportion for all industries. High-technology occupations include scientific, engineering, and technician occupations that employ workers who generally possess in-depth knowledge of the theories and principles of science, engineering, and mathematics at a postsecondary level.

States often consider such industries desirable, in part because they tend to compensate workers better than other industries do. This indicator includes all establishments with an employer identification number regardless of the number of people they employ.

The data pertaining to establishments for the years 2003 to 2008 are based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). The data for the years 2009 and 2010 are based on their classification according to the 2007 edition of the NAICS. See table 8-A in the chapter introduction for a list of the industries (by NAICS code) that are defined as high technology. Data for years prior to 2003 are not directly comparable.

Table 8-53

High-technology establishments as a percentage of all business establishments, by state: 2003, 2007, and 2010

	High-technology establishments			All business establishments			High-technology/all business establishments (%)		
State	2003	2007	2010	2003	2007	2010	2003	2007	2010
EPSCoR states	80,403	87,616	88,727	1,150,925	1,221,996	1,173,884	6.99	7.17	7.56
Non-EPSCoR states	504,364	556,553	553,299	6,001,637	6,392,070	6,135,209	8.40	8.71	9.02
Average EPSCoR state value	na	na	na	na	na	na	7.20	7.34	7.73
Average non-EPSCoR state value	na	na	na	na	na	na	8.23	8.52	8.86
United States	590,417	650,707	648,993	7,223,240	7,689,821	7,384,267	8.17	8.46	8.79
Alabama	6,347	6,783	6,786	99,453	105,388	99,097	6.38	6.44	6.85
Alaska	1,345	1,538	1,698	19,037	20,146	19,922	7.07	7.63	8.52
Arizona	10,433	12,540	11,875	120,966	142,649	131,661	8.62	8.79	9.02
Arkansas	4,012	4,550	4,852	64,058	67,513	65,069	6.26	6.74	7.46
California	77,614	87,815	85,787	822,751	889,726	848,238	9.43	9.87	10.11
Colorado	15,532	18,016	18,306	143,398	157,570	151,765	10.83	11.43	12.06
Connecticut	7,827	7,868	7,472	91,207	93,444	89,078	8.58	8.42	8.39
Delaware	3,964	3,573	3,256	24,739	25,476	24,263	16.02	14.02	13.42
District of Columbia	2,589	3,158	3,507	19,357	20,957	21,478	13.38	15.07	16.33
Florida	38,118	44,745	44,577	458,823	522,710	490,492	8.31	8.56	9.09
Georgia	18,820	21,586	21,413	208,350	231,418	216,787	9.03	9.33	9.88
Hawaii	2,097	2,305	2,309	30,950	33,321	31,904	6.78	6.92	7.24
Idaho	2,515	3,107	3,071	39,582	47,284	43,365	6.35	6.57	7.08
Illinois	27,606	29,222	28,886	310,589	324,628	313,654	8.89	9.00	9.21
Indiana	9,626	10,355	10,276	147,073	152,604	144,802	6.55	6.79	7.10
Iowa	4,316	4,679	4,745	80,745	83,008	80,637	5.35	5.64	5.88
Kansas	5,716	6,076	6,144	74,637	76,984	74,163	7.66	7.89	8.28
Kentucky	5,453	5,850	5,913	90,358	93,428	90,665	6.03	6.26	6.52
Louisiana	7,218	7,574	7,850	101,933	104,459	103,234	7.08	7.25	7.60
Maine	2,466	2,612	2,652	40,519	42,409	40,506	6.09	6.16	6.55
Maryland	13,428	15,151	15,589	132,782	141,076	134,417	10.11	10.74	11.60
Massachusetts	17,183	17,470	17,148	177,910	176,304	169,475	9.66	9.91	10.12
Michigan	16,937	17,321	16,555	236,221	234,971	218,752	7.17	7.37	7.57
Minnesota	12,834	13,590	13,014	145,364	151,304	145,247	8.83	8.98	8.96
Mississippi	3,269	3,405	3,496	59,565	61,727	59,196	5.49	5.52	5.91
Missouri	9,562	10,238	9,956	149,753	154,201	149,628	6.39	6.64	6.65
Montana	2,108	2,515	2,593	33,616	37,645	35,950	6.27	6.68	7.21
Nebraska	2,797	3,257	3,361	50,213	52,452	51,803	5.57	6.21	6.49
Nevada	5,387	6,087	6,031	53,080	62,706	59,113	10.15	9.71	10.20
New Hampshire	3,511	3,575	3,539	38,119	39,363	37,385	9.21	9.08	9.47
New Jersey	24,286	24,688	23,686	237,097	242,967	228,577	10.24	10.16	10.36
New Mexico	3,322	3,658	3,611	43,386	46,763	44,134	7.66	7.82	8.18
New York	35,926	38,368	38,636	500,559	518,608	518,527	7.18	7.40	7.45
North Carolina	14,869	17,671	17,967	207,500	227,444	217,768	7.17	7.77	8.25
North Dakota	964	1,075	1,151	20,371	21,477	21,792	4.73	5.01	5.28
Ohio	19,875	20,486	20,180	269,202	269,855	253,136	7.38	7.59	7.97
Oklahoma	6,859	7,512	7,610	85,633	91,054	89,868	8.01	8.25	8.47
Oregon	7,500	8,453	8,587	102,462	113,054	107,181	7.32	7.48	8.01
Pennsylvania	22,266	23,778	23,956	297,040	304,721	296,514	7.50	7.80	8.08
Rhode Island	1,976	2,108	2,071	29,172	30,299	28,477	6.77	6.96	7.27
South Carolina	5,869	6,942	7,010	98,735	107,685	101,902	5.94	6.45	6.88
South Dakota	1,206	1,347	1,426	24,314	25,797	25,562	4.96	5.22	5.58
Tennessee	8,196	8,980	8,702	129,458	137,547	131,302	6.33	6.53	6.63
Texas	45,062	49,237	50,180	481,804	520,405	521,248	9.35	9.46	9.63
Utah	5,474	6,960	7,139	60,011	71,722	68,725	9.12	9.70	10.39
Vermont	1,453	1,570	1,581	21,747	22,298	21,422	6.68	7.04	7.38
Virginia	18,868	22,607	23,623	182,783	200,131	192,780	10.32	11.30	12.25
Washington	13,171	15,138	15,335	166,229	183,984	175,486	7.92	8.23	8.74
West Virginia	2,257	2,352	2,490	40,225	40,415	38,599	5.61	5.82	6.45
Wisconsin	9,035	9,591	9,709	141,560	146,019	139,332	6.38	6.57	6.97
Wyoming	1,353	1,625	1,686	18,804	20,705	20,189	7.20	7.85	8.35
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

na = not applicable; NA = not available.

EPSCoR = Experimental Program to Stimulate Competitive Research.

NOTE: For an explanation of EPSCoR and non-EPSCoR averages, see the chapter introduction.

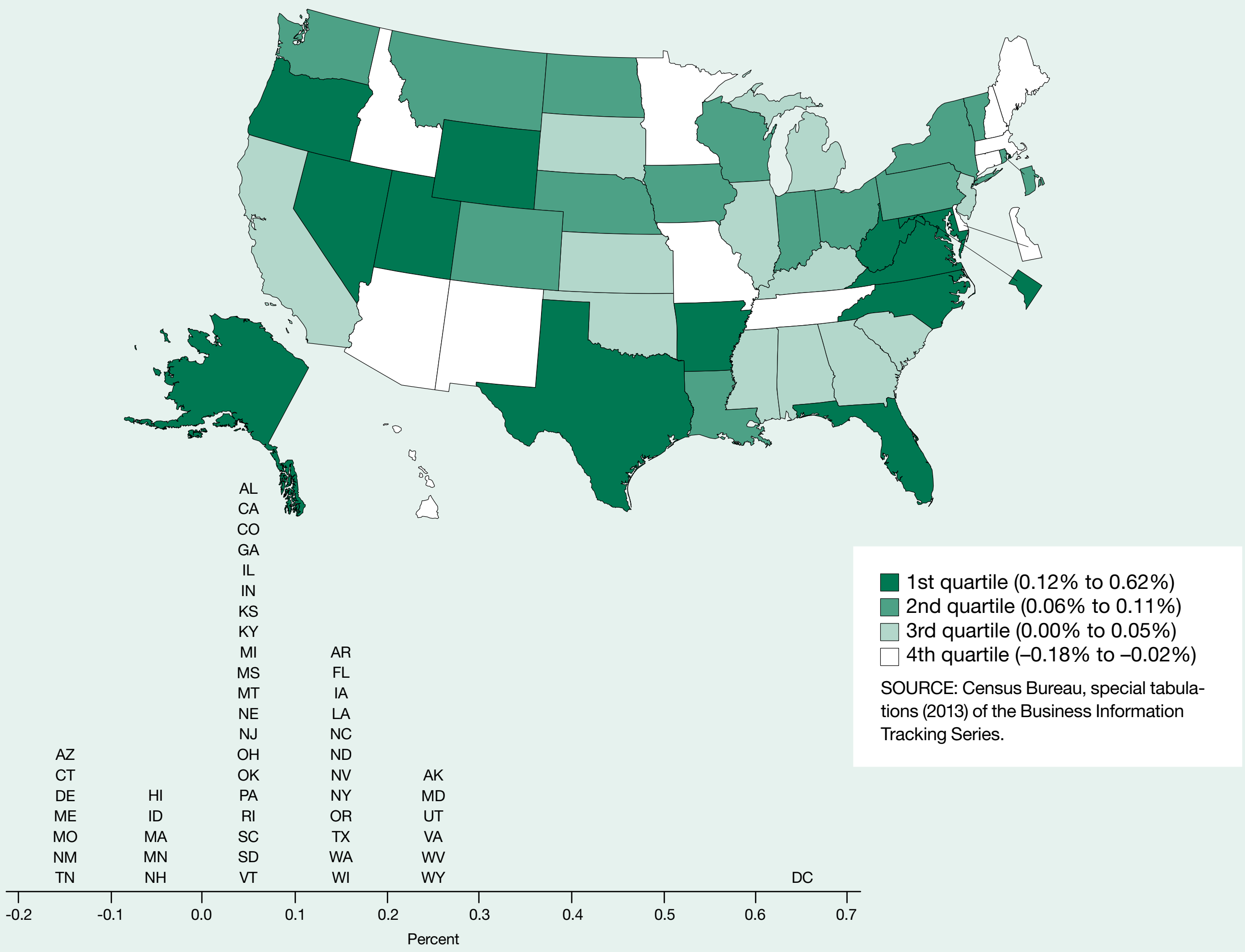
SOURCE: Census Bureau, special tabulations (2007, 2010, 2013) of the Business Information Tracking Series (various years).

Science and Engineering Indicators 2014

Net High-Technology Business Formations as a Percentage of All Business Establishments

Figure 8-54

Net high-technology business formations as a percentage of all business establishments: 2010



SOURCE: Census Bureau, special tabulations (2013) of the Business Information Tracking Series.

Findings

- In 2010, about 4,600 more businesses in high-technology industries were formed than ceased operations in the United States. From a base of approximately 7.4 million total business establishments, 78,862 new business establishments were formed in high-technology industries and 74,231 ceased operations in those same industries.
- The lingering effects of the business downturn were still evident in 2010 as 12 states had more businesses in high-technology industries ceasing operations than were being formed.
- Many of the top-ranking states on this indicator were Experimental Program to Stimulate Competitive Research states. However, the largest numbers of net new businesses were formed in Florida and Texas.

The business base of a state is constantly changing as new businesses form and others cease to exist. The term "net business formations" refers to the difference between the number of businesses that are formed and the number that cease operations during any particular year.

The ratio of the number of net business formations that occur in high-technology industries to the number of business establishments in a state indicates the changing role of high-technology industries in a state's economy. High positive values indicate an increasingly prominent role for these industries.

The data on business establishments in high-technology industries in 2003 through 2008 are based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). The data for the years 2009 and 2010 are based on their classification according to the 2007 edition of the NAICS. See table 8-A in the chapter introduction for a list of the industries (by NAICS code) that are defined as high technology. Data for years prior to 2003 are not directly comparable.

Changes in company name, ownership, or address are not counted as business formations or business deaths. Net business formations cannot be used to directly link the number of high-technology business establishments in different years because the primary industry of some establishments may have changed during the period.

Table 8-54

Net high-technology business formations as a percentage of all business establishments, by state: 2004, 2007, and 2010

State	Net high-technology business formations			All business establishments			High-technology business formations/ all business establishments (%)		
	2004	2007	2010	2004	2007	2010	2004	2007	2010
United States	11,598	15,113	4,631	7,355,122	7,689,821	7,384,267	0.16	0.20	0.06
Alabama	63	141	-3	100,402	105,388	99,097	0.06	0.13	0.00
Alaska	22	55	49	19,266	20,146	19,922	0.12	0.27	0.25
Arizona	357	464	-213	125,126	142,649	131,661	0.30	0.33	-0.16
Arkansas	123	114	120	65,022	67,513	65,069	0.19	0.17	0.18
California	1,099	1,929	-8	836,783	889,726	848,238	0.13	0.22	0.00
Colorado	490	751	97	146,747	157,570	151,765	0.34	0.48	0.06
Connecticut	-47	62	-113	92,552	93,444	89,078	-0.05	0.07	-0.13
Delaware	-52	-131	-36	25,311	25,476	24,263	-0.21	-0.51	-0.15
District of Columbia	66	143	134	19,498	20,957	21,478	0.34	0.68	0.62
Florida	1,743	873	616	482,910	522,710	490,492	0.38	0.17	0.13
Georgia	642	731	106	213,906	231,418	216,787	0.31	0.32	0.05
Hawaii	51	-30	-32	31,497	33,321	31,904	0.16	-0.09	-0.10
Idaho	54	185	-13	41,121	47,284	43,365	0.14	0.39	-0.03
Illinois	452	545	92	314,707	324,628	313,654	0.15	0.17	0.03
Indiana	208	171	122	148,864	152,604	144,802	0.14	0.11	0.08
Iowa	12	97	91	81,216	83,008	80,637	0.01	0.12	0.11
Kansas	160	41	31	75,478	76,984	74,163	0.21	0.05	0.04
Kentucky	116	48	14	91,437	93,428	90,665	0.13	0.05	0.02
Louisiana	-38	225	117	102,732	104,459	103,234	-0.04	0.22	0.11
Maine	81	0	-44	41,061	42,409	40,506	0.20	0.00	-0.11
Maryland	475	478	342	135,515	141,076	134,417	0.36	0.34	0.25
Massachusetts	156	304	-36	175,154	176,304	169,475	0.09	0.17	-0.02
Michigan	44	267	113	237,062	234,971	218,752	0.02	0.11	0.05
Minnesota	185	276	-54	148,053	151,304	145,247	0.13	0.18	-0.04
Mississippi	7	79	25	60,267	61,727	59,196	0.01	0.13	0.04
Missouri	195	62	-262	153,328	154,201	149,628	0.13	0.04	-0.18
Montana	108	87	26	34,473	37,645	35,950	0.32	0.23	0.07
Nebraska	64	144	32	50,735	52,452	51,803	0.13	0.27	0.06
Nevada	169	181	112	55,590	62,706	59,113	0.32	0.29	0.19
New Hampshire	30	-23	-28	38,650	39,363	37,385	0.08	-0.06	-0.07
New Jersey	-80	-77	31	239,692	242,967	228,577	-0.03	-0.03	0.01
New Mexico	37	93	-69	44,024	46,763	44,134	0.09	0.20	-0.16
New York	702	977	530	509,079	518,608	518,527	0.14	0.19	0.10
North Carolina	514	559	383	212,170	227,444	217,768	0.25	0.25	0.18
North Dakota	-1	52	25	20,739	21,477	21,792	0.00	0.24	0.11
Ohio	204	205	173	270,693	269,855	253,136	0.08	0.08	0.07
Oklahoma	75	245	47	87,064	91,054	89,868	0.09	0.27	0.05
Oregon	156	309	198	104,808	113,054	107,181	0.15	0.27	0.18
Pennsylvania	474	233	198	300,408	304,721	296,514	0.16	0.08	0.07
Rhode Island	67	69	22	29,845	30,299	28,477	0.23	0.23	0.08
South Carolina	175	294	44	100,759	107,685	101,902	0.18	0.27	0.04
South Dakota	16	76	5	24,646	25,797	25,562	0.07	0.29	0.02
Tennessee	39	99	-156	131,161	137,547	131,302	0.03	0.07	-0.12
Texas	401	1,588	600	488,935	520,405	521,248	0.08	0.31	0.12
Utah	283	397	156	62,539	71,722	68,725	0.47	0.55	0.23
Vermont	42	37	17	22,041	22,298	21,422	0.19	0.17	0.08
Virginia	845	844	567	188,281	200,131	192,780	0.46	0.42	0.29
Washington	346	657	185	170,428	183,984	175,486	0.21	0.36	0.11
West Virginia	16	40	99	40,665	40,415	38,599	0.04	0.10	0.26
Wisconsin	215	78	138	143,466	146,019	139,332	0.15	0.05	0.10
Wyoming	37	69	41	19,216	20,705	20,189	0.20	0.33	0.20
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available.

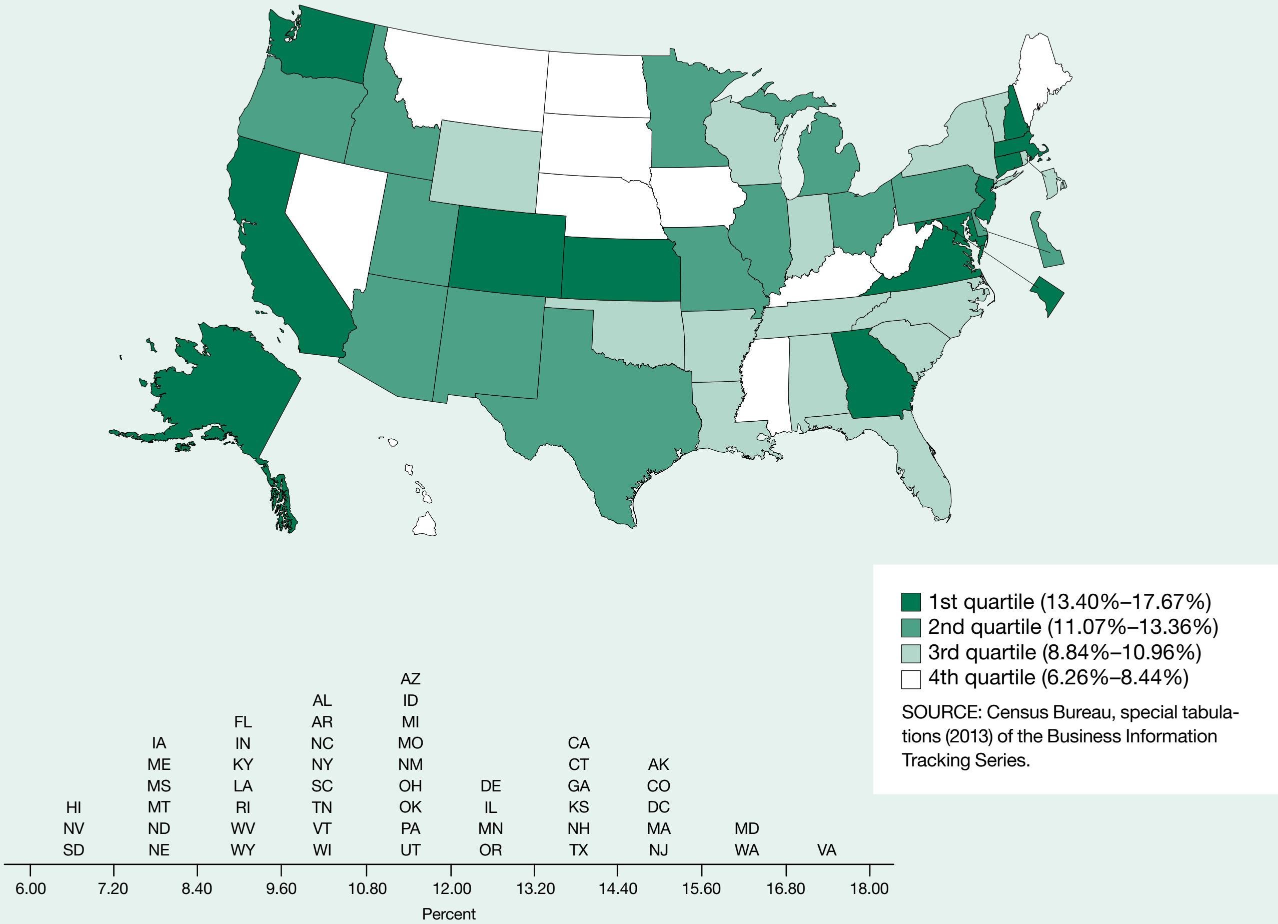
SOURCE: Census Bureau, special tabulations (2007, 2010, 2013) of the Business Information Tracking Series (various years).

Science and Engineering Indicators 2014

Employment in High-Technology Establishments as a Percentage of Total Employment

Figure 8-55

Employment in high-technology establishments as a percentage of total employment: 2010



SOURCE: Census Bureau, special tabulations (2013) of the Business Information Tracking Series.

Findings

- Employment in high-technology industries in the United States decreased slightly from 13.6 million in 2003 to 13.4 million in 2010.
- Nationwide, the value of this indicator changed little from 2003 (11.96%) to 2010 (11.99%).
- States varied greatly on this indicator in 2010, ranging from 6.26% to 17.67% of their workforce employed in high-technology industries.
- During the 2003–10 period, Michigan and New York recorded the largest net losses of jobs in high-technology industries, while Virginia, Georgia, and Colorado posted the largest net gains of jobs in high-technology industries.
- States were distributed similarly on the high-technology employment and high-technology establishment indicators.

This indicator represents the extent to which a state's workforce is employed in high-technology industries. High-technology industries are defined as those in which the proportion of employees in technology-oriented occupations is at least twice the average proportion for all industries. High-technology occupations include scientific, engineering, and technician occupations that employ workers who generally possess in-depth knowledge of the theories and principles of science, engineering, and mathematics at a postsecondary level.

The data pertaining to establishments in 2003 through 2008 are based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). The data for the years 2009 and 2010 are based on their classification according to the 2007 edition of the NAICS. See table 8-A in the chapter introduction for a list of the industries (by NAICS code) that are defined as high technology. Data on total employment and NAICS industry establishment employment in high-technology establishments are provided by the U.S. Census Bureau and differ from workforce data provided by the Bureau of Labor Statistics. Total employment refers to all U.S. business establishments with paid employees, but does not include crop and animal production, rail transportation, the postal service, or most government employees.

Table 8-55

Employment in high-technology establishments as a percentage of total employment, by state: 2003, 2007, and 2010

State	Employment in high-technology establishments 2003	2007	2010	Total employment 2003	2007	2010	High-technology/ total employment (%) 2003	2007	2010
United States	13,563,122	14,152,153	13,428,176	113,373,663	120,579,971	111,956,736	11.96	11.74	11.99
Alabama	152,879	160,545	164,889	1,597,265	1,722,354	1,567,725	9.57	9.32	10.52
Alaska	21,851	30,766	36,813	216,707	244,560	254,694	10.08	12.58	14.45
Arizona	234,603	263,246	238,931	1,997,990	2,403,472	2,065,596	11.74	10.95	11.57
Arkansas	95,180	89,819	95,963	988,822	1,031,129	964,899	9.63	8.71	9.95
California	1,781,830	1,838,795	1,715,056	12,986,496	13,767,970	12,534,832	13.72	13.36	13.68
Colorado	274,979	302,681	303,701	1,883,883	2,075,404	1,955,624	14.60	14.58	15.53
Connecticut	210,114	208,417	195,895	1,550,615	1,538,977	1,436,754	13.55	13.54	13.63
Delaware	52,349	47,144	44,535	385,098	396,251	358,811	13.59	11.90	12.41
District of Columbia	54,314	59,284	67,828	422,912	454,512	463,070	12.84	13.04	14.65
Florida	576,274	632,765	585,325	6,548,276	7,423,816	6,624,005	8.80	8.52	8.84
Georgia	413,384	435,409	447,211	3,386,590	3,647,746	3,315,180	12.21	11.94	13.49
Hawaii	25,777	28,932	29,955	458,952	518,928	478,798	5.62	5.58	6.26
Idaho	55,706	60,056	54,000	466,379	544,337	487,901	11.94	11.03	11.07
Illinois	646,285	644,910	606,229	5,204,887	5,397,867	4,978,701	12.42	11.95	12.18
Indiana	219,598	240,529	220,867	2,540,554	2,647,861	2,400,566	8.64	9.08	9.20
Iowa	102,387	98,655	103,641	1,232,709	1,303,265	1,252,828	8.31	7.57	8.27
Kansas	155,023	160,739	156,591	1,109,699	1,168,907	1,127,221	13.97	13.75	13.89
Kentucky	121,838	132,400	122,950	1,471,622	1,550,035	1,456,297	8.28	8.54	8.44
Louisiana	137,029	145,219	141,384	1,603,492	1,645,547	1,600,202	8.55	8.82	8.84
Maine	35,184	39,004	37,840	488,788	503,725	480,302	7.20	7.74	7.88
Maryland	315,887	353,025	331,437	2,088,552	2,238,894	2,075,391	15.12	15.77	15.97
Massachusetts	460,984	495,550	442,407	2,974,164	3,073,572	2,928,453	15.50	16.12	15.11
Michigan	499,133	449,369	390,824	3,884,881	3,686,604	3,287,170	12.85	12.19	11.89
Minnesota	315,994	351,940	308,919	2,381,860	2,525,488	2,358,867	13.27	13.94	13.10
Mississippi	66,566	64,539	63,467	912,004	941,215	881,489	7.30	6.86	7.20
Missouri	254,299	265,680	254,464	2,387,245	2,457,551	2,292,521	10.65	10.81	11.10
Montana	20,296	23,340	24,377	302,932	353,717	338,366	6.70	6.60	7.20
Nebraska	68,975	65,653	63,881	774,858	795,489	769,404	8.90	8.25	8.30
Nevada	61,847	74,288	64,882	970,678	1,195,473	1,002,731	6.37	6.21	6.47
New Hampshire	63,264	66,235	75,371	540,132	573,026	562,382	11.71	11.56	13.40
New Jersey	550,224	563,587	518,502	3,578,674	3,661,138	3,365,857	15.38	15.39	15.40
New Mexico	60,399	71,616	70,027	571,057	642,068	600,269	10.58	11.15	11.67
New York	823,992	796,369	744,789	7,415,430	7,528,488	7,264,463	11.11	10.58	10.25
North Carolina	349,424	379,831	347,943	3,337,552	3,585,951	3,233,868	10.47	10.59	10.76
North Dakota	20,584	29,850	24,590	258,878	292,851	294,794	7.95	10.19	8.34
Ohio	531,491	520,079	490,703	4,769,406	4,781,448	4,353,123	11.14	10.88	11.27
Oklahoma	132,887	142,168	136,082	1,184,312	1,307,578	1,241,178	11.22	10.87	10.96
Oregon	152,140	162,690	164,454	1,338,380	1,476,970	1,350,947	11.37	11.02	12.17
Pennsylvania	566,406	558,193	556,446	5,028,650	5,194,723	4,975,537	11.26	10.75	11.18
Rhode Island	35,806	40,738	37,962	427,369	441,293	398,960	8.38	9.23	9.52
South Carolina	163,373	166,710	154,343	1,550,227	1,647,759	1,502,540	10.54	10.12	10.27
South Dakota	18,890	21,680	23,558	299,723	330,071	328,930	6.30	6.57	7.16
Tennessee	219,898	244,256	218,686	2,298,836	2,475,155	2,262,886	9.57	9.87	9.66
Texas	1,158,481	1,222,727	1,173,479	8,049,300	9,038,702	8,785,658	14.39	13.53	13.36
Utah	99,856	123,602	120,574	900,331	1,102,528	1,021,872	11.09	11.21	11.80
Vermont	29,402	26,216	27,984	256,401	268,023	264,076	11.47	9.78	10.60
Virginia	459,017	545,693	529,869	2,932,471	3,196,510	2,999,409	15.65	17.07	17.67
Washington	401,413	380,962	387,568	2,292,462	2,500,835	2,325,825	17.51	15.23	16.66
West Virginia	46,635	46,395	47,252	561,317	580,953	560,311	8.31	7.99	8.43
Wisconsin	233,967	260,033	245,381	2,382,979	2,483,664	2,320,269	9.82	10.47	10.58
Wyoming	15,008	19,824	18,351	180,866	215,571	205,184	8.30	9.20	8.94
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available.

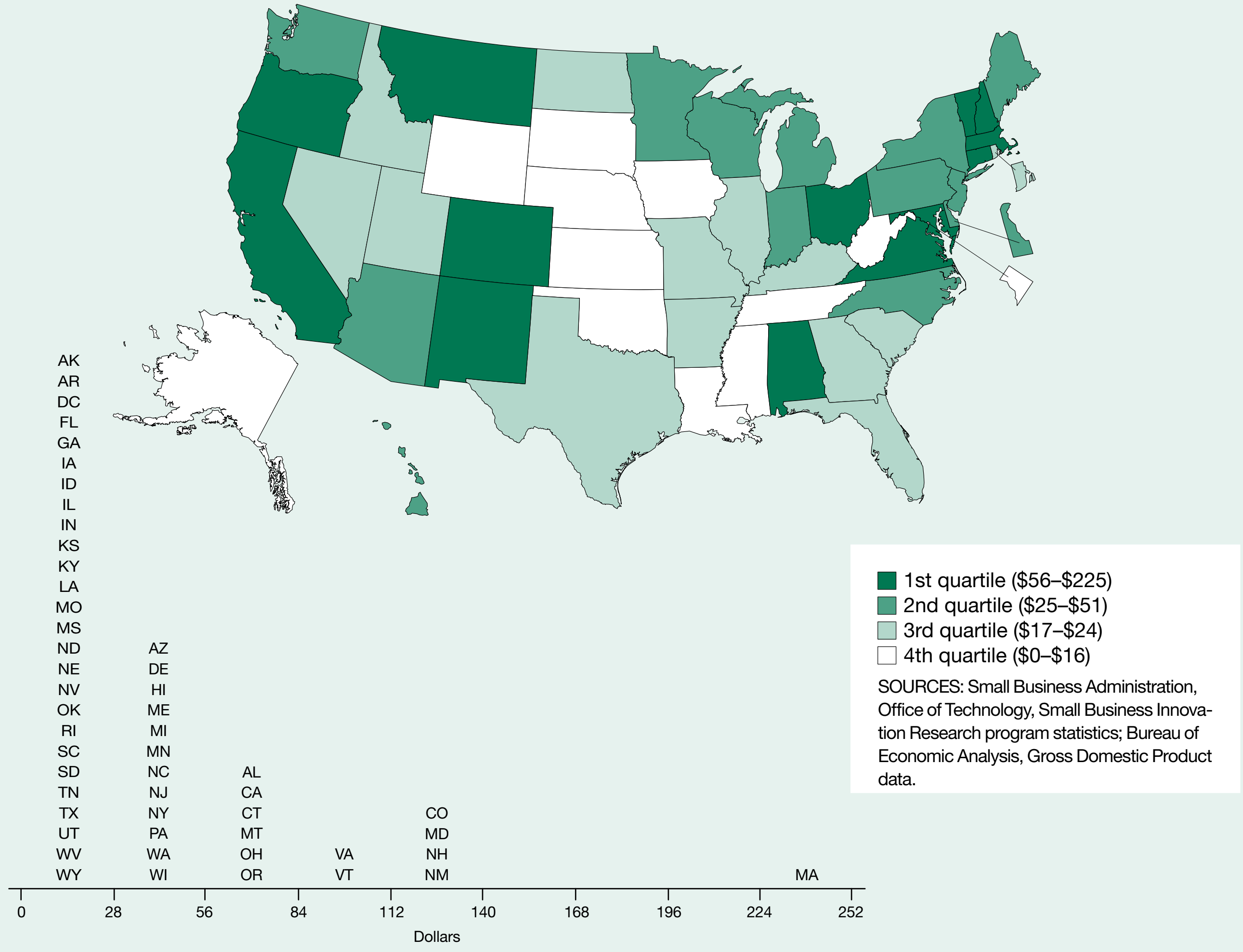
SOURCE: Census Bureau, special tabulations (2007, 2010, 2013) of the Business Information Tracking Series (various years).

Science and Engineering Indicators 2014

Average Annual Federal Small Business Innovation Research Funding per $1 Million of Gross Domestic Product

Figure 8-56

Average annual federal Small Business Innovation Research funding per $1 million of gross domestic product: 2010–12



SOURCES: Small Business Administration, Office of Technology, Small Business Innovation Research program statistics; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The SBIR program decreased in size from $1.7 billion in 2002–04 to $700 million in 2010–12.
- Over the 3-year period of 2010–12, SBIR funds were concentrated in relatively few states; the average annual state awards during this period ranged from $23,000 to nearly $133 million.
- Many of the states with the highest rankings on this indicator are locations of federal laboratories or well-recognized academic research institutions from which innovative small businesses have emerged.
- States with a high ranking on this indicator also tended to rank high on the high-technology and venture capital indicators.

Funds awarded through the federal Small Business Innovation Research (SBIR) program support technological innovation in companies with 500 or fewer employees. Awards are made to evaluate the feasibility and scientific merit of new technology (Phase 1—up to $150,000) and to develop the technology to a point where it can be commercialized (Phase 2—up to $750,000). The total award dollars include both Phase 1 and Phase 2 SBIR awards.

Because of year-to-year fluctuations, this indicator is calculated using 3-year averages. The 3-year average annual SBIR award dollars won by small businesses in a state are divided by the 3-year average annual gross domestic product for the same period. A high value indicates that small business firms in a state are doing innovative development work that attracts federal support.

Table 8-56

Average annual federal Small Business Innovation Research funding per $1 million of gross domestic product, by state: 2002–04, 2006–08, and 2010–12

	Average SBIR funding ($thousands)			Average state GDP ($millions)			SBIR funding ($)/ $1 million GDP		
State	2002–04	2006–08	2010–12	2002–04	2006–08	2010–12	2002–04	2006–08	2010–12
United States	1,729,004	1,801,190	699,675	11,138,210	13,806,188	14,971,555	155	130	47
Alabama	33,192	39,376	11,461	132,668	164,976	178,307	250	239	64
Alaska	495	707	23	31,382	45,377	50,335	16	16	0
Arizona	28,534	29,003	11,280	189,045	255,461	256,736	151	114	44
Arkansas	3,240	6,965	2,463	78,672	97,210	106,428	41	72	23
California	361,242	350,717	133,814	1,472,700	1,856,525	1,919,238	245	189	70
Colorado	81,320	86,126	31,818	193,378	241,785	264,444	421	356	120
Connecticut	29,454	24,046	12,721	176,775	216,690	225,498	167	111	56
Delaware	4,195	7,215	3,292	47,198	57,943	64,398	89	125	51
District of Columbia	5,840	3,339	709	72,509	91,808	106,913	81	36	7
Florida	37,543	44,269	16,919	577,287	746,840	750,525	65	59	23
Georgia	16,484	17,983	7,069	327,221	394,815	417,671	50	46	17
Hawaii	5,772	7,820	3,350	48,379	63,680	69,901	119	123	48
Idaho	3,664	3,496	1,138	40,426	53,308	56,993	91	66	20
Illinois	22,500	28,052	14,109	520,654	619,747	669,418	43	45	21
Indiana	10,739	17,080	7,193	220,221	257,119	284,569	49	66	25
Iowa	4,875	4,290	1,949	106,253	130,673	145,624	46	33	13
Kansas	4,971	4,626	1,115	95,996	118,862	133,453	52	39	8
Kentucky	4,237	5,602	4,085	126,177	150,155	167,516	34	37	24
Louisiana	3,126	4,326	2,416	155,554	208,573	236,009	20	21	10
Maine	5,604	7,378	1,464	41,950	48,720	52,496	134	151	28
Maryland	93,753	79,860	39,756	218,398	270,963	306,278	429	295	130
Massachusetts	242,347	228,472	87,740	298,795	350,526	389,769	811	652	225
Michigan	33,544	44,746	19,609	360,031	377,254	384,245	93	119	51
Minnesota	24,805	26,318	8,603	213,719	253,502	281,098	116	104	31
Mississippi	3,232	1,040	1,070	73,636	91,141	98,262	44	11	11
Missouri	7,342	8,792	5,161	200,162	232,695	250,751	37	38	21
Montana	7,045	8,278	2,561	25,765	34,373	38,625	273	241	66
Nebraska	2,998	2,471	1,575	65,767	81,288	95,566	46	30	16
Nevada	7,772	3,364	2,452	90,871	129,638	129,281	86	26	19
New Hampshire	22,208	24,343	8,703	48,944	57,481	63,059	454	423	138
New Jersey	47,712	42,988	22,392	393,407	469,391	494,728	121	92	45
New Mexico	21,965	24,776	8,918	58,588	74,300	79,280	375	333	112
New York	75,741	83,045	33,447	852,183	1,062,116	1,170,594	89	78	29
North Carolina	22,739	36,235	14,732	313,544	394,114	439,664	73	92	34
North Dakota	1,960	918	691	22,033	28,794	40,455	89	32	17
Ohio	67,568	73,611	30,032	411,939	461,850	488,446	164	159	61
Oklahoma	6,630	7,104	2,065	105,269	141,926	154,887	63	50	13
Oregon	19,556	27,406	11,352	127,142	167,326	189,735	154	164	60
Pennsylvania	65,170	78,761	25,430	442,445	527,391	580,324	147	149	44
Rhode Island	7,783	7,056	1,004	40,575	46,991	49,650	192	150	20
South Carolina	7,397	4,630	3,146	129,895	155,340	169,075	57	30	19
South Dakota	1,291	526	110	29,034	34,818	40,809	44	15	3
Tennessee	9,411	13,239	4,072	202,354	242,165	264,755	47	55	15
Texas	71,023	79,874	25,681	836,983	1,137,028	1,315,029	85	70	20
Utah	14,299	15,540	2,820	78,275	107,495	124,388	183	145	23
Vermont	4,808	5,286	2,685	20,671	24,034	26,550	233	220	101
Virginia	98,902	102,923	38,430	309,279	387,343	434,083	320	266	89
Washington	46,963	47,165	13,361	247,384	319,661	358,496	190	148	37
West Virginia	6,002	2,186	1,060	46,373	56,765	66,074	129	39	16
Wisconsin	17,592	25,174	12,125	199,081	233,769	253,437	88	108	48
Wyoming	2,418	2,647	504	21,223	34,443	37,690	114	77	13
Puerto Rico	216	8	120	78,948	92,624	NA	3	0	NA

NA = not available.

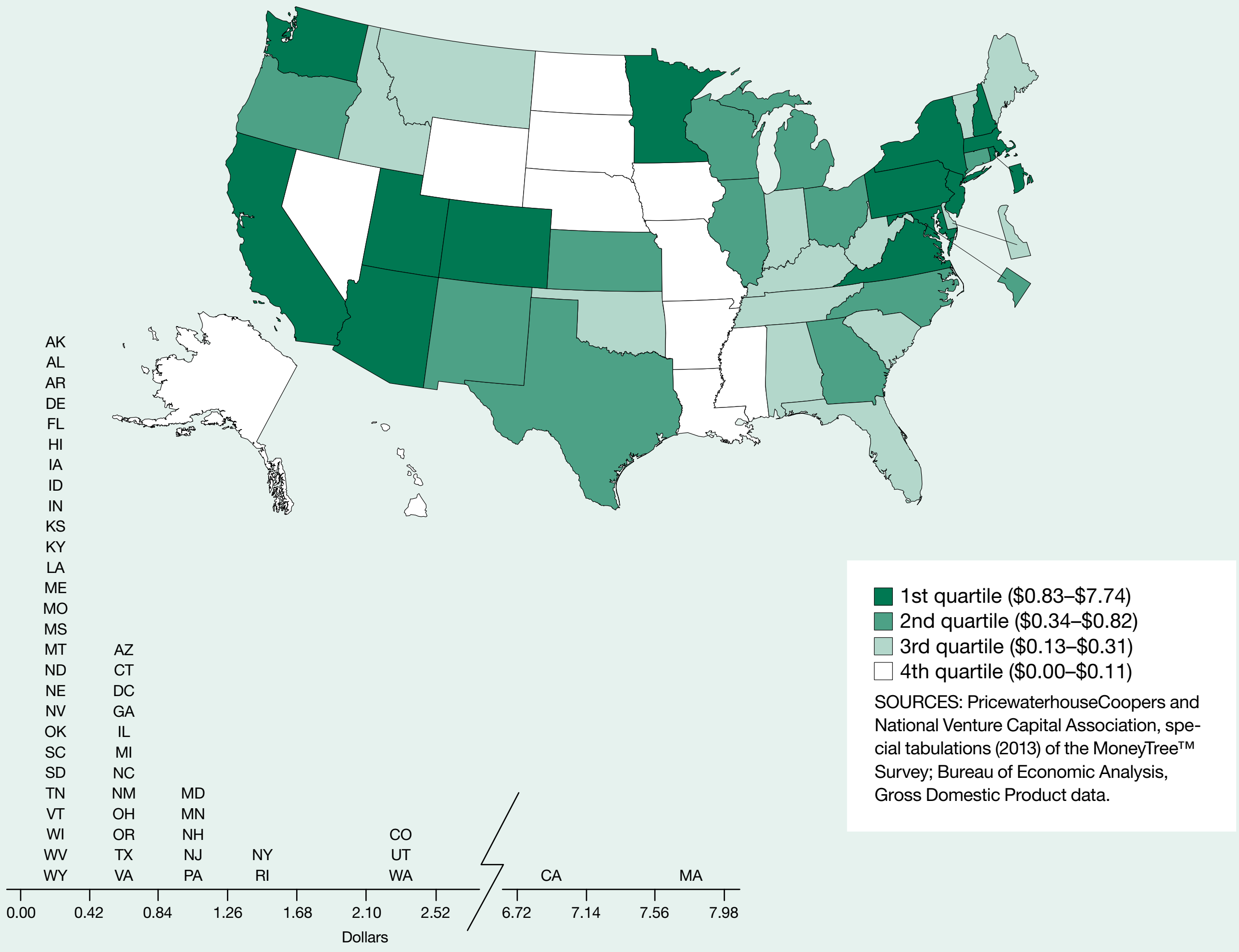
GDP = gross domestic product; SBIR = Small Business Innovation Research.

SOURCES: Small Business Administration, Office of Technology, Small Business Innovation Research program statistics (various years); Bureau of Economic Analysis, Gross Domestic Product data (June 2013).

Science and Engineering Indicators 2014

Venture Capital Disbursed per $1,000 of Gross Domestic Product

Figure 8-57
Venture capital disbursed per $1,000 of gross domestic product: 2012



SOURCES: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2013) of the MoneyTree™ Survey; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The total amount of venture capital invested in the United States has increased from $22 billion in 2002 to nearly $27 billion in 2012. The average value for venture capital disbursed per $1,000 of gross domestic product for the United States was $2.08 in 2002 and $1.73 in 2012.
- Venture capital investment is concentrated in relatively few states. Companies in California received more than 50% of the total venture capital disbursed in the United States in 2012, followed by companies in Massachusetts with 12%. Three states reported no venture capital investment in 2012, and a total of 11 states reported less than $10 million.
- In 2012, the value of this indicator across states ranged from $0.00 to $7.74.
- The average indicator value for Experimental Program to Stimulate Competitive Research (EPSCoR) states was substantially lower than that for non-EPSCoR states. The state distribution of venture capital was similar to indicators of high-technology business activity.

Venture capital represents an important source of funding for startup companies. It supports the growth and expansion of these companies early in their development, before they establish a predictable sales history that would qualify them for other types of financing.

This indicator represents the relative magnitude of venture capital investments in a state after adjusting for the size of the state's economy. The indicator is expressed as dollars of venture capital disbursed per $1,000 of gross domestic product. High values indicate that companies in those states are successfully attracting venture capital to fuel their growth. Access to venture capital financing varies greatly among states.

Venture capital data measure cash-for-equity investments by the professional venture capital community in private emerging companies in the United States. Data exclude debt, buy-outs, recapitalizations, initial public offerings, and other forms of private equity that do not involve cash. Results are updated periodically. All data are subject to change at any time.

Table 8-57

Venture capital disbursed per $1,000 of gross domestic product, by state: 2002, 2007, and 2012

	Venture capital disbursed ($millions)			State GDP ($millions)			Venture capital ($)/$1,000 GDP		
State	2002	2007	2012	2002	2007	2012	2002	2007	2012
United States	22,010	30,871	26,873	10,572,388	13,936,196	15,566,076	2.08	2.22	1.73
Alabama	57	31	23	125,168	165,665	183,547	0.46	0.19	0.13
Alaska	0	0	0	28,894	44,540	51,859	0.00	0.00	0.00
Arizona	197	203	222	177,068	259,157	266,891	1.11	0.78	0.83
Arkansas	10	0	5	74,167	97,470	109,557	0.13	0.00	0.05
California	9,528	14,735	14,194	1,387,213	1,870,916	2,003,479	6.87	7.88	7.08
Colorado	537	610	585	186,529	242,633	274,048	2.88	2.51	2.13
Connecticut	183	296	158	168,865	221,133	229,317	1.08	1.34	0.69
Delaware	19	7	9	43,672	59,592	65,984	0.44	0.12	0.14
District of Columbia	20	91	64	67,924	91,896	109,793	0.29	0.99	0.58
Florida	410	768	199	536,061	760,936	777,164	0.76	1.01	0.26
Georgia	565	475	262	313,952	399,579	433,569	1.80	1.19	0.60
Hawaii	4	5	1	44,752	64,070	72,424	0.09	0.08	0.01
Idaho	11	16	15	37,729	54,273	58,243	0.29	0.29	0.26
Illinois	309	505	570	497,802	626,611	695,238	0.62	0.81	0.82
Indiana	40	83	84	208,674	261,755	298,625	0.19	0.32	0.28
Iowa	2	6	5	98,584	134,053	152,436	0.02	0.04	0.03
Kansas	7	82	47	91,671	120,599	138,953	0.08	0.68	0.34
Kentucky	14	53	24	121,436	150,487	173,466	0.12	0.35	0.14
Louisiana	19	16	11	139,202	207,312	243,264	0.14	0.08	0.05
Maine	15	5	13	39,989	49,065	53,656	0.38	0.10	0.24
Maryland	637	613	284	206,624	271,985	317,678	3.08	2.25	0.89
Massachusetts	2,530	3,714	3,127	288,352	352,378	403,823	8.77	10.54	7.74
Michigan	108	105	237	351,832	386,591	400,504	0.31	0.27	0.59
Minnesota	403	488	253	201,559	253,374	294,729	2.00	1.93	0.86
Mississippi	5	6	10	69,527	92,107	101,490	0.07	0.07	0.10
Missouri	76	92	21	192,189	232,959	258,832	0.40	0.39	0.08
Montana	0	4	6	23,781	35,085	40,422	0.00	0.11	0.15
Nebraska	13	0	11	61,384	82,135	99,557	0.21	0.00	0.11
Nevada	32	29	7	82,764	133,185	133,584	0.39	0.22	0.05
New Hampshire	208	135	61	46,730	57,868	64,697	4.45	2.33	0.94
New Jersey	905	632	444	376,922	471,372	508,003	2.40	1.34	0.87
New Mexico	54	129	36	53,662	74,356	80,600	1.01	1.73	0.45
New York	799	1,130	1,864	822,408	1,076,255	1,205,930	0.97	1.05	1.55
North Carolina	563	547	197	302,201	396,740	455,973	1.86	1.38	0.43
North Dakota	0	0	2	20,439	28,549	46,016	0.00	0.00	0.05
Ohio	268	193	286	397,966	467,138	509,393	0.67	0.41	0.56
Oklahoma	33	8	34	98,778	140,378	160,953	0.33	0.06	0.21
Oregon	151	312	124	119,571	167,088	198,702	1.26	1.87	0.62
Pennsylvania	456	819	521	424,103	531,098	600,897	1.08	1.54	0.87
Rhode Island	96	7	85	38,135	47,293	50,956	2.52	0.15	1.67
South Carolina	80	87	39	124,391	157,712	176,217	0.64	0.55	0.22
South Dakota	18	4	0	27,610	34,885	42,464	0.65	0.11	0.00
Tennessee	116	125	87	193,069	242,220	277,036	0.60	0.52	0.31
Texas	1,296	1,468	934	782,780	1,147,404	1,397,369	1.66	1.28	0.67
Utah	136	188	318	74,603	108,474	130,486	1.82	1.73	2.44
Vermont	4	9	4	19,599	24,043	27,296	0.20	0.37	0.16
Virginia	429	557	372	290,904	389,570	445,876	1.47	1.43	0.83
Washington	580	1,383	908	237,117	325,118	375,730	2.45	4.25	2.42
West Virginia	16	10	15	44,533	56,864	69,380	0.36	0.18	0.22
Wisconsin	51	90	95	190,241	236,522	261,548	0.27	0.38	0.36
Wyoming	0	0	0	19,262	33,708	38,422	0.00	0.00	0.00
Puerto Rico	NA	NA	0	74,827	93,263	NA	NA	NA	NA

NA = not available.

GDP = gross domestic product.

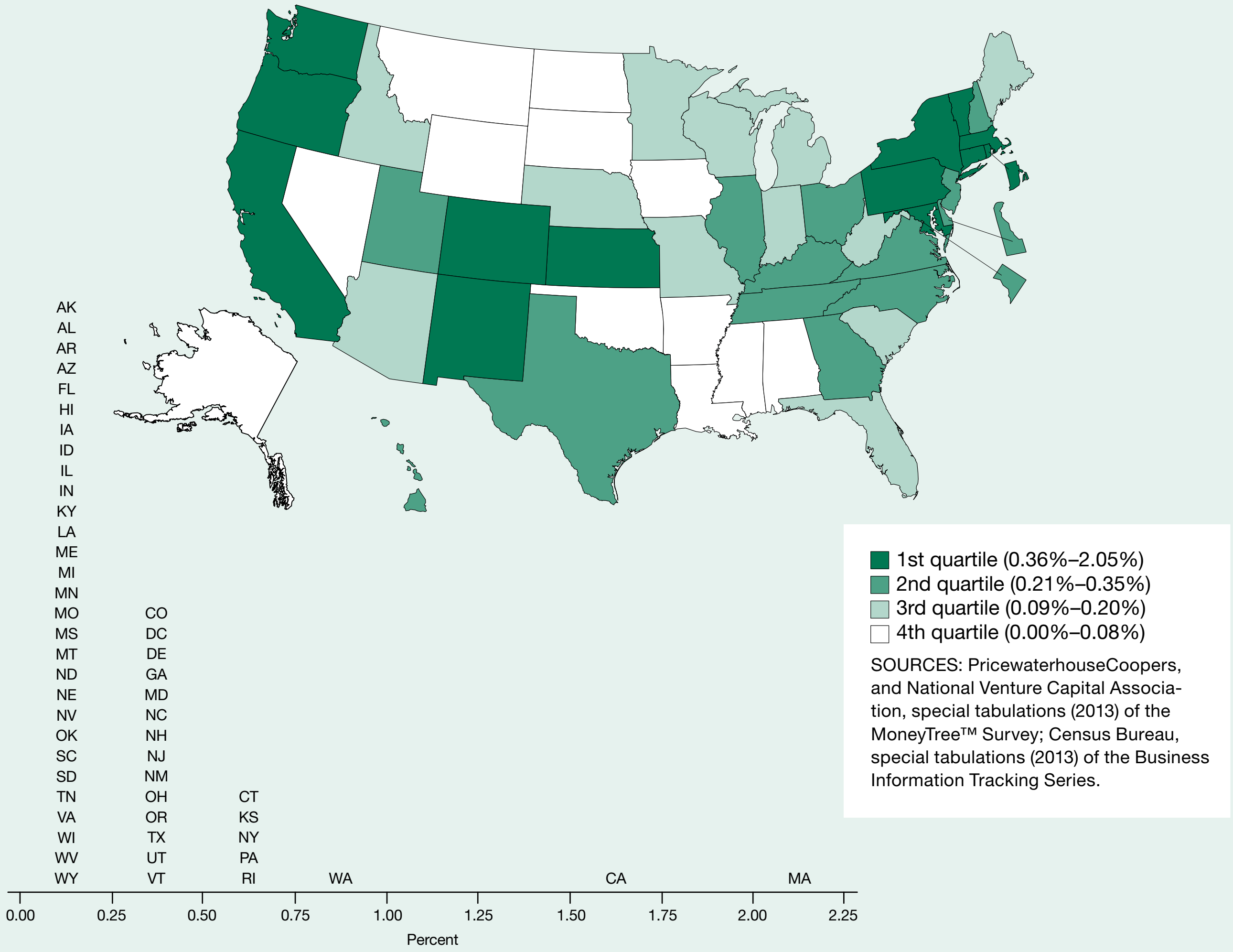
SOURCES: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2011, 2011, 2013) of the MoneyTree™ Survey (various years); Bureau of Economic Analysis, Gross Domestic Product data (June 2013).

Science and Engineering Indicators 2014

Venture Capital Deals as a Percentage of High-Technology Business Establishments

Figure 8-58

Venture capital deals as a percentage of high-technology business establishments: 2010



SOURCES: PricewaterhouseCoopers, and National Venture Capital Association, special tabulations (2013) of the MoneyTree™ Survey; Census Bureau, special tabulations (2013) of the Business Information Tracking Series.

Findings

- The number of venture capital deals that involved U.S. companies increased from about 2,900 deals in 2003 to nearly 3,300 deals in 2010.
- In 2010, venture capital deals were concentrated in only a few states. Indicator values ranged from a low of 0.00% to a high of 2.05% with a median value of 0.21%.
- Companies in high-technology industries located in Massachusetts were the most successful in accessing venture capital investments in 2010, with a 2.05% rate. California companies in high-technology industries obtained venture capital investment at a rate of 1.50%. No other states reached a rate of 1.00%.
- In 2010, companies in Experimental Program to Stimulate Competitive Research (EPSCoR) states tended to receive little venture capital investment, and no venture capital deals were reported in three EPSCoR states.

This indicator represents the extent to which high-technology companies in a state receive venture capital investments. The value of the indicator is calculated by dividing the number of venture capital deals by the number of companies operating in high-technology industries in that state. High values indicate that high-technology companies in a state are frequently using venture capital to facilitate their growth and development. In most cases, a company will not receive more than one infusion of venture capital in a given year.

Venture capital data measure cash-for-equity investments by the professional venture capital community in private emerging companies in the United States. Data exclude debt, buy-outs, recapitalizations, initial public offerings, and other forms of private equity that do not involve cash. Results are updated periodically. All data are subject to change at any time. Venture capital investment can help to grow a high-technology company.

Data on business establishments operating in high-technology industries for the years 2003 through 2008 are based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). The data for the years 2009 and 2010 are based on their classification according to the 2007 edition of the NAICS. See table 8-A in the chapter introduction for a list of the industries (by NAICS code) that are defined as high technology. Data for years prior to 2003 are not directly comparable.

Table 8-58

Venture capital deals as a percentage of high-technology business establishments, by state: 2003, 2007, and 2010

	Venture capital deals			High-technology establishments			Venture capital deals/ high-technology establishments (%)		
State	2003	2007	2010	2003	2007	2010	2003	2007	2010
United States	2,903	3,948	3,266	590,417	650,707	648,993	0.49	0.61	0.50
Alabama	9	4	2	6,347	6,783	6,786	0.14	0.06	0.03
Alaska	0	0	0	1,345	1,538	1,698	0.00	0.00	0.00
Arizona	16	28	17	10,433	12,540	11,875	0.15	0.22	0.14
Arkansas	3	1	1	4,012	4,550	4,852	0.07	0.02	0.02
California	1,122	1,626	1,289	77,614	87,815	85,787	1.45	1.85	1.50
Colorado	72	97	77	15,532	18,016	18,306	0.46	0.54	0.42
Connecticut	34	37	52	7,827	7,868	7,472	0.43	0.47	0.70
Delaware	1	4	9	3,964	3,573	3,256	0.03	0.11	0.28
District of Columbia	6	17	11	2,589	3,158	3,507	0.23	0.54	0.31
Florida	61	65	39	38,118	44,745	44,577	0.16	0.15	0.09
Georgia	55	76	63	18,820	21,586	21,413	0.29	0.35	0.29
Hawaii	6	4	5	2,097	2,305	2,309	0.29	0.17	0.22
Idaho	5	4	4	2,515	3,107	3,071	0.20	0.13	0.13
Illinois	58	69	60	27,606	29,222	28,886	0.21	0.24	0.21
Indiana	8	17	14	9,626	10,355	10,276	0.08	0.16	0.14
Iowa	1	3	2	4,316	4,679	4,745	0.02	0.06	0.04
Kansas	2	16	36	5,716	6,076	6,144	0.03	0.26	0.59
Kentucky	3	8	14	5,453	5,850	5,913	0.06	0.14	0.24
Louisiana	1	7	3	7,218	7,574	7,850	0.01	0.09	0.04
Maine	2	7	5	2,466	2,612	2,652	0.08	0.27	0.19
Maryland	84	96	70	13,428	15,151	15,589	0.63	0.63	0.45
Massachusetts	378	446	351	17,183	17,470	17,148	2.20	2.55	2.05
Michigan	17	22	33	16,937	17,321	16,555	0.10	0.13	0.20
Minnesota	58	57	26	12,834	13,590	13,014	0.45	0.42	0.20
Mississippi	4	2	0	3,269	3,405	3,496	0.12	0.06	0.00
Missouri	23	17	14	9,562	10,238	9,956	0.24	0.17	0.14
Montana	1	1	2	2,108	2,515	2,593	0.05	0.04	0.08
Nebraska	2	0	3	2,797	3,257	3,361	0.07	0.00	0.09
Nevada	6	8	3	5,387	6,087	6,031	0.11	0.13	0.05
New Hampshire	32	23	10	3,511	3,575	3,539	0.91	0.64	0.28
New Jersey	88	92	71	24,286	24,688	23,686	0.36	0.37	0.30
New Mexico	5	25	13	3,322	3,658	3,611	0.15	0.68	0.36
New York	119	193	266	35,926	38,368	38,636	0.33	0.50	0.69
North Carolina	76	69	57	14,869	17,671	17,967	0.51	0.39	0.32
North Dakota	2	1	0	964	1,075	1,151	0.21	0.09	0.00
Ohio	25	56	52	19,875	20,486	20,180	0.13	0.27	0.26
Oklahoma	2	6	2	6,859	7,512	7,610	0.03	0.08	0.03
Oregon	21	42	33	7,500	8,453	8,587	0.28	0.50	0.38
Pennsylvania	90	158	153	22,266	23,778	23,956	0.40	0.66	0.64
Rhode Island	10	4	13	1,976	2,108	2,071	0.51	0.19	0.63
South Carolina	4	10	8	5,869	6,942	7,010	0.07	0.14	0.11
South Dakota	1	2	0	1,206	1,347	1,426	0.08	0.15	0.00
Tennessee	22	20	18	8,196	8,980	8,702	0.27	0.22	0.21
Texas	165	172	143	45,062	49,237	50,180	0.37	0.35	0.28
Utah	22	33	25	5,474	6,960	7,139	0.40	0.47	0.35
Vermont	6	8	6	1,453	1,570	1,581	0.41	0.51	0.38
Virginia	80	94	51	18,868	22,607	23,623	0.42	0.42	0.22
Washington	81	175	116	13,171	15,138	15,335	0.61	1.16	0.76
West Virginia	5	4	4	2,257	2,352	2,490	0.22	0.17	0.16
Wisconsin	8	21	19	9,035	9,591	9,709	0.09	0.22	0.20
Wyoming	1	1	1	1,353	1,625	1,686	0.07	0.06	0.06
Puerto Rico	1	NA	1	NA	NA	NA	NA	NA	NA

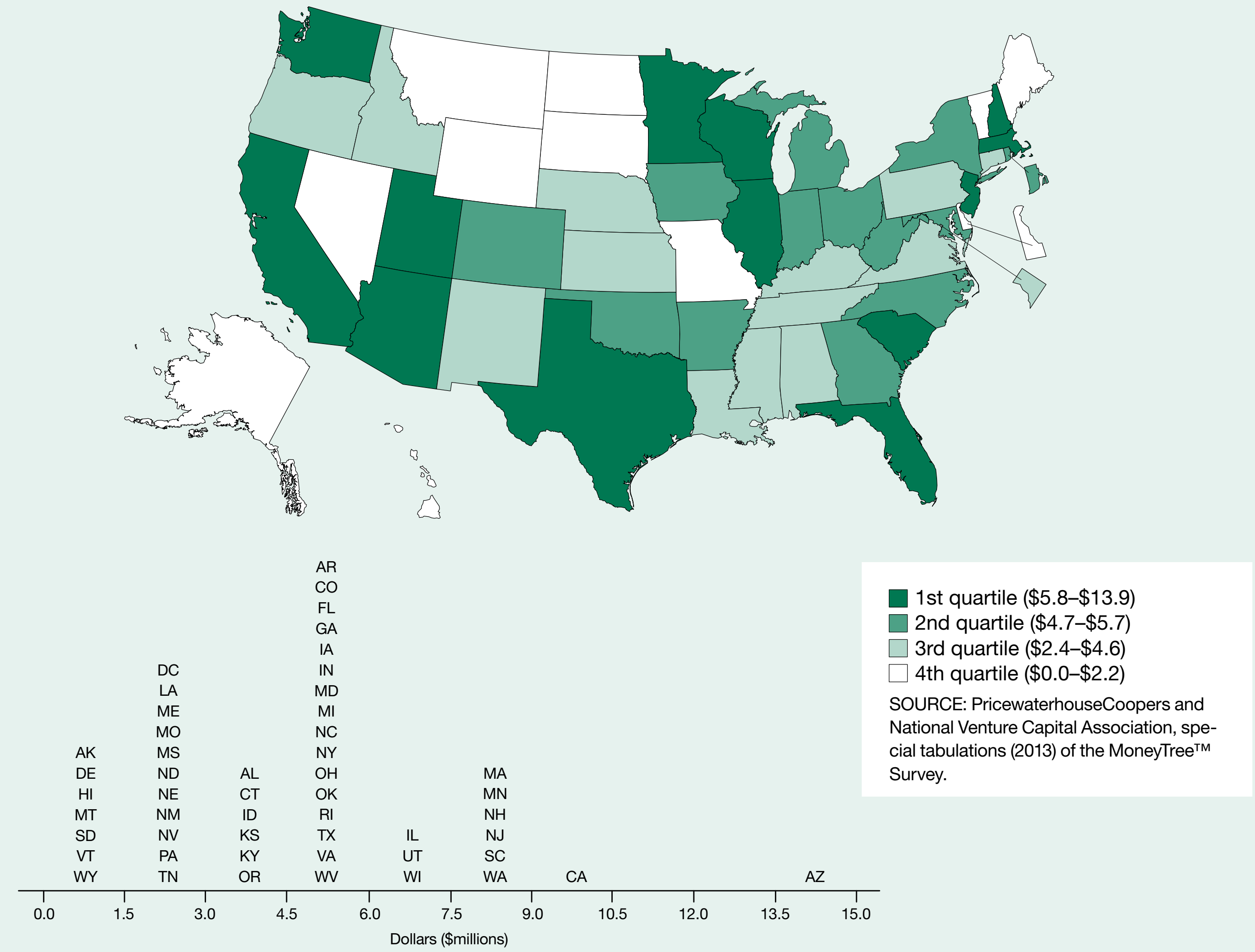
NA = not available.

SOURCES: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2011, 2011, 2013) of the MoneyTree™ Survey (various years); Census Bureau, special tabulations (2007, 2010, 2013) of the Business Information Tracking Series (various years).

Science and Engineering Indicators 2014

Venture Capital Disbursed per Venture Capital Deal

Figure 8-59
Venture capital disbursed per venture capital deal: 2012



SOURCE: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2013) of the MoneyTree™ Survey.

Findings

- In 2012, the size of the average venture capital investment in the United States was about $7.1 million per deal. This is essentially unchanged from the same investment per deal in 2002.
- The value of this indicator continued to show a high level of variability from year to year and among states.
- The total number of venture capital deals fluctuated between 2002 and 2012. There were 3,101 such deals in 2002, which rose to 3,948 in 2007 and then decreased slightly to 3,769 in 2012.
- Among those states that received venture capital investments in 2012, the state distribution on this indicator was skewed from a high value of nearly $14 million per deal to a low of $300,000 per deal, with a median value of about $4.9 million per deal.

This indicator represents the average size of the venture capital investments being made in a state. The indicator is expressed as the total dollars of venture capital invested in millions divided by the number of companies receiving venture capital. The availability of venture capital may vary widely based on stage of investment, type of company, and numerous other factors.

Venture capital data measure cash-for-equity investments by the professional venture capital community in private emerging companies in the United States. Data exclude debt, buy-outs, recapitalizations, initial public offerings, and other forms of private equity that do not involve cash. Results are updated periodically. All data are subject to change at any time.

This indicator provides some measure of the magnitude of investment that developing companies in a state have attracted from venture capital sources. Some states have relatively few venture capital deals taking place in a given year; thus, the value of this indicator may show large fluctuations on a year-to-year basis. Twenty-two states reported fewer than 10 venture capital deals in 2012. In such states, a single large or small venture capital investment can substantially affect the value of this indicator.

Table 8-59

Venture capital disbursed per venture capital deal, by state: 2002, 2007, and 2012

State	Venture capital disbursed ($millions)			Venture capital deals			Venture capital/deal ($millions)		
	2002	2007	2012	2002	2007	2012	2002	2007	2012
United States	22,010	30,871	26,873	3,101	3,948	3,769	7.10	7.82	7.13
Alabama	57	31	23	13	4	6	4.38	7.75	3.83
Alaska	0	0	0	0	0	0	0.00	0.00	0.00
Arizona	197	203	222	24	28	16	8.21	7.25	13.88
Arkansas	10	0	5	5	1	1	2.00	0.00	5.00
California	9,528	14,735	14,194	1,074	1,626	1,551	8.87	9.06	9.15
Colorado	537	610	585	88	97	103	6.10	6.29	5.68
Connecticut	183	296	158	38	37	52	4.82	8.00	3.04
Delaware	19	7	9	2	4	7	9.50	1.75	1.29
District of Columbia	20	91	64	6	17	27	3.33	5.35	2.37
Florida	410	768	199	58	65	34	7.07	11.82	5.85
Georgia	565	475	262	79	76	53	7.15	6.25	4.94
Hawaii	4	5	1	2	4	3	2.00	1.25	0.33
Idaho	11	16	15	2	4	4	5.50	4.00	3.75
Illinois	309	505	570	77	69	83	4.01	7.32	6.87
Indiana	40	83	84	11	17	17	3.64	4.88	4.94
Iowa	2	6	5	1	3	1	2.00	2.00	5.00
Kansas	7	82	47	7	16	11	1.00	5.13	4.27
Kentucky	14	53	24	3	8	7	4.67	6.63	3.43
Louisiana	19	16	11	8	7	4	2.38	2.29	2.75
Maine	15	5	13	4	7	6	3.75	0.71	2.17
Maryland	637	613	284	91	96	51	7.00	6.39	5.57
Massachusetts	2,530	3,714	3,127	373	446	419	6.78	8.33	7.46
Michigan	108	105	237	26	22	50	4.15	4.77	4.74
Minnesota	403	488	253	56	57	30	7.20	8.56	8.43
Mississippi	5	6	10	3	2	4	1.67	3.00	2.50
Missouri	76	92	21	28	17	10	2.71	5.41	2.10
Montana	0	4	6	0	1	6	0.00	4.00	1.00
Nebraska	13	0	11	3	0	4	4.33	0.00	2.75
Nevada	32	29	7	6	8	4	5.33	3.63	1.75
New Hampshire	208	135	61	38	23	8	5.47	5.87	7.63
New Jersey	905	632	444	91	92	57	9.95	6.87	7.79
New Mexico	54	129	36	7	25	15	7.71	5.16	2.40
New York	799	1,130	1,864	154	193	333	5.19	5.85	5.60
North Carolina	563	547	197	85	69	37	6.62	7.93	5.32
North Dakota	0	0	2	0	1	1	0.00	0.00	2.00
Ohio	268	193	286	49	56	61	5.47	3.45	4.69
Oklahoma	33	8	34	4	6	7	8.25	1.33	4.86
Oregon	151	312	124	26	42	29	5.81	7.43	4.28
Pennsylvania	456	819	521	96	158	182	4.75	5.18	2.86
Rhode Island	96	7	85	14	4	15	6.86	1.75	5.67
South Carolina	80	87	39	7	10	5	11.43	8.70	7.80
South Dakota	18	4	0	2	2	1	9.00	2.00	0.00
Tennessee	116	125	87	22	20	32	5.27	6.25	2.72
Texas	1,296	1,468	934	172	172	160	7.53	8.53	5.84
Utah	136	188	318	28	33	44	4.86	5.70	7.23
Vermont	4	9	4	6	8	4	0.67	1.13	1.00
Virginia	429	557	372	85	94	81	5.05	5.93	4.59
Washington	580	1,383	908	108	175	116	5.37	7.90	7.83
West Virginia	16	10	15	8	4	3	2.00	2.50	5.00
Wisconsin	51	90	95	11	21	14	4.64	4.29	6.79
Wyoming	0	0	0	0	1	0	0.00	0.00	0.00
Puerto Rico	NA	NA	0	NA	NA	1	NA	NA	0.00

NA = not available.

NOTE: Venture capital amounts are reported in current dollars.

SOURCE: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2011, 2011, 2013) of the MoneyTree™ Survey (various years).

Science and Engineering Indicators 2014

Appendix
Methodology and Statistics

Introduction

Science and Engineering Indicators (SEI) contains data compiled from a variety of sources. This appendix explains the methodological and statistical criteria used to assess possible data sources for inclusion in SEI and to develop statements about the data. It also provides basic information about how statistical procedures and reasoning are applied.

This appendix has four main sections. The first describes the statistical considerations that are part of the selection process for data sets to be included in SEI. The second discusses the different types of data (e.g., sample surveys, censuses, and administrative records) used in the report and provides information about each type. The third discusses factors that can affect accuracy at all stages of the survey process. The fourth discusses the statistical testing employed to determine whether differences between sample survey-based estimates are *statistically significant*, i.e., greater than could be expected by chance. The appendix concludes with a glossary of statistical terms commonly used or referred to in the text.

Selection of Data Sources

Four criteria guide the selection of data for SEI:

Representativeness. Data should represent national or international populations of interest.

Relevance. Data should include indicators central to the functioning of the science and technology enterprise.

Timeliness. Data that are not part of a time series should be timely, i.e., substantial and unmeasured changes in the population under study should not have occurred since the data were collected.

Statistical and methodological quality. Survey methods used to acquire data should provide sufficient assurance that statements based on statistical analysis of the data are valid and reliable.

Data that are collected by U.S. government agencies and are products of the federal statistical system meet rigorous statistical and methodological criteria as described below. Unless otherwise indicated, these data are representative of the nation as a whole and of the demographic, organizational, or geographic subgroups that constitute it.

For data collected by governments in other countries and by nongovernment sources, including private survey firms and academic researchers, methodological information is examined to assess conformity with the criteria U.S. federal agencies typically use. Government statistical agencies in the developed world cooperate extensively both in developing data-quality standards and in improving international comparability for key data, and methodological information about the data generated by this international statistical system is relatively complete.

Often, methodological information about data from nongovernmental sources and from governmental agencies outside the international statistical system is less well documented. These data must meet basic scientific standards for representative sampling of survey respondents and adequate and unbiased coverage of the population under study. The resulting measurements must be sufficiently relevant and meaningful to warrant publication despite methodological uncertainties that remain after the documentation has been scrutinized. The most important statistical criteria are described in general terms below and in greater detail in the following sections.

Many data sources that contain pertinent information about a segment of the S&E enterprise are not cited in SEI because their coverage of the United States is partial in terms of geography, incomplete in terms of segments of the population, or otherwise not representative. For example, data may be available for only a limited number of states, or studies may be based on populations not representative of the United States as a whole. Similarly, data for other countries should cover and be representative of the entire country. (In some cases, data that have limited coverage or are otherwise insufficiently representative are referenced in sidebars.)

Data included in SEI must be of high quality. Data quality can be measured in a variety of ways, some of which are described in the following sections. Some key dimensions of quality include the following.

Validity. Data have *validity* to the degree that they accurately measure the phenomenon they are supposed to represent.

Reliability. Data have *reliability* to the degree that the same results would be produced if the same measurement or procedure were performed multiple times on the same population.

Lack of bias. Data are *unbiased* to the degree that estimates from the data do not deviate from the population value of a phenomenon in a systematic fashion.

Data Sources

Much of the data cited in SEI come from surveys. Surveys strive to measure characteristics of target populations. To generalize survey results correctly to the population of interest, a survey's *target population* must be rigorously defined and the criteria determining membership in the population must be applied consistently in determining which units to include in the survey.

Some surveys are censuses (also known as *universe surveys*), in which the survey attempts to obtain data for all population units. The decennial census, in which the target population is all U.S. residents, is the most familiar census survey. SEI uses data from the Survey of Earned Doctorates, an annual census of individuals who earn research doctorates from accredited U.S. institutions, for information about the numbers and characteristics of new U.S. doctorate holders.

Other surveys are *sample surveys*, in which data are obtained for only a representative portion of the population units. The National Survey of Recent College Graduates, which gathers data on individuals who recently received bachelor's or master's degrees in science, engineering, or health fields from U.S. institutions, is an example of a sample survey.

A sample is a *probability sample* if each unit in the sampling frame has a known, nonzero probability of being selected for the sample. Probability samples are necessary for inferences about a population to be evaluated statistically. Except for some Asian surveys referenced in chapter 7, sample surveys included in SEI use probability sampling. In *nonprobability sampling*, a sample is selected haphazardly, purposively, or conveniently, and inferences about the population cannot be evaluated statistically. Internet surveys and phone-in polls that elicit responses from self-selected individuals are examples of nonprobability sample surveys.

In sample surveys, after a survey's target population has been defined, the next step is to establish a list of all members of that target population (i.e., a *sampling frame*). Members of the population must be selected from this list in a scientific manner so that it will be possible to generalize from the sample to the population as a whole. Surveys frequently sample from lists that to varying extents omit members of the target population, because complete lists are typically unavailable.

Surveys may be conducted of individuals or of organizations, such as businesses, universities, or government agencies. Surveys of organizations are often referred to as *establishment surveys.* An example of an establishment survey used in SEI is the Higher Education Research and Development Survey.

Surveys may be longitudinal or cross-sectional. In a *longitudinal survey*, the same individuals (or organizations) are surveyed repeatedly. The primary purpose of longitudinal surveys is to investigate how individuals or organizations change over time. The Survey of Doctorate Recipients is a longitudinal sample survey of individuals who received research doctorates from U.S. institutions. SEI uses results from this survey to analyze the careers of doctorate holders.

Cross-sectional surveys provide a "snapshot" at a given point of time. When conducted periodically, cross-sectional surveys produce repeated snapshots of a population, enabling analysis of how the population changes over time. However, because the same individuals or organizations are not included in each survey cycle, cross-sectional surveys cannot, in general, track changes for specific individuals or organizations. National and international assessments of student achievement in K–12 education, such as those discussed in chapter 1, are examples of repeated cross-sectional surveys. Most of the surveys cited in SEI are conducted periodically, although the frequency with which they are conducted varies.

Surveys are conducted using a variety of modes (e.g., postal mail, telephone, the Internet, or in person). They can be self or interviewer administered. Many surveys are conducted in more than one mode. The National Survey of College Graduates, a sample survey that collects data on individuals with S&E-related degrees and/or occupations, is an example of a multimode survey. It is conducted primarily via the Web, with potential participants who did not respond to the questionnaire later contacted by telephone.

Some of the data in SEI come from *administrative records* (data previously collected for the purpose of administering various programs). Examples of data drawn directly from administrative records in SEI include patent data from the records of government patent offices; bibliometric data on publications in S&E journals, compiled from information collected and published by the journals themselves; and data on foreign S&E workers temporarily in the United States, drawn from the administrative records of immigration agencies.

Many of the establishment surveys that SEI uses depend heavily, although indirectly, on administrative records. Universities and corporations that respond to surveys about their R&D activities often use administrative records developed for internal management or income tax reporting purposes to respond to these surveys.

Data Accuracy

Accurate information is a primary goal of censuses and sample surveys. Accuracy can be defined as the extent to which results deviate from the true values of the characteristics in the target population. Statisticians use the term "error" to refer to this deviation. Good survey design seeks to minimize survey error.

Statisticians usually classify the factors affecting the accuracy of survey data into two categories: nonsampling and sampling errors. *Nonsampling error* applies to all surveys, including censuses, whereas *sampling error* applies only to sample surveys. The sources of nonsampling error in surveys have analogues for administrative records: the processes through which such records are created affect the degree to which the records accurately indicate the characteristics of relevant populations (e.g., patents, journal articles, immigrant scientists and engineers).

Nonsampling Error

Nonsampling error refers to error related to survey design, data collection, and processing procedures. Nonsampling error may occur at each stage of the survey process; however, the extent of nonsampling error has no practical method of measurement. A brief description of five sources of nonsampling error follows. Although for convenience the descriptions occasionally refer to samples, they apply equally to censuses.

Specification Error. Survey questions often do not perfectly measure the concept for which they are intended as indicators. For example, the number of patents is not the same as the amount of invention.

Frame Error. The sampling frame, the list of the target population members used for selecting survey respondents, is often inaccurate. If the frame has omissions or other flaws, the survey is less representative because coverage of the target population is incomplete. Frame errors often require extensive effort to correct.

Nonresponse Error. Nonresponse errors occur because not all members of the sample respond to the survey. *Response rates* indicate what proportion of sample members respond to the survey. Other things being equal, lower response rates create a greater possibility that, had nonrespondents supplied answers to the questionnaire, the survey estimates might have been different.

Nonresponse can cause *nonresponse bias*, which occurs when the people or establishments that respond to a question, or to the survey as a whole, differ in systematic ways from those who do not respond. For example, in surveys of national populations, complete or partial nonresponse is often more likely among lower-income or less-educated respondents. Evidence of nonresponse bias is an important factor in decisions about whether survey data should be included in SEI.

Managers of high-quality surveys, such as those in the U.S. federal statistical system, do research on nonresponse patterns to assess whether and how nonresponse might bias survey estimates. SEI notes instances where reported data may be subject to substantial nonresponse bias.

The response rate does not indicate whether a survey has a problem of nonresponse bias. Surveys with high response rates sometimes have substantial nonresponse bias, and surveys with relatively low response rates, if nonrespondents do not differ from respondents on important variables, may have relatively little.

Measurement Error. There are many sources of measurement error, but respondents, interviewers, and survey questionnaires are the most important. Knowingly or unintentionally, respondents may provide incorrect information. Interviewers may inappropriately influence respondents' answers or record their answers incorrectly. The questionnaire can be a source of error if there are ambiguous, poorly worded, or confusing questions, instructions, or terms, or if the questionnaire layout is confusing.

In addition, the records or systems of information that a respondent may refer to, the mode of data collection, and the setting for the survey administration may contribute to measurement error. Perceptions about whether data will be treated as confidential may affect the accuracy of survey responses to sensitive questions about business profits or personal incomes.

Processing Error. Processing errors include errors in recording, checking, coding, and preparing survey data to make them ready for analysis.

Sampling Error

Sampling error is probably the best-known source of survey error and the most commonly reported measure of a survey's precision or accuracy. Unlike nonsampling error, sampling error can be quantitatively estimated in most scientific sample surveys.

Chance is involved in selecting the members of a sample. If the same, random procedures were used repeatedly to select samples from the population, numerous samples would be selected, each containing different members of the population with different characteristics. Each sample would produce different population estimates. When there is great variation among the samples drawn from a given population, the sampling error is high and there is a large chance that the survey estimate is far from the true population value. In a census, because the entire population is surveyed, there is no sampling error.

Sampling error is reduced when samples are large, and most of the surveys used in SEI have large samples. Typically, sampling error is a function of the sample size, the variability of the measure of interest, and the methods used to produce estimates from the sample data.

Sampling error associated with an estimate is measured by the coefficient of variation or margin of error, both of which are measures of the amount of uncertainty in the estimate.

Statistical Testing for Data from Sample Surveys

Statistical tests determine whether differences observed in sample survey data could have happened by chance (i.e., as the result of random variation in which people or establishments in the population were sampled). Differences that are very unlikely to have been produced by chance variations in sample selection are termed *statistically significant.* When SEI reports statements about differences on the basis of sample surveys, the differences are statistically significant at the .10 level. This means that, if there were no true difference in the population, the chance of drawing a sample with the observed difference would be no more than 10%.

A statistically significant difference is not necessarily large, important, or significant in the usual sense of the word. It is simply a difference that cannot be attributed to chance variation in sampling. With the large samples common in SEI data, extremely small differences can be found to be statistically significant. Conversely, quite large differences may not be statistically significant if the sample or population sizes of the groups being compared are small. Occasionally, apparently large differences are noted in the text as not being statistically significant to alert the reader that these differences may have occurred by chance.

Numerous differences are apparent in every table in SEI that reports sample data. The tables permit comparisons between different groups in the survey population and in the same population in different years. It would be impractical to test and indicate the statistical significance of all possible comparisons in tables involving sample data.

As explained in “About Science and Engineering Indicators” at the beginning of this volume, SEI presents indicators. It does not model the dynamics of the S&E enterprise, although analysts could construct models using the data in SEI. Accordingly, SEI does not make use of statistical procedures suitable for causal modeling and does not compute effect sizes for models that might be constructed using these data.

Glossary

Most glossary definitions are drawn from U.S. Office of Management and Budget, Office of Statistical Policy (2006), “Standards and Guidelines for Statistical Surveys” and U.S. Bureau of the Census (2006), “Organization of Metadata, Census Bureau Standard Definitions for Surveys and Census Metadata.” In some cases, glossary definitions are somewhat more technical and precise than those in the text, where fine distinctions are omitted to improve readability.

Administrative records: Data collected for the purpose of carrying out various programs (e.g., tax collection).

Bias: Systematic deviation of the survey estimated value from the true population value. Bias refers to systematic errors that can occur with any sample under a specific design.

Coverage: Extent to which all elements on a frame list are members of the population and to which every element in a population appears on the frame list once and only once.

Coverage error: Discrepancy between statistics calculated on the frame population and the same statistics calculated on the target population. *Undercoverage* errors occur when target population units are missed during frame construction, and *overcoverage* errors occur when units are duplicated or enumerated in error.

Cross-sectional sample survey: Based on a representative sample of respondents drawn from a population at a particular point in time.

Estimate: A numerical value for a population parameter derived from information collected from a survey or other sources.

Estimation error: Difference between a survey estimate and the true value of the parameter in the target population.

Frame: A mapping of the universe elements (i.e., sampling units) onto a finite list (e.g., the population of schools on the day of the survey).

Item nonresponse: Occurs when a respondent fails to respond to one or more relevant item(s) on a survey.

Longitudinal sample survey: Follows the experiences and outcomes over time of a representative sample of respondents (i.e., a cohort).

Measurement error: Difference between observed values of a variable recorded under similar conditions and some fixed true value (e.g., errors in reporting, reading, calculating, or recording a numerical value).

Nonresponse bias: Occurs when the observed value deviates from the population parameter due to differences between respondents and nonrespondents. Nonresponse bias may occur as a result of not obtaining 100% response from the selected units.

Nonresponse error: Overall error observed in estimates caused by differences between respondents and nonrespondents. It consists of a variance component and nonresponse bias.

Nonsampling error: Includes measurement errors due to interviewers, respondents, instruments, and mode; nonresponse error; coverage error; and processing error.

Population: See “target population.”

Precision of survey results: How closely results from a sample can reproduce the results that would be obtained from a complete count (i.e., census) conducted using the same techniques. The difference between a sample result and the result from a complete census taken under the same conditions is an indication of the precision of the sample result.

Probabilistic methods: Any of a variety of methods for survey sampling that gives a known, nonzero probability of selection to each member of a target population. The advantage of probabilistic sampling methods is that sampling error can be calculated. Such methods include random sampling, systematic sampling, and stratified sampling. They do not include convenience sampling, judgment sampling, quota sampling, and snowball sampling.

Reliability: Degree to which a measurement technique would yield the same result each time it is applied. A measurement can be both reliable and inaccurate.

Response bias: Deviation of the survey estimate from the true population value due to measurement error from the data collection. Potential sources of response bias include the respondent, the instrument, and the interviewer.

Response rates: Measure the proportion of the sample frame represented by the responding units in each study.

Sample design: Sampling plan and estimation procedures.

Sampling error: Error that occurs because all members of the frame population are not measured. It is associated with the variation in samples drawn from the same frame population. The sampling error equals the square root of the variance.

Standard error: Standard deviation of the sampling distribution of a statistic. Although the standard error is used to estimate sampling error, it includes some nonsampling error.

Statistical significance: Attained when a statistical procedure applied to a set of observations yields a *p* value that exceeds the level of probability at which it is agreed that the null hypothesis will be rejected.

Target population: Any group of potential sample units or individuals, businesses, or other entities of interest.

Unit nonresponse: Occurs when a respondent fails to respond to all required response items (i.e., fails to fill out or return a data collection instrument).

Universe survey: Involves the collection of data covering all known units in a population (i.e., a census).

Validity: Degree to which an estimate is likely to be true and free of bias (systematic errors).

List of Appendix Tables

Detailed appendix tables are available online at http://www.nsf.gov/statistics/indicators/appendix/.

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Chapter 2. Higher Education in Science and Engineering

Chapter 3. Science and Engineering Labor Force

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