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ABSTRACT

This is the second of four reports representing an effort to develop a system of indicators of scientific technical information. This particular report is concerned with the data analyses which led to the system of statistical indicators described in the first report. It includes a discussion of the overall framework upon which the study was based as well as of the analysis and mathematical models used to generate the indicators. It is organized into sections covering the major functions involved in the communication of scientific and technical information--research and information generation, trends in publishing and technical information, acquisition and storage of information, organization and control, identification and physical access, assimilation and use of information, and total cost of communicating scientific and technical information. The report is heavily illustrated with graphs and charts. The background and trends for this data are discussed in the first volume (IR 004 374). (Author/DAG)

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STATISTICAL INDICATORS OF SCIENTIFIC & TECHNICAL COMMUNICATION (1960-1980)

VOLUME II: A RESEARCH REPORT

For

National Science Foundation
Division of Science Information
Under Contract No. NSF-C878

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PREFACE

This report is one of four generated during a National Science Foundation - supported study of statistical indicators of scientific and technical communication. The four reports are as follows:

(1) Statistical Indicators of Scientific and Technical Communication (1960-1980), Volume I: A Summary Report. This volume describes the major indicators identified during the study and their significance to the field of communication of scientific and technical information. These indicators are addressed to information managers, administrators and policymakers.

(2) Statistical Indicators of Scientific and Technical Communication (1960-1980), Volume II: A Research Report. This volume is concerned with the data analyses which led to the system of statistical indicators. It includes discussion of the overall framework upon which the study was based as well as of the analysis and mathematical models used to generate the indicators. This volume will be of interest to those engaged in research involving communication of scientific and technical information.

(3) Statistical Indicators of Scientific and Technical Communication (1960-1980), Volume III: A Data Appendix to Volume II. This contains listings of the raw data obtained for a sample of scholarly scientific and technical journals as a part of a Journal Tracking Survey. The data are accompanied by a discussion of the methodology utilized in collecting them, and by guidelines for their interpretation. It is hoped that this volume will be of use as a data reference tool to other researchers involved in the study of the scientific and technical journal literature.

(4) The Status of Journal Publishing in the United States: 1975. This volume focuses exclusively on the role of the journal literature in scientific and technical communication, describing the flow of article information among authors, publishers, libraries, colleagues and users. A large number of distribution channels are discussed.

These reports highlight the results of an intensive search of secondary data sources for relevant information on scientific and technical communication activities. As a part of an ongoing effort in this area, the Center for Quantitative Sciences will provide additional data and special analyses on request. Questions should be addressed to:

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The work performed under this contract was conducted primarily by the identified authors. Other professional staff members of the Center for Quantitative Sciences who were heavily involved in the study were Katherine McEvoy, Mary Yates, Colleen Schell, Charles Schueller, and Alice Newman. A substantial con[illegible]bution was also made by Sandra Baker and Jane Hurst, who patiently typed [illegible]ous versions of the reports.

Consultants on the project were Francois Kertesz, Klaus Otten, William Creager, and Betti Goldwasser. We also received a good deal of help from a large number of voluntary reviewers and organizations. Finally, the project monitor, Helene Ebenfield, provided support and critical insight throughout the project.

Donald W. King
Principal Investigator

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SECTION 1

INTRODUCTION

1.1 Background

The Division of Science Information of the National Science Foundation places a major emphasis on providing aid to management across the national scientific and technical information enterprise. One source of such assistance is in the form of data and statistical indicators that can be used for planning and policy purposes. Thus, NSF requested proposals to develop statistical indicators in the STI field. The statement for this work is quoted as follows:

> Numerous studies have focused on the transfer of research results from originators to users. But most of these investigations have been limited to one phase of information transfer or to one field of science or to one point in time. The need for a comprehensive and continuing information base for policy and planning is by no means new, but it becomes even more urgent as the volume of scientific and technical information rises beyond the reach of manual processing, while automation on a massive scale approaches the point of economic feasibility. In order to monitor and assess these developments, a statistical system for gathering, organizing, and analyzing data relevant to all aspects of scientific and technical communication is indispensable. The objective of this project is to develop and initiate a system of statistical indicators of scientific and technical communication. Each indicator, as a time series, will trace out some aspect of the production of new scientific and technical information, of the transfer of that information to users, or of the resources needed to preserve it for future use and to retrieve it when needed. The indicators are intended for analysis and interpretation by planners and policy makers in Government and in the private sector and as data in modeling and simulation studies. Taken together they can be used to describe trends, anticipate new developments, and guide the evolution of the nation's information resources toward better and more economical service (104).

One of the constraints of the study was that all data were to be of a secondary nature, that is, obtained from existing and available sources. We have attempted to exhaust these sources of data and also to analyze them in terms of their limitations. The second constraint of the study was that the number of statistical indicators be not less than five nor more than twenty, which means that a great deal of information had to be molded into a few, highly useful statistical indicators.

1.2 Study Design

The study was designed by the Center for Quantitative Sciences to include five major tasks - a background study, development of a framework for the indicators, data collection, development of the system of statistical indicators and reporting. The first four tasks are described briefly below. The study reports are discussed in Section 1.3.

The background study included a number of visits to experts in the fields of communications and information science. The purpose of these visits was to help determine what indicators might be of use, how they would be used and where data could be found to be incorporated into the system of indicators. A wide range of sources of data was identified from these visits.

The second major task of the study was to develop a framework for the system of statistical indicators. In a sense the framework serves as a general model for the communication of scientific and technical information. Once this framework was determined, we formulated broad descriptions of statistical indicators that fit this framework and that we felt, based on the background study, would be of most use in the STI enterprise. The framework used is described in Section 1.4.

Data collection involved a large number of secondary sources. Among these, various National Science Foundation, Bureau of the Census and Bureau of Labor Statistics publications provided information on scientific manpower and R&D funding patterns, and survey results from the Library Surveys Branch of the National Center for Educational Statistics were used in discussions of libraries. Both the Statistical Abstract of the United States (24) and the Bowker Annual of Library and Book Trade Information (18) are heavily cited throughout the study.

In the important area of journal publishing, a valuable source was the SATCOM report (59) prepared by the Task Group on the Economics of Primary Publication of the Committee on Scientific and Technical Communication of the

National Academy of Sciences and the National Academy of Engineering. This report presented results of a study, prepared by Conyers Herring, that carefully analyzed a number of economic factors in publishing such as costs, price, circulation, and sources of revenue.

Additional data on journals came from two studies sponsored by the National Science Foundation, Division of Science Information. One study (48), recently completed by Indiana University under the direction of Dean Bernard M. Fry, obtained economic data from journal publishers for three years over a five year period (1969, 1971, 1973). Our results use some of these data. The second study sponsored by NSF is currently underway at New York University under the direction of Dr. Fritz Machlup (73). This study will provide the best data gathered thus far on publishers, including costs, price and circulation. We expect that some of our data will be superseded by these results since the data gathering procedures (personal interview and collection by graduate students) are superior to procedures used by others in the past.

An important part of our data collection was a special study of journal publishing conducted to fill a gap in the available secondary data sources. This study was subdivided into three fairly distinct parts. The first part involved a sample of 191 scholarly scientific and technical journals. These journals were tracked back to 1962 to obtain information about their physical characteristics such as number of issues per year, number of articles per issue, number of pages per article, number of characters per page, number of special graphics, and number of citations. The second part involved a survey of authors of journal articles to determine information about their articles such as page charges, reprints distributed and number of manuscript revisions. We also determined information about journal articles that were cited by the authors, including how the authors identified their cited articles and how they gained physical access to them. The third part of the study involved a thorough review of secondary sources of data such as other studies and available publisher records. Initial plans to conduct a small publisher survey were felt to be duplicative of Dr. Machlup's previously referenced project. This survey of publishers is very comprehensive and should yield better publisher data than we could have achieved on this study from secondary sources.

The journal tracking study provided information over the 1962 - 1974 period on the prices charged to various subscribers. There is a dearth of information on publishing costs over an extended period of time. Therefore, we applied a cost model developed in an earlier NSF study (14) to estimate costs of typical journals. This model provides estimates of prerun and runoff costs as a function of various model parameters: (1) journal characteristics including number of issues, pages per issue, pages per article, characters per page, and graphics; (2) cost factors such as paper and supplies, labor, postage and equipment; and (3) process factors, including the process techniques used such as typesetting versus photocomposition and process flow characteristics such as percent rejection. Averages for each of the model parameters were estimated from 1962 to 1974 and forecast to 1980 so that we could estimate costs over this duration of time. Thus, the journal tracking study provided data for prices and journal publishing parameters from which we could estimate costs. We also obtained other interesting indicators such as sources of funding of research leading to the articles, delay time from submission of articles to publication, and number of journal articles citations as well as citations to books and technical reports.

To the extent possible, all data collection was conducted in terms of the following fields of science used by the National Science Foundation. These nine fields are:

I. Physical Sciences (Astronomy, Chemistry, Physics, Other Physical Sciences)

II. Mathematics

III. Computer Scie and Engineering

IV. Environmental Sciences (Atmospheric Sciences, Geological Sciences, Biological Oceanography, Physical and Chemical Oceanography, Ecology, Other Environmental Sciences)

V. Engineering (Aeronautical, Astronautical, Chemical, Civil, Electrical, Mechanical, Metallurgy and Materials, Other Engineering)

VI. Life Sciences (Biological, Clinical Medical, Other Medical, Other Life Sciences)

VII. Psychology (Biological Aspects, Social Aspects, Other Psychological Sciences)

VIII. Social Sciences (Anthropology, Economics, History, Linguistics, Political Science, Sociology, Law, Other Social Sciences)

IX. Other Sciences (Science and Technology Assessment, Science Policy, Other Sciences not elsewhere classified)

The next two sections briefly discuss the reports generated for this project and the overall framework used for analysis.

1.3 Study Reports

In order to develop a system of statistical indicators, it was necessary to study hundreds of secondary data sources and, from these sources, derive a small number of indicators that suggest the direction of scientific and technical communications over the past and in the future. It is anticipated that these indicators will be useful to information science managers (administrators and policymakers) as well as to others engaged in scientific and technical communication activities.

Since the range of available data is so broad and since the data are imbedded in the small number of indicators in diverse ways, we have chosen to present results of our investigation in three distinct volumes as follows:

1) The first volume is a presentation of the STI Communications Statistical Indicators. This volume includes only a description of the major indicators and their significance to the field of communication of scientific and technical information. These indicators are addressed to information managers, administrators and policymakers.

2) The second volume is an STI Communications Statistical Indicators Research Report concerning the analysis of data leading to the system of statistical indicators. It includes description of the framework leading to the system of statistical indicators as well as the analysis and mathematical models used to generate the statistical indicators. This volume will be of interest to those engaged in research involving communication of scientific and technical information. It will also serve those who are interested in the details of how the system of statistical indicators was derived.

3) The third volume is A Data Appendix to Volume II. It contains listings of the "raw" data obtained for a sample of scholarly scientific and technical journals as a part of our Journal Tracking Survey. The data are accompanied by a discussion of the methodology utilized in collecting them, and by guidelines for their interpretation. It is hoped that this volume will be of use as a data reference tool to other researchers involved in the study of the scientific and technical journal literature.

This report, the second volume, is organized into sections covering the major functions involved in the communication of scientific and technical information. Section 2, Research and Information Generation, covers the number of scientists and engineers and the volume of R&D funding in some detail and is included primarily as background information.

Section 3, Trends in Publishing and Technical Information, focuses on the composition, recording, reproduction and initial distribution of scientific and technical information. It discusses the range of document types, including books, journals, technical reports and others. Major subsections deal with the growth of the literature, trends in factors related to publishing, and the costs of publication.

Sections 4, 5 and 6 are concerned with the functions occurring between publication and use of an S&T information source. The emphasis is on libraries, an important communications channel. Section 4, The Acquisition and Storage of Information, consists of an introduction to the topic of libraries and a discussion of the volume and costs of library acquisitions of scientific and technical materials. Organization and Control is covered in Section 5, including both trends in library cataloging activities and the role of abstracting and indexing services in the communications process. Section 6 is entitled Identification and Physical Access and discusses the means by which the scientist identifies needed materials and gains physical access to them.

Section 7 completes the communications flow by describing the Assimilation and Use of Information, primarily measured through the use of citation analysis. In Section 8, Total Cost of Communicating Scientific and Technical Information, the costs of the various functions are combined and cost-effectiveness relationships are explored. The Reader is also referred to the Index to Tables at the end of Volume II.

1.4 Framework for the Statistical Indicators

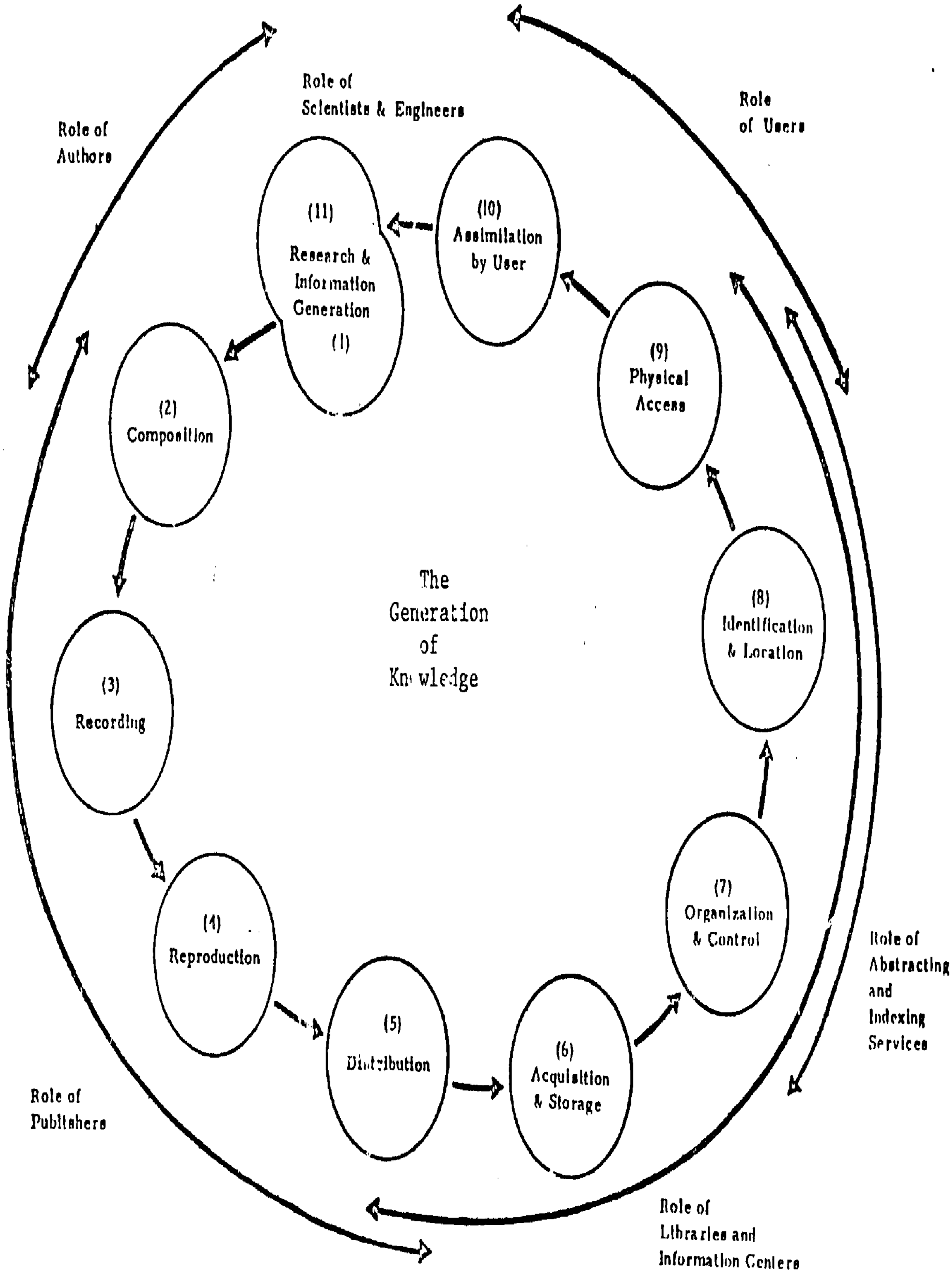
It can be safely said that communication of scientific and technical information is one of the most important aspects of scientific research for this is the mechanism that leads to its use and ultimate benefits. Communication, however, becomes increasingly difficult as the number of persons engaged in science and technology multiplies and as interdisciplinary and multidisciplinary scientific research becomes increasingly important to scientific advancement. The difficulties encountered in communication of scientific and technical information are further compounded by increased costs and decreased resources with which to perform the basic functions necessary. Furthermore, the use or anticipated use of innovative processes further complicates the situation since we have no clear picture as to the impact of these innovations.

In order to gain some understanding of what has happened and to anticipate what is likely to occur in the future, a system of statistical indicators of the communication of scientific and technical information is needed. The indicators developed as a part of this study are based on a framework or a model of communication of scientific and technical information. This framework is depicted in Figure 1.1. The diagram represents an information transfer spiral based on published documents, although some of the functions described in it are applicable to other forms of communication as well. The spiral includes ten functions that are essential to complete the transfer of information.

It is convenient to consider the spiral as beginning at Research which results in Generation of Information (1). This function is the role of scientists and engineers. Obviously, without research results to report or to communicate, there would be little need for communications media. As shown later in this report, the generation of research results and their subsequent use are related to the number of scientists and engineers and to the resources expended on research.

As a result of scientific research projects, manuscripts (books, articles, reports) are Composed (2). The composition function refers to writing, editing and reviewing the manuscripts. When a manuscript is in a form to be communicated it is considered to be Recorded (3). These two functions are the role of authors, publishers and other scientists when editing and review are

Figure 1.1 SCIENTIFIC AND TECHNICAL INFORMATION TRANSFER



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performed. At this stage in isolation, authors have very little impact on the scientific community by means of formal communication. It is not until the work has been reproduced and distributed that it has the potential for widespread influence on an audience beyond the author's circle of colleagues and fellow specialists.

The Reproduction (4) and Distribution (5) functions are usually the role of the publisher of scientific materials. However, as demonstrated later, the authors, libraries and colleagues also play an important role in reproduction and distribution. Transfer of documents through the latter three participants may be thought of as indirect reproduction and distribution which cannot take place without Acquisition and Storage (6). Although many individuals may acquire scientific and technical books, articles or reports, and may store them, at least for a while, this stage of the spiral is best represented by acquisition and storage by libraries and other information centers. Through their acquisition and storage policies, libraries provide a permanent archive of scientific achievement. They also provide a guaranteed source of access to this record.

Libraries also have an important role to play in Organization and Control functions (7). As well as collecting publications, libraries and other information centers provide access to these documents through cataloging, classification, indexing and other related procedures. The major indexing and abstracting services and bibliographic services play an important role in organization and control as well. Needed publications may be Identified and Located (8) by a number of processes including reference to one's own subscription, library search and, recently, computerized search and retrieval systems. This function is usually accomplished by the user or an intermediary from a library or other information service. The Physical Access function (9) may include direct distribution of scientific and technical articles from publishers to users as well as indirect distribution through libraries and other information centers. The final function in the cycle, that of Assimilation by User (10), is the least tangible. The assimilation function is the stage at which information (as opposed to documents) is transferred, and, thus, the state of the user's knowledge is altered. The functional framework is presented as a spiral because the communication process is continuous and may be regenerative. Through assimilation a reader may gain information that can be used in his research in such phases as conceptualization, design, conduct, analysis, and composition. This research may, in turn, generate new composition and recording, and so the process continues.

SECTION 2

RESEARCH AND INFORMATION GENERATION

The quantity of scientific and technical information generated over a period of time can be assumed to bear a relationship to three general crends: The numbers of scientists and engineers; the educational levels of scientists and engineers, and the dollars available for research and development. This section deals in detail with these three trends and some of the forecasts of the literature growth are based on these trends. Persons not having a specific interest in these background details may want to skip t is section and go on to those sections dealing with communications functions.

Resources available for the research and generation function are discussed separately below as human resources and financial resources. The characteristics of the outlets for recorded and informal information, although closely related, are handled under the Composition and Recording function, and, therefore, are only referred to in this section.

2.1 Human Resources, the Population Base

A number of population trends (including projections) provide a basis from which to view such human resource elements as college enrollments, degrees granted, employment, etc. For this purpose there are particular groups of the population which can be examined such as:

- total population;
- college age populations; and
- labor force age populations.

Certain other population breaks such as degree recipient and employment rates for women might also be considered. However, these increasing rates are imbedded in the statistics for the labor force and degree recipient trends and a detailed view of the impact of career involvement by women can be obtained from other sources such as the publications of the

Department of Labor and the National Center for Educational Statistics. The discussion here will deal with total population by age grouping only. The decision as to which specific age breaks would be used evolved as an understanding was gained of the statistics on college enrollments, degrees granted and labor force.

College age-groups are considered in terms of first year enrollments, total enrollments, enrollments by field of science and degrees granted by level and by field. An increase in part-time enrollments tends to expand the age range under consideration, as does our interest in PhD degrees. Thus the 18-21 year range is too limited for many purposes. An 18-24 group may be expected to cover a much larger proportion of students below the master's level at least. In addition a 17-18 year old population is frequently used as a base for comparing first-time enrollments in college.

Most labor force statistics are based upon a 16 and over population. For our purposes, as we are almost exclusively concerned with college graduates, a 21 and over population may be more appropriate. In addition, and especially as the 65 and over population is becoming a larger proportion of total population, some basis may exist for examining a population group which covers a narrower age range that has higher proportion of members in the labor force, such as 21-64. At least to the extent that our concern is the more highly educated, or experienced professionals, perhaps a 25-64 population base would be more valid.

There are some other age breaks which might be examined, especially as they relate to differences in "information generation productivity" over the professional life-time of scientists* (123).

All population projection data used in this section are Census Bureau Series II data for the 50 states, and D.C., including armed forces overseas unless otherwise specified. The use of the other projections might provide differing proportions, but the greatest credibility appears to lie with the above mentioned series.

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*DeSolla Price divides the productive life of a scientist into three periods, each having a different productivity.

2.1.1 Total Population

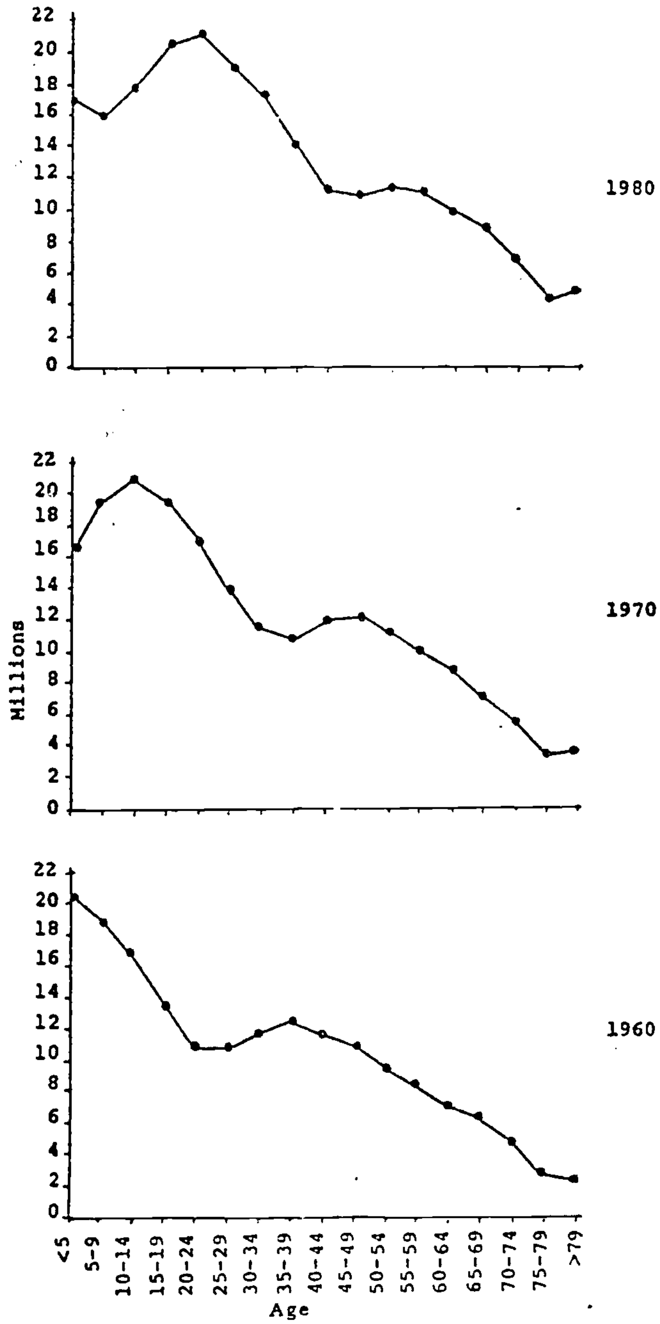
A salient characteristic of the U.S. population profile, graphed on the following page (Figure 2.1), may be expected to have more impact on education and employment than any other; the large number of births around 1960 creates a dramatic peak in the age distribution profile. This cohort of young people centers around the 15-19 year old group currently (1975). If all else were to remain the same proportional to total enrollment and age-specific populations, the passing of this peak or bulge through the prime college enrollment age, into the newly employed, and then through employment years and into retirement would unavoidably result in significant effects on the numbers of and employment opportunities for scientists and engineers.

Total population of the U.S. (including armed forces overseas) has grown from 181 million in 1960 to an estimated 214 million in 1975 and is projected to reach 223 million by 1980 (Table 2.1). Overall annual rates of increase shown in Table 2.2 have been declining since 1961, with minor exceptions (1970, 1975). This generally decreasing growth rate is expected to continue through 1980. However, trends within specific age groups have differed considerably over the same period. For example, the 35-44 year old group has experienced real declines in population since 1963 (22).

Over the same period, median age of the population decreased during most of the 60's and early 70's from 29.4 in 1960 to a low of 27.9 in 1971. Since then it has been generally increasing and is predicted to reach 29.9 by 1980.

The rightward movement (in terms of the graph) of this "bulge" needs to be constantly kept in mind in considering projection data. Upsurges in total numbers of new entrants into scientific fields over the next decade will most certainly be followed by subsequent decreases. If the information generating capability of scientists as well as their information needs differ by length of time in the labor force, then the movement of this bulge through labor force participation years also need to be kept in mind.

Figure 2.1 TOTAL POPULATION OF THE UNITED STATES BY AGE GROUP
1960, 1970, 1980



SOURCE: U.S. Bureau of the Census, Series P-25, #519 and #541.

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Table 2.1 TOTAL POPULATION OF UNITED STATES, BY SELECTED AGE GROUPS: 1960-1980, 1985

(Millions)

Year	Total	Median Age	16 & Over	21 & Over	25 & Over	17-18	18-21	18-24	16-24	16-64	21-64	25-64
1960 . . .	180.8	29.4	121.8	108.9	100.0	5.6	9.6	15.1	21.8	105.2	92.2	83.3
1961 . . .	183.7	29.2	123.4	109.9	100.9	5.8	10.3	17.0	22.5	106.3	92.8	83.8
1962 . . .	186.5	28.9	124.9	111.1	101.7	5.6	10.8	17.7	23.1	107.4	93.6	84.2
1963 . . .	189.2	28.6	127.3	112.3	102.5	5.5	11.2	18.3	24.7	109.5	94.5	84.7
1964 . . .	191.9	28.3	129.4	113.8	103.4	6.5	11.3	18.8	26.0	111.3	95.7	85.3
1965 . . .	194.3	28.1	131.5	115.2	104.3	7.3	12.2	20.3	27.3	113.1	96.7	85.8
1966 . . .	196.6	28.0	133.7	116.5	105.3	7.0	12.9	21.4	28.4	114.9	97.8	86.5
1967 . . .	198.7	27.9	135.9	117.8	106.5	7.0	13.7	22.3	29.4	116.8	98.8	87.4
1968 . . .	200.7	28.0	138.2	120.1	107.9	7.2	14.5	22.9	30.2	118.8	100.7	88.6
1969 . . .	202.7	28.0	140.5	122.0	109.2	7.4	14.4	23.7	31.3	120.8	102.3	89.5
1970 . . .	204.9	27.9	142.9	124.0	110.5	7.6	14.7	24.7	32.5	122.9	103.9	90.4
1971 . . .	207.0	27.9	145.4	126.0	111.7	7.8	15.0	25.8	33.7	124.9	105.5	91.2
1972 . . .	208.8	28.1	147.9	128.1	113.9	8.0	15.4	25.9	34.0	127.0	107.2	93.0
1973 . . .	210.4	28.4	150.5	130.2	115.8	8.1	15.8	26.4	34.6	129.1	108.8	94.5
1974 . . .	211.9	28.6	153.1	132.4	117.7	8.3	16.1	26.9	35.3	131.2	110.6	95.9
1975 . . .	213.5	28.8	155.6	134.7	119.5	8.5	16.5	27.6	36.0	133.3	112.3	97.2
1976 . . .	215.1	28.9	158.1	137.0	121.5	8.5	16.8	28.2	36.6	135.3	114.2	[illegible]
1977 . . .	216.8	29.3	160.6	139.3	123.6	8.4	17.0	28.6	37.0	137.4	116.1	100.4
1978 . . .	218.7	29.5	163.1	141.8	125.6	8.5	17.1	29.0	37.4	139.4	118.1	102.0
1979 . . .	220.7	29.7	165.4	144.2	127.8	8.5	17.1	29.3	37.6	141.3	120.1	103.7
1980 . . .	222.8	29.9	169.7	149.0	130.0	8.3	17.0	29.5	37.6	143.1	122.1	105.5
1985 . . .	234.1	31.1	176.5	158.2	141.7	7.1	15.4	27.8	34.9	149.9	131.5	115.1
					PERCENT CHANGE							
1960-65 . . .	8	-4	8	6	4	30	27	26	25	8	5	3
1965-70 . .	6	-1	9	8	6	4	20	22	19	9	7	5
1970-75 . .	4	3	9	9	8	12	12	12	11	8	8	8
1975-80 . .	4	4	9	11	9	-2	3	7	4	7	9	9
1980-85 . .	5	4	4	6	9	-14	-10	-6	-7	5	8	9

SOURCE: Bureau of the Census, DOC, 1960-73 data: "Estimates of the Population of the United States, By Age, Sex, and Race: April 11, 1960 to July 1, 1973," Current Population Reports; Population Estimates and Projections (Series P-25. No. 519), April 1974.

__________, 1974-80 data: "Projections of the Population of the United States, by Age and Sex, 1975 to 2000, with Extension of Total Population to 2025," Current Population Reports; Population Estimates and Projections (Series P-25. No. 541). February 1975.

Table 2.2 TOTAL POPULATION AND COLLEGE AGE POPULATIONS, ANNUAL RATES OF INCREASE: 1960-1980, 1985

(Percent)

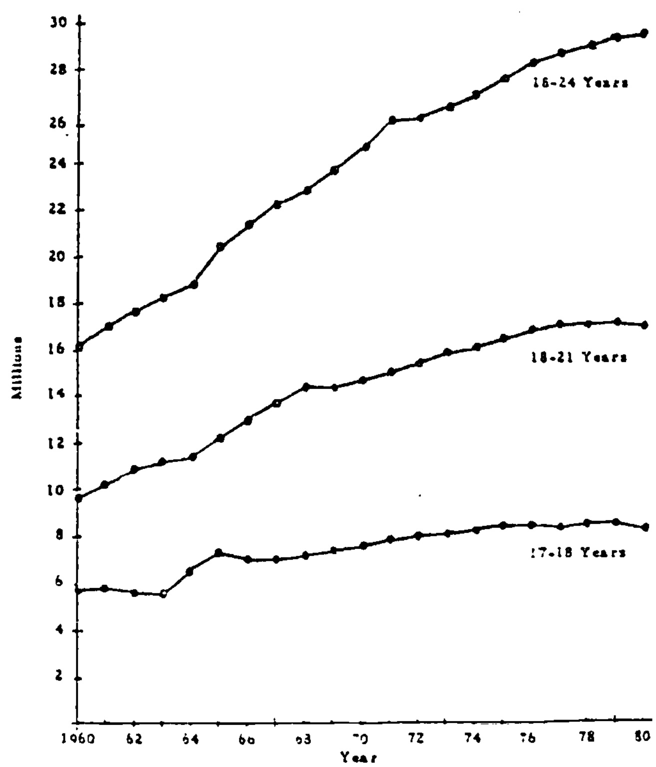
Year	Total Population	Age Group 17-18	18-21	18-24
1960 . . .	-	-	-	-
1961 . . .	1.7	3.6	7.3	5.6
1962 . . .	1.5	-3.4	4.9	4.1
1963 . . .	1.4	-1.8	3.7	3.4
1964 . . .	1.4	18.2	0.9	2.7
1965 . . .	1.3	12.3	8.0	8.0
1966 . . .	1.2	-4.1	5.7	5.4
1967 . . .	1.1	-	6.2	4.2
1968 . . .	1.0	2.9	5.8	2.7
1969 . . .	1.0	2.8	-0.7	3.5
1970 . . .	1.1	2.7	2.1	4.2
1971 . . .	1.0	2.6	2.0	4.5
1972 . . .	0.9	2.6	2.7	0.4
1973 . . .	0.8	1.3	2.6	1.9
1974 . . .	0.7	2.5	1.9	1.9
1975 . . .	0.8	2.4	2.5	2.6
1976 . . .	0.7	-	1.8	2.2
1977 . . .	0.8	-1.2	1.2	1.4
1978 . . .	0.9	1.2	0.6	1.4
1979 . . .	0.9	-	-	1.0
1980 . . .	1.0	-2.4	-0.1	0.7
1985 . . .	1.0	-2.5	-3.4	-2.2

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.1.

College Age Population

The projected 17-18 year-old population (Table 2.2 and Figure 2.2) levels off from 1975-1979 and then begins to decrease. Thus if college enrollment rates for 17-18 year olds remained constant, enrollments could still be expected to decrease by 1980. (In fact, these rates are not remaining constant, but have begun to decrease.) In the 18-21 and 18-24 age groups leveling off occurs somewhat later, but still will similarly affect total college enrollments by 1980. Decreasing college enrollments (even if the same proportion of appropriate age groups were to continue to enroll) after 1980 or so will impact severely on job opportunities for Ph.D. holders, and at the time when the number of Ph.D. holders (again assuming continuation of present rates of Ph.D. achievement) has just increased.

Figure 2.2 COLLEGE AGE POPULATION GROUPS: 1960-1980



SOURCE: Table 2.1

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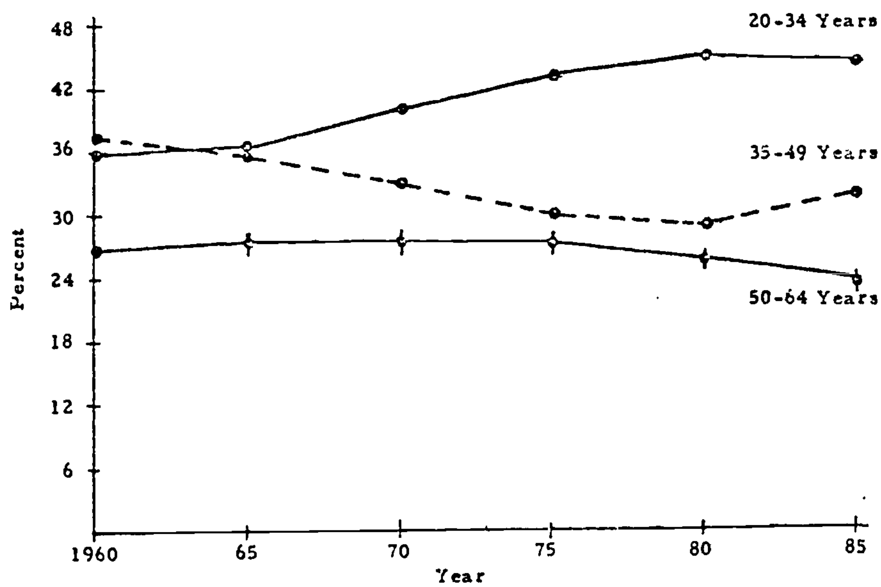
Labor Force Population

In the 15 years since 1960, the population age group from which the large majority of the labor force is drawn (21-64) accounts for approximately half of the total population. From a low of 51.2 percent in 1966-67, the proportion grew to 54.5 percent in 1975 and is expected to reach almost 57 percent in 1980 (Table 2.3 and Figure 2.3). These increases compounded by increased labor force participation by women will substantially increase the size of the labor force over the next five years.

Figure 2.3 SELECTED LABOR FORCE AGE GROUPS AS A PERCENT OF ALL 20-64 YEAR OLDS: 1960-1985



SOURCE: Table 2.3

2.1.2 Education

Data connected with the education of scientists and engineers is of interest for two reasons. Not only do they provide a description of the numbers of scientists and engineers that can be expected to be participants in the scientific labor force in subsequent years but they also impact on labor force utilization, as colleges and universities are major sources of employment especially for Ph.D. scientists. Slowing enrollments over the next decade can reasonably be expected to adversely affect employment

Table 2.3 POPULATION IN LABOR FORCE AGE BRACKET BY 15 YEAR AGE GROUPS: 1960-1980, 1985

Year	20-34 (Millions)	% of 20-64	35-49 (Millions)	% of 20-64	50-64 (Millions)	% of 20-64	20-64 Total (Millions)	20-64 as % of Total (Population)
1960 . .	34.1	36.1	35.1	37.1	25.3	26.8	94.5	52.3
1961 . .	34.2	35.9	35.4	37.1	25.7	27.0	95.3	51.9
1962 . .	34.5	35.8	35.6	37.0	26.2	27.2	96.3	51.6
1963 . .	35.1	36.0	35.7	36.7	26.6	27.3	97.4	51.5
1964 . .	35.7	36.2	35.8	36.3	27.1	27.5	98.6	51.4
1965 . .	36.2	36.4	35.8	36.0	27.5	27.6	99.5	51.2
1966 . .	36.8	36.6	35.8	35.6	28.0	27.8	100.6	51.2
1967 . .	38.4	37.4	35.8	34.8	28.5	27.8	102.7	51.7
1968 . .	39.8	38.1	35.7	34.2	28.9	27.7	104.4	52.0
1969 . .	41.2	38.8	35.5	33.5	29.4	27.7	106.1	52.3
1970 . .	42.5	40.0	35.3	32.8	29.8	27.7	107.6	52.5
1971 . .	43.9	40.2	35.1	32.1	30.3	27.7	109.3	52.8
1972 . .	45.4	40.9	34.9	31.4	30.8	27.7	111.1	53.2
1973 . .	46.9	41.6	34.8	30.9	31.1	27.6	112.8	53.6
1974 . .	48.5	42.3	34.7	30.3	31.5	27.5	114.7	54.1
1975 . .	50.1	43.0	34.6	29.7	31.7	27.2	116.4	54.5
1976 . .	51.7	43.7	34.7	29.3	32.0	27.0	118.4	55.1
1977 . .	53.2	44.2	35.0	29.1	32.2	26.7	120.4	55.5
1978 . .	54.4	44.4	35.7	29.1	32.4	26.4	122.5	56.0
1979 . .	55.7	44.7	36.3	29.2	32.5	26.1	124.5	56.4
1980 . .	57.1	45.1	36.7	29.0	32.7	25.8	126.5	56.8
1985 . .	60.3	44.5	42.8	31.6	32.3	23.9	135.4	57.8

SOURCE: Bureau of the Census, DOC, 1960-73 data: "Estimates of the Population of the United States, By Age, Sex, and Race: April 11, 1960 to July 1, 1973," Current Population Reports; Population Estimates and Projections (Series P-25, No. 519), April 1974.

________________, 1974-80 data: "Projections of the Population of the United States, by Age and Sex, 1975 to 2000, with Extension of Total Population to 2025," Current Population Reports; Population Estimates and Projections (Series P-25, No. 541), February 1975.

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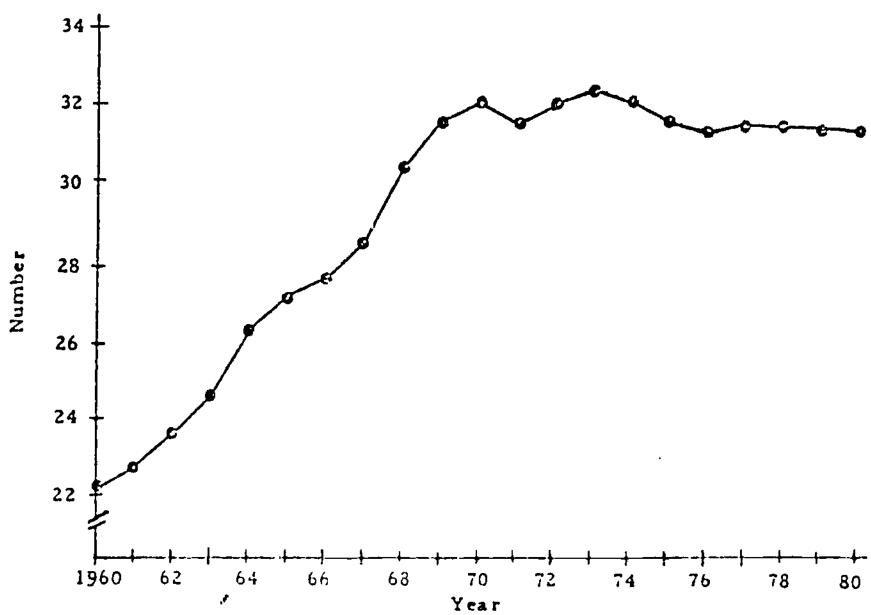
opportunities for doctorates in the immediate future. The employment aspects are further explored in subsequent pages, while the immediately following discussion concentrates on educational statistics, exclusive of faculty.

College Enrollment

College enrollments, especially as they relate to total population within the 18-24 year age group, serve to provide indications of potential future supply of scientists and engineers. Relevant highlights of education projections at the post-secondary institution level include the following:

College enrollments (graduate and undergraduate) in degree-credit programs total approximately 30 percent of the 18-24 year old population (Figure 2.4). This proportion has steadily increased from 18 percent in 1955 through the early 1970's and then leveled off at the present rate. It is projected to remain at the same level (31 percent) through the mid 1980's. However, the National Center for Education Statistics questions whether this assumption will really hold and provides alternative projections for high and low enrollment rates (83).

Figure 2.4 COLLEGE ENROLLEES PER 100 18-24 YEAR OLDS: 1960-1980



SOURCE: 1960-1973; Digest of Educational Statistics 1974, OE, DHEW
1974-1980; calculated from Projections of Educational Statistics, OE, DHEW and population projections, U.S. Bureau of the Census.

Undergraduate degree-credit enrollments increased steadily to 47 percent of the 18-21 year old population in the mid 1970's and similarly are projected to remain at that rate for the next decade. The rates expressed above are comparisons between enrollments and numbers of persons within the specified age group (e.g., for every 100 18-24 year olds, there are 31 persons enrolled in college). As such they are not the percentage of the specified age group actually enrolled in degree programs. A survey of a sample of students in 1973 (25) revealed that for all students 16-34, 74 percent were in the 18 and 24 age group, and an additional 22 percent were between 24 and 35.

However, even if the proportion of the population which is enrolled in degree-credit programs remains stable, the ratio of full-time to part-time students is expected to decrease over the next decade. The projected increase in the proportion of part-time students appears to occur at the undergraduate level. Part-time undergraduate degree-credit enrollments decreased from 28 percent of all enrollments in 1963 to a low of 24 percent in 1965-68, then rose steadily to 29 percent by 1973. They are projected to continue to increase steadily over the next decade. Graduate part-time students are projected to remain at about 64 percent*, a level they have maintained since the early 1960's. (See Tables 2.4 and 2.5).

Thus the average length of time from first year college enrollment to baccalaureate can be expected to increase. However, time lapses from graduate entry to doctorate award which were studied by NSF in 1971-72 may be expected to remain stable. According to the NSF Science Education Studies Group (83) results, an average of six years from graduate entry is spent obtaining a doctorate degree in most science and engineering fields. A year longer is average for Social Science (and for women in Agriculture, Natural Sciences and Psychology). These results contrast with the three to four years beyond the bachelor's degree usually required by educational

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*NCES data for undergraduate and graduate degree credit enrollments for 50 states and D.C.. NSF, Science Education Studies Groups data for graduate enrollments which covers "aggregate U.S." including Puerto Rico & outlying U.S. possessions, shows percentage of part-time graduate students averaging approximately 54 percent.

Table 2.4 UNDERGRADUATE DEGREE-CREDIT ENROLLMENT: 1960-1980

(Thousands)

Fall	Total	Part-time	Percent	Full-time	Percent
1960 . . .	3,227	904	28.0	2,323	72.0
1961 . . .	3,474	922	26.5	2,552	73.5
1962 . . .	3,753	1,028	27.4	2,725	72.6
1963 . . .	3,974	1,093	27.5	2,881	72.5
1964 . . .	4,342	1,145	26.4	3,196	73.6
1965 . . .	4,829	1,175	24.3	3,654	75.7
1966 . . .	5,160	1,220	23.6	3,940	76.4
1967 . . .	5,557	1,318	23.7	4,239	76.3
1968 . . .	6,043	1,443	23.9	4,600	76.1
1969 . . .	6,529	1,639	25.1	4,890	74.9
1970 . . .	6,889	1,779	25.8	5,110	74.2
1971 . . .	7,104	1,816	25.6	5,289	74.5
1972 . . .	7,199	1,946	27.0	5,253	73.0
1973 . . .	7,397	2,122	28.7	5,275	71.3
PROJECTIONS					
1974 . . .	7,419	2,186	29.5	5,233	70.5
1975 . . .	7,502	2,272	30.3	5,230	69.7
1976 . . .	7,624	2,370	31.1	5,254	68.9
1977 . . .	7,762	2,470	31.8	5,290	68.2
1978 . . .	7,861	2,566	32.6	5,295	67.4
1979 . . .	7,902	2,642	33.4	5,260	66.6
1980 . . .	7,920	2,713	34.3	5,207	65.7
PERCENT CHANGE					
1960-65 .	50	30		57	
1965-70 .	43	51		40	
1970-75 .	9	28		2	
1975-80 .	6	19		-	
1963-73 .	86	94		83	

Note: Data are for 50 states and the District of Columbia for all years.

SOURCE: National Center for Education Statistics, DHEW, 1960-62 data: Projections of Educational Statistics to 1980-81, 1971 edition and 1963-1980 data: Projections of Educational Statistics to 1983-84, 1974 edition.

Table 2.5 GRADUATE DEGREE-CREDIT ENROLLMENT
MASTER'S DEGREE OR HIGHER: 1960-1980

(Thousands)

Fall	Total	Part-time	Percent	Full-time	Percent
1960 . . .	356	213	59.8	143	40.2
1961 . . .	386	224	58.0	162	42.0
1962 . . .	422	245	58.1	177	41.9
1963 . . .	521	333	63.9	188	36.1
1964 . . .	608	387	63.7	221	36.3
1965 . . .	697	441	63.3	256	36.7
1966 . . .	768	483	62.9	285	37.1
1967 . . .	849	532	62.7	317	37.3
1968 . . .	885	548	61.9	337	38.1
1969 . . .	955	591	61.9	364	38.1
1970 . . .	1,031	652	63.2	379	36.8
1971 . . .	1,012	624	61.7	388	38.3
1972 . . .	1,066	673	63.1	393	36.9
1973 . . .	1,123	714	63.6	409	36.4
PROJECTIONS					
1974 . . .	1,141	724	63.5	417	36.5
1975 . . .	1,163	739	63.5	424	36.5
1976 . . .	1,200	763	63.6	437	36.4
1977 . . .	1,232	783	63.6	449	36.4
1978 . . .	1,257	800	63.6	457	36.4
1979 . . .	1,273	810	63.6	463	36.4
1980 . . .	1,290	822	63.7	468	36.3
PERCENT CHANGE					
1960-65 .	96	107		79	
1965-70 .	48	48		48	
1970-75 .	13	13		12	
1975-80 .	11	11		10	
1963-73 .	116	114		118	

Note: Data are for 50 states and the District of Columbia for all years.

SOURCE: National Center for Education Statistics, (DHEW), 1960-62 data: Projections of Educational Statistics to 1980-81, 1971 edition and 1963-80 data: Projections of Educational Statistics to 1983-84, 1974 edition.

institutions. The extended time quite obviously is largely the influence of the large number of part-time students at the graduate level.

Enrollments by Field of Science

For total enrollment at all levels, the Bureau of Census (26) surveys conducted in 1966 and 1972 provide interesting contrasts:

Table 2.6 PERCENTAGE OF TOTAL ENROLLMENT: 1966, 1972

Year	Math & Statistics	Physical & Earth Sciences	Engineering	Biology & Health	Social Sciences
1966 . . .	3.9	3.8	8.[illegible]	10.0	10.7
1972 . . .	2.9	1.9	4.3	11.5	11.5

SOURCE: Bureau of the Census, DOC, "Social and Economic Characteristics of Students," Current Population Reports; Population Characteristics (Series P-20, No. 260), October 1972.

In these surveys, the largest increase was in "other fields not reported" which grew from 19 percent to 33 percent.

In looking at the statistics on enrollment by field (and in subsequent pages on degrees granted) we will be examining data tabulated by the Science Education Studies Group (SESG) of NSF. Although similar data is available from NCES and is in fact the source for the NSF data, the NSF categories are more consistent with scientific field definitions that are used in later sections of this report.

Graduate enrollment for advanced degrees in science and engineering amount to just under one third of all such enrollments. The proportion appears to be decreasing and dropped from 33 percent in 1968 to 28 percent in 1972. Within science and technology, distributions have changed somewhat over the same period: Physical Sciences, Engineering, and Mathematics show a decreasing proportion of enrollees while Computer Sciences, Life Sciences, Social Sciences, and Psychology are attracting larger proportions. Records for first year graduate enrollments indicate these trends may continue.

Degrees Granted

The supply of new degree-holding scientists and engineers has been followed in serial data from NCES for several decades. Additional categorical breakdowns by field of science as well as a special series on doctoral recipients have been tabulated by NSF. The basic data (number of degrees granted by level and by field of science since the 1950's) appear more meaningful when presented as proportions of total populations.

Both the NCES and the NSF tabulations are provided in Tables 2.11 through 2.22 on the following pages. The NSF tabulations provide totals by field of science which (as with enrollments) are consistent with the fields of science used in the subsequent sections of this report. The NCES tabulations, however, include projections to 1980 and although the field definitions differ somewhat, are presented in order to show trends over a longer period.

Science and engineering degrees accounted for 30 percent of all baccalaureate degrees in 1972, the lowest proportion since 1958. The proportion of master's degrees in science and engineering dropped from a high of over 30 percent in 1965 to a low in 1972 of about 21 percent. Although science and engineering degrees make up a much larger proportion of doctor's degrees, 55 percent in 1972, this proportion has also been dropping since 1963.

The NCES data show the trend in decreasing proportions for science and engineering master's and doctor's degrees continuing through 1980, while bachelor's degrees in science and engineering remain more stable.

Table 2.7 TOTAL[1] GRADUATE[2] DEGREE-CREDIT ENROLLMENT, BY FIELD OF SCIENCE: 1965-1972

(Thousands)

Fall	Total	Total Science and Engineering	Physical Sciences	Engineering	Computer Sciences	Mathematics	Life Sciences	Social Sciences	Psychology
1965 . . .	535.3	195.3	36.5	57.5	0.8	20.2	34.7	30.0	15.6
1966 . . .	583.0	207.0	38.0	58.3	2.0	21.1	37.0	33.9	16.7
1967 . . .	649.7	224.5	40.4	62.6	2.7	22.3	39.9	37.3	19.1
1968 . . .	703.7	234.7	40.9	63.7	3.9	22.9	41.7	39.9	21.6
1969 . . .	756.9	243.7	39.9	65.0	6.2	23.0	44.2	42.7	22.7
1970 . . .	816.2	252.2	40.1	64.8	7.9	22.7	46.3	45.0	25.3
1971 . . .	836.3	246.1	38.9	59.3	8.3	20.5	47.7	44.6	26.7
1972 . . .	858.6	243.0	36.0	55.8	8.8	19.2	49.1	44.8	29.2
				PERCENT CHANGE					
1965-70 .	52	29	10	13	888	12	33	50	62
1967-72 .	32	8	-11	-11	226	-14	23	20	53

1 Part-time plus Full-time.

2 Master's degree or higher.

SOURCE: National Science Foundation compilation of the National Center for Education Statistics Survey of Students Enrolled for Advanced Degrees, annual series.

Table 2.8 TOTAL GRADUATE* DEGREE-CREDIT ENROLLMENT, BY FIELD OF SCIENCE: 1965-1972

(Percent Distribution)

Enrollment Field	Fall							
	1965	1966	1967	1968	1969	1970	1971	1972
Total Graduate Enrollments . .	100							
Science & Engineering . . .	36.5	35.5	34.6	33.4	32.2	30.9	29.4	28.3
Total Science & Engineering .	100							
Physical Sciences	18.7	18.4	18.0	17.4	16.4	15.9	15.8	14.8
Engineering	29.4	28.2	27.9	27.1	26.7	25.7	24.1	23.0
Computer Sciences	0.4	1.0	1.2	1.7	2.5	3.1	3.4	3.6
Mathematics	10.3	10.2	9.9	9.8	9.4	9.0	8.3	7.9
Life Sciences	17.8	17.9	17.8	17.8	18.1	18.4	19.4	20.2
Social Sciences	15.4	16.4	16.6	17.0	17.5	17.8	18.1	18.4
Psychology	8.0	8.1	8.5	9.2	9.3	10.0	10.8	12.0

* Master's degrees or higher.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.7.

Table 2.9 PART-TIME GRADUATE* DEGREE-CREDIT ENROLLMENT, BY FIELD OF SCIENCE: 1965-1972

(Thousands)

Fall	Total	Total Science and Engineering	Physical Sciences	Engineering	Computer Sciences	Mathematics	Life Sciences	Social Sciences	Psychology
1965	304.4	86.2	12.9	32.6	0.3	10.5	11.6	11.9	6.3
1966	312.0	82.7	11.2	31.4	1.0	10.0	10.7	12.4	6.0
1967	348.6	89.1	11.9	33.6	1.3	10.9	11.5	13.1	6.9
1968	380.8	92.9	11.6	33.9	2.0	11.4	12.0	14.3	7.7
1969	415.9	99.9	12.1	35.1	3.4	11.8	13.1	15.8	8.5
1970	443.1	102.8	12.3	33.2	4.2	11.2	14.5	17.4	10.0
1971	447.8	95.0	11.2	[illegible]	4.5	9.7	14.9	16.8	10.0
1972	471.1	96.0	10.8	[illegible]	4.8	9.2	16.2	17.7	11.5
				PERCENT CHANGE					
1965-70 . .	46	19	-5	2	1300	7	25	46	59
1967-72 . .	35	8	-9	-23	269	-16	41	35	67

* Master's degrees or higher.

SOURCE: National Science Foundation compilation of the National Center for Education Statistics Survey of Students Enrolled for Advanced Degrees, annual series.

Table 2.10 PART-TIME GRADUATE DEGREE-CREDIT ENROLLMENT AS PERCENT OF TOTAL GRADUATE ENROLLMENT, BY FIELD OF SCIENCE: 1965-1972

(Percent)

Fall	Total (100)	Total Science and Engineering (100)	Physical Sciences (100)	Engineering (100)	Computer Sciences (100)	Mathematics (100)	Life Sciences (100)	Social Sciences (100)	Psychology (100)
1965 . . .	56.9	44.1	35.3	56.7	37.5	52.0	33.4	39.7	40.4
1966 . . .	53.5	40.0	29.5	53.9	50.0	47.4	28.9	36.6	35.9
1967 . . .	53.7	39.7	29.5	53.7	48.1	48.9	28.8	35.1	36.1
1968 . . .	54.1	39.6	28.4	53.2	51.3	49.8	28.8	36.8	35.6
1969 . . .	54.9	41.0	30.3	54.0	54.8	45.3	29.6	37.0	37.4
1970 . . .	54.3	40.8	30.7	51.2	53.2	49.3	31.3	38.7	39.5
1971 . . .	53.5	38.6	28.8	47.2	5[illegible].2	47.3	31.2	37.7	37.5
1972 . . .	54.9	39.5	30.0	46.2	54.5	47.9	33.0	39.5	39.4

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.9.

Table 2.11 EARNED BACHELOR'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1980

Academic Year Ending	Total All Fields	Total Science and Engineering	Natural Sciences: Total	Natural Sciences: Life Sciences[1]	Natural Sciences: Physical Sciences	Natural Sciences: Mathematics	Natural Sciences: Computer Sciences	Engineering	Social Sciences: Total	Social Sciences: Psychology	Social Sciences: Other Social Sciences[2]
1960 . . .	389,183	146,399	50,466	23,060	16,007	11,399	-	37,679	58,234	8,061	50,193
1961 . . .	393,203	147,692	51,342	22,793	15,432	13,097	-	35,698	60,632	8,460	52,192
1962 . . .	387,530	156,263	53,661	23,240	15,851	14,570	-	36,070	66,532	9,578	56,954
1963 . . .	414,421	168,889	57,892	25,597	16,217	16,078	-	34,972	76,025	10,993	65,032
1964 . . .	466,486	192,640	65,482	29,401	17,457	18,624	-	37,014	90,144	13,258	76,886
1965 . . .	501,248	207,409	69,655	32,249	17,853	19,460	87	38,514	99,240	14,527	84,713
1966 . . .	520,248	220,317	71,627	34,428	17,129	19,977	89	37,971	110,723	16,841	93,882
1967 . . .	558,075	239,397	76,287	37,119	17,739	21,207	222	38,696	124,414	19,303	105,111
1968 . . .	631,923	270,439	83,996	40,644	19,380	23,513	459	40,341	145,902	23,768	122,134
1969 . . .	728,167	313,709	95,376	45,954	21,480	27,209	933	45,517	172,616	29,295	143,321
1970 . . .	791,510	339,811	99,738	49,413	21,329	27,442	1,544	49,678	190,395	33,536	156,859
1971 . . .	839,730	352,993	97,016	48,415	21,412	24,801	2,388	50,046	205,931	37,880	168,051
1972 . . .	881,460	365,810	98,270	50,870	20,400	23,630	3,370	50,310	217,230	43,080	174,150
1973* . . .	954,000	393,790	106,280	55,030	21,650	25,470	4,130	48,740	238,770	48,990	189,780
1974* . . .	977,000	401,130	107,360	55,550	21,400	25,800	4,610	47,180	246,690	52,420	194,270
PROJECTIONS											
1975 . . .	975,000	396,690	107,110	55,390	20,990	25,670	5,060	39,970	249,610	54,690	194,920
1976 . . .	967,000	390,600	104,690	54,070	20,080	25,190	5,350	36,180	249,730	56,520	193,210
1977 . . .	983,000	397,670	105,660	54,500	19,900	25,420	5,840	35,940	256,070	59,530	196,540
1978 . . .	1005,000	411,120	107,370	55,330	19,930	25,730	6,380	40,060	263,690	62,910	200,780
1979 . . .	1015,000	418,670	107,480	55,350	19,640	25,710	6,780	43,130	268,060	65,640	202,420
1980 . . .	1029,000	427,740	108,870	55,990	19,670	25,890	7,320	44,840	274,030	68,780	205,250
PERCENT CHANGE											
1960-65 . .	29	42	38	40	12	71	-	2	70	80	69
1965-70 . .	58	84	43	53	19	41	1675	31	92	131	85
1970-75 . .	23	17	7	12	-2	-6	228	-20	31	63	24
1975-80 . .	6	8	2	1	-6	1	45	12	10	26	5
1964-74 . .	109	108	64	89	23	39	-	27	174	295	153

* NCES estimate.

1 Biological Science + Agriculture and Natural Resources.

2 Social Science + Public Affairs & Services + Library Science.

Note: Data cover 50 States and District of Columbia.

SOURCE: National Center for Education Statistics, DHEW, 1962-80 data: Projections of Educational Statistics to 1983-84, 1974 edition, and 1960-61 data: Projections of Educational Statistics to 1980-81, 1971 edition.

Table 2.12 EARNED BACHELOR'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1972

Academic Year Ending	Total All Fields	Total Science and Engineering	Natural Sciences: Total	Natural Sciences: Life Sciences	Natural Sciences: Physical Sciences	Natural Sciences: Mathematics	Natural Sciences: Computer Sciences	Engineering	Social Sciences: Total	Social Sciences: Psychology	Social Sciences: Other Social Sciences
1960	394,889	120,937	51,635	24,141	16,057	11,437	-	37,808	31,494	8,111	23,383
1961	401,784	121,660	52,527	23,900	15,500	13,127	-	35,866	33,267	8,524	24,743
1962	420,485	127,469	55,704	25,200	15,894	14,610	-	34,735	37,030	9,638	27,392
1963	450,592	135,964	60,198	27,801	16,276	16,121	-	33,458	42,308	11,062	31,246
1964	502,104	153,361	67,815	31,611	17,527	18,677	-	35,226	50,320	13,359	36,961
1965	538,930	164,936	72,426	34,842	17,916	19,581	87	36,795	55,715	14,721	40,994
1966	555,613	173,471	74,232	36,864	17,186	20,093	89	35,815	63,424	17,022	46,402
1967	594,862	187,849	78,732	39,408	17,794	21,308	222	36,108	72,929	19,496	53,433
1968	671,591	212,174	86,786	43,260	19,442	23,625	459	37,614	87,774	23,972	63,802
1969	769,683	244,519	98,567	48,713	21,591	27,330	933	41,553	104,399	29,495	74,904
1970	833,322	264,122	102,789	52,129	21,551	27,565	1,544	44,772	116,561	33,854	82,707
1971	884,386	271,176	100,316	51,461	21,549	24,918	2,388	45,387	125,473	38,154	87,319
1972	937,884	281,228	101,621	53,484	20,887	23,848	3,402	46,003	133,604	43,421	90,183
PERCENT CHANGE											
1960-65 . .	36	36	40	44	12	71	-	-3	77	81	75
1965-70 . .	55	60	42	50	20	41	1675	22	109	130	102
1962-72 . .	123	121	82	112	31	63	-	32	261	351	229

Note: Data cover aggregate U.S.A., including outlying territories (Puerto Rico, Virgin Islands, etc.).

SOURCE: National Science Foundation compilation of data from the National Center for Education Statistics Annual Survey, Earned Degrees Conferred.

Table 2.13 EARNED BACHELOR'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1980

(Percent Distribution)

Field of Science	Academic Year Ending																				
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
All Fields, Total	100																				
Total S&E	37.6	37.4	40.3	40.6	41.3	41.4	42.3	42.9	42.8	43.1	42.9	42.0	41.4	41.3	41.1	40.7	40.4	40.5	40.9	41.2	41.6
Natural Science	13.0	13.0	13.8	13.9	14.0	13.9	13.8	13.7	13.3	13.1	12.6	11.6	11.1	11.1	11.0	11.0	10.8	10.7	10.7	10.6	10.6
Engineering	9.7	9.0	9.3	8.4	7.9	7.7	7.3	6.9	6.4	6.2	6.3	6.0	5.7	5.1	4.8	4.1	3.7	3.7	4.0	4.2	4.4
Social Sciences	15.0	15.3	17.2	18.3	19.3	19.8	21.3	22.3	23.1	23.7	24.1	24.5	24.6	25.0	25.2	25.6	25.8	26.0	26.2	26.4	26.6
Science & Engineering, Total .	100																				
Life Sciences	15.8	15.4	14.9	15.2	15.3	15.5	15.6	15.5	15.0	14.6	14.5	13.7	13.9	14.0	13.8	14.0	13.8	13.7	13.5	13.2	13.1
Physical Sciences	10.9	10.5	10.1	9.6	9.1	8.6	7.8	7.4	7.2	6.8	6.3	6.1	5.6	5.5	5.3	5.3	5.1	5.0	4.8	4.7	4.6
Mathematics	7.8	8.9	9.3	9.5	9.7	9.4	9.1	8.9	8.7	8.7	8.1	7.0	6.5	[illegible]	6.4	6.5	6.4	6.4	6.3	6.1	6.1
Computer Sciences	-	-	-	-	-	-	-	-	0.2	0.3	0.5	0.7	0.9	1.0	1.1	1.3	1.4	1.5	1.6	1.6	1.7
Engineering	25.7	24.2	23.1	20.7	19.2	18.6	17.2	16.2	15.0	14.5	14.6	14.2	13.8	12.4	11.8	10.1	9.3	9.0	9.7	10.3	10.5
Psychology	5.5	5.7	6.1	6.5	6.9	7.0	7.6	8.1	8.8	9.3	9.9	10.7	11.8	12.4	13.1	13.8	14.5	15.0	15.3	15.7	16.1
Social Sciences	34.3	35.3	36.4	38.5	39.9	40.8	42.6	43.9	45.2	45.7	46.2	47.6	47.6	48.2	48.4	49.1	49.5	49.4	48.8	48.3	48.0

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.11.

Table 2.14 EARNED BACHELOR'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1972

(Percent Distribution)

Field of Science	Academic Year Ending 1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
All Fields, Total	100	100	100	100	100	100	100	100	100	100	100	100	100
Total S&E	30.6	30.3	30.3	30.2	30.5	30.6	31.2	31.6	31.6	31.8	31.7	30.7	30.0
Natural Science	13.1	13.1	13.2	13.4	13.5	13.4	13.4	13.2	12.9	12.8	12.3	11.3	10.8
Engineering	9.6	8.9	8.3	7.4	7.0	6.8	6.4	6.1	5.6	5.4	5.4	5.1	4.9
Social Sciences	8.0	8.3	8.8	9.4	10.0	10.1	11.4	12.3	13.1	13.6	14.0	14.2	14.2
Science & Engineering, Total	100	100	100	100	100	100	100	100	100	100	100	100	100
Life Sciences	20.0	19.6	19.8	20.4	20.6	21.1	21.3	21.0	20.4	19.9	19.7	19.0	19.0
Physical Sciences	13.3	12.7	12.5	12.0	11.4	10.9	9.9	9.5	9.2	8.8	8.2	7.9	7.4
Mathematics	9.5	10.8	11.5	11.9	12.2	11.9	11.6	11.3	11.1	11.2	10.4	9.2	8.5
Computer Sciences	-	-	-	-	-	-	-	0.1	0.2	0.4	0.6	0.9	1.2
Engineering	31.3	29.5	27.2	24.6	23.0	22.3	20.6	19.3	17.7	17.0	17.0	16.7	16.4
Psychology	6.7	7.0	7.6	8.1	8.7	8.9	9.8	10.4	11.3	12.1	12.8	14.1	15.4
Social Sciences	19.3	20.3	21.5	23.0	24.1	24.9	26.7	28.4	30.1	30.6	31.3	32.2	32.1

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.12.

Table 2.15 EARNED MASTER'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1980

Academic Year Ending	Total All Fields	Total Science and Engineering	Natural Sciences: Total	Natural Sciences: Life Sciences[1]	Natural Sciences: Physical Sciences	Natural Sciences: Mathematics	Natural Sciences: Computer Sciences	Engineering	Social Sciences: Total	Social Sciences: Psychology	Social Sciences: Other Social Sciences[2]
1960	692	23,371	8,841	3,708	3,376	1,797	-	7,159	7,371	1,406	5,965
1961	,735	26,256	9,981	3,960	3,790	2,231	-	8,178	8,097	1,719	6,378
1962	88,414	32,932	10,936	4,363	3,913	2,680	-	8,953	13,023	1,832	11,191
1963	95,470	36,368	11,957	4,522	4,115	3,320	-	9,666	14,725	1,918	12,807
1964	105,551	40,561	13,158	4,978	4,555	3,625	-	10,857	16,546	2,059	14,487
1965	117,152	45,186	14,397	5,295	4,906	4,196	-	12,093	18,696	2,187	16,509
1966	140,548	52,271	16,013	6,267	4,977	4,769	-	13,717	22,541	2,423	20,118
1967	157,707	58,703	17,798	7,115	5,405	5,278	-	13,986	25,919	2,898	23,021
1968	176,749	62,611	18,766	7,740	5,499	5,527	-	15,247	28,598	3,237	25,361
1969	193,756	68,400	20,859	8,239	5,895	5,713	1,012	15,372	32,169	3,736	28,433
1970	208,291	70,628	21,027	7,997	5,935	5,636	1,459	15,723	33,870	3,953	29,925
1971	230,509	74,974	21,331	8,185	6,367	5,191	1,588	16,443	37,200	4,431	32,769
1972	250,000	79,170	21,960	8,760	6,160	5,190	1,850	16,650	40,510	5,290	35,220
1973	256,300	80,190	22,050	8,860	6,080	5,210	1,900	16,420	41,720	5,410	36,310
1974	270,100	83,570	22,770	9,200	6,160	5,410	2,000	16,640	44,160	5,690	38,470
PROJECTIONS											
1975	279,600	85,880	23,220	9,420	6,210	5,510	2,080	16,800	45,860	5,870	39,990
1976	284,900	87,040	23,390	9,530	6,170	5,550	2,140	16,780	46,870	5,980	40,890
1977	297,300	88,970	23,790	9,710	6,210	5,660	2,230	16,940	48,240	6,130	42,110
1978	300,600	91,100	24,250	9,910	6,270	5,740	2,330	17,160	49,690	6,290	43,400
1979	307,700	92,930	24,620	10,080	6,300	5,820	2,420	17,350	50,980	6,430	44,550
1980	312,900	94,200	24,850	10,180	6,300	5,870	2,500	17,400	51,950	6,530	45,420
PERCENT CHANGE											
1960-65 . . .	51	93	63	43	45	139	-	69	154	56	177
1965-70 . . .	78	56	46	51	21	34	-	30	81	81	81
1970-75 . . .	34	22	10	18	5	-2	43	7	35	48	34
1975-80 . . .	12	10	7	8	1	7	20	4	13	11	14
1964-74 . . .	156	106	73	85	35	49	-	53	167	176	166

* NCES estimates.

1 Biological Science + Agriculture + Natural Resources.

2 Social Science + Public Affairs & Services + Library Science.

Note: Data cover 50 States and District of Columbia.

SOURCE: National Center for Education Statistics, DHEW, 1962-80 data: Projections of Educational Statistics to 1983-84, 1974 ., and 1960-61 data: Projections of Educational Statistics to 1980-81, 1971 edition.

Table 2.16 EARNED MASTER'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1972

Academic Year Ending	Total All Fields	Total Science and Engineering	Natural Sciences: Total	Natural Sciences: Life Sciences	Natural Sciences: Physical Sciences	Natural Sciences: Mathematics	Natural Sciences: Computer Sciences	Engineering	Social Sciences: Total	Social Sciences: Psychology	Social Sciences: Other Social Sciences
1960	74,497	20,012	8,903	3,751	3,387	1,765	-	7,159	3,950	1,406	2,544
1961	78,269	22,786	10,122	4,085	3,799	2,238	-	8,178	4,486	1,719	2,767
1962	84,889	25,146	11,281	4,672	3,929	2,680	-	8,909	4,956	1,832	3,124
1963	91,418	27,367	12,173	4,718	4,132	3,323	-	9,635	5,559	1,918	3,641
1964	101,122	30,271	13,527	5,357	4,567	3,603	-	10,827	5,917	2,059	3,858
1965	112,195	33,835	15,190	5,978	4,918	4,148	146	12,056	6,589	2,241	4,348
1966	140,772	38,083	16,668	6,666	4,992	4,772	238	13,678	7,737	2,530	5,207
1967	157,892	41,800	18,610	7,465	5,412	5,284	449	13,885	9,305	3,138	6,167
1968	177,150	45,425	19,904	8,315	5,508	5,533	548	15,188	10,333	3,482	6,851
1969	194,414	48,425	21,455	8,809	5,911	5,723	1,012	15,243	11,727	4,013	7,714
1970	209,387	49,318	21,638	8,590	5,948	5,648	1,459	15,597	12,076	4,120	7,956
1971	231,486	50,624	21,495	8,320	6,386	5,201	1,588	16,347	12,782	4,438	8,344
1972	252,774	53,567	22,407	8,914	6,307	5,209	1,977	16,802	14,358	5,293	9,065
PERCENT CHANGE											
1960-65 . .	51	69	71	59	45	135	-	68	67	59	71
1965-70 . .	87	46	42	44	21	36	899	29	83	84	83
1962-72 . .	198	113	99	91	61	94	-	89	190	189	190

Note: Data cover aggregate U.S.A., including outlying territories (Puerto Rico, Virgin Islands, etc.).

SOURCE: National Science Foundation compilation of data from the National Center for Education Statistics Annual Survey, Earned Degrees Conferred.

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Table 2.17 EARNED MASTER'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1980

(Percent Distribution)

Field of Science	Academic Year Ending																				
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
All Fields, Total	100																				
Total S&E	30.1	32.2	37.2	38.1	38.4	38.6	37.2	37.2	35.4	35.3	33.9	32.5	31.6	31.3	30.9	30.7	30.6	30.4	30.3	30.2	30.1
Natural Science	11.4	12.2	12.4	12.5	12.5	12.3	11.4	11.3	10.6	10.8	10.1	9.3	8.8	8.6	8.4	8.3	8.2	8.1	8.1	8.0	7.9
Engineering	9.2	10.0	10.1	10.1	10.3	10.3	9.8	8.9	8.6	7.9	7.5	7.1	6.7	6.4	6.2	6.0	5.9	5.8	5.7	5.6	5.6
Social Sciences	9.5	9.9	14.7	15.4	15.7	16.0	16.0	16.4	16.2	16.6	16.3	16.1	16.2	16.3	16.3	16.4	16.5	16.5	16.5	16.6	16.6
Science & Engineering, Total .	100																				
Life Sciences	15.9	15.1	13.2	12.4	12.3	11.7	12.0	12.1	12.4	12.0	11.3	10.9	11.1	11.0	11.0	11.0	10.9	10.9	10.9	10.8	10.8
Physical Sciences	14.4	14.4	11.9	11.3	11.2	10.9	9.5	9.2	8.8	8.6	8.4	8.3	7.8	7.6	7.4	7.2	7.1	7.0	6.9	6.8	6.7
Mathematics	7.5	8.5	8.1	9.1	8.9	9.3	9.1	9.0	8.8	8.4	8.0	6.9	6.6	6.5	6.5	6.4	6.4	6.3	6.3	6.3	6.2
Computer Sciences	-	-	-	-	-	-	-	-	-	1.5	2.1	2.1	2.3	2.4	2.4	2.4	2.5	2.5	2.6	2.6	2.7
Engineering	30.6	31.1	27.2	26.6	26.8	26.8	26.2	23.8	24.4	22.5	22.3	21.9	21.0	20.3	19.9	19.6	19.3	19.0	18.8	18.7	18.5
Psychology	6.0	6.5	5.6	5.3	5.1	4.8	4.6	4.9	5.2	5.5	5.6	5.9	6.7	6.7	6.8	6.8	6.9	6.9	6.9	6.9	6.9
Social Sciences	23.5	24.3	34.0	35.2	35.7	36.5	38.5	39.2	40.5	41.6	42.4	43.7	44.3	45.3	46.0	46.6	47.0	47.3	47.6	47.9	48.2

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.15.

Table 2.18 EARNED MASTER'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1972

(Percent Distribution)

Field of Science	Academic Year Ending												
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
All Fields, Total	100												
Total S&E	26.9	29.1	29.6	29.9	29.9	30.2	27.1	26.5	25.6	24.9	23.6	21.9	21.2
Natural Science	12.0	12.9	13.3	13.3	13.4	13.5	11.8	11.8	11.2	11.0	10.3	9.3	8.9
Engineering	9.6	10.4	10.5	10.5	10.7	10.7	9.7	8.8	8.6	7.8	7.4	7.1	6.6
Social Sciences	5.3	5.7	5.8	6.1	5.9	5.9	5.5	5.9	5.8	6.0	5.8	5.5	5.7
Science & Engineering, Total . .	100												
Life Sciences	18.7	17.9	18.6	17.2	17.7	17.7	17.5	17.9	18.3	18.2	17.4	16.4	16.6
Physical Sciences	16.9	16.7	15.6	15.1	15.1	14.5	13.1	12.9	12.1	12.2	12.1	12.6	11.8
Mathematics	8.8	9.8	10.7	12.1	11.9	12.3	12.5	12.6	12.2	11.8	11.4	10.3	9.7
Computer Sciences	-	-	-	-	-	0.4	0.6	1.1	1.2	2.1	3.0	3.1	3.7
Engineering	35.8	35.9	35.4	35.2	35.8	35.6	35.9	33.2	33.4	31.5	31.6	32.3	31.4
Psychology	7.0	7.5	7.3	7.0	6.8	6.6	6.6	7.5	7.7	8.3	8.4	8.8	9.9
Social Sciences	12.7	12.1	12.4	13.3	12.7	12.9	13.7	14.8	15.1	15.9	16.1	16.5	16.9

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.16.

Table 2.19 EARNED DOCTOR'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1980

Academic Year Ending	Total All Fields	Total Science and Engineering	Natural Sciences: Total	Life Sciences[1]	Physical Sciences	Mathematics	Computer Sciences	Engineering	Social Sciences: Total	Psychology	Other Social Sciences[2]
1960	9,829	6,511	3,602	1,661	1,335	303	-	786	1,923	641	1,282
1961	10,575	7,006	3,991	1,656	1,991	344	-	943	2,072	703	1,369
1962	11,622	7,745	4,432	1,914	2,122	395	-	1,216	2,097	781	1,316
1963	12,822	8,609	4,877	2,007	2,380	490	-	1,355	2,347	844	1,503
1964	14,490	9,725	5,344	2,293	2,455	596	-	1,705	2,[illegible]	939	1,728
1965	16,467	11,011	6,102	2,585	2,829	682	6	2,133	2,776	839	1,937
1966	18,237	12,103	6,659	2,813	3,045	782	19	2,315	3,129	1,037	2,092
1967	20,617	13,618	7,358	3,026	3,462	832	38	2,619	3,641	1,190	2,451
1968	23,089	15,097	8,160	3,584	3,593	947	36	2,933	4,004	1,232	2,772
1969	26,188	16,747	8,957	3,937	3,859	1,097	64	3,391	4,599	1,508	3,091
1970	29,866	19,022	9,948	4,293	4,312	1,236	107	3,691	5,383	1,620	3,763
1971	32,107	19,888	10,448	4,731	4,390	1,199	128	3,638	5,802	1,782	4,020
1972	33,330	20,060	10,010	[illegible],620	4,093	1,130	170	3,660	6,390	1,880	4,510
1973[e]	34,100	20,190	10,120	4,530	4,330	1,040	220	3,380	6,690	1,360	4,830
1974[e]	33,700	19,420	9,490	4,180	4,040	1,000	270	3,320	6,610	1,970	4,640
PROJECTIONS											
1975	34,900	19,760	9,380	4,250	3,820	970	340	3,340	7,040	2,150	4,890
1976	36,900	21,080	9,920	4,490	4,040	980	410	3,330	7,830	2,560	5,270
1977	39,200	21,420	10,040	4,680	3,930	880	500	2,940	8,440	2,830	5,610
1978	40,100	21,760	10,140	4,730	4,030	890	490	2,980	8,640	2,940	5,700
1979	40,200	21,820	10,170	4,750	4,040	890	490	2,980	8,670	2,950	5,720
1980	41,200	22,380	10,430	4,870	4,140	920	500	3,060	8,890	3,030	5,860
PERCENT CHANGE											
1960-65 . . .	68	69	60	56	54	125	-	171	44	31	51
1965-70 . . .	81	73	63	66	52	81	1683	73	94	93	94
1970-75 . . .	17	4	-6	-1	-11	-22	218	-10	31	33	30
1975-80 . . .	18	13	11	15	8	-5	47	-8	26	41	20
1964-74 . . .	133	100	78	82	65	68	-	95	147	110	262

[e] NCES estimates.

[1] Biological Science + Agriculture + Natural Resources.

[2] Social Science + Public Affairs & Services + Library Science.

Note: Data cover 50 States and District of Columbia.

SOURCE: National Center for Education Statistics, HEGIS, 1962-70 data; [illegible] of Educational Statistics to [illegible], 1974 edition, and 1960-61 data: Projections of Educational Statistics to [illegible], 1971 edition.

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Table 2.20 EARNED DOCTOR'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1972

Academic Year Ending	All All Fields	Total Science and Engineering	Natural Science					Engineering	Social Sciences		
			Total	Life Sciences	Physical Sciences	Mathematics	Computer Sciences		Total	Psychology	Other Social Sciences
1960	9,829	6,056	3,788	1,647	1,838	303	-	786	1,482	641	841
1961	10,575	6,531	3,981	1,646	1,991	344	-	943	1,607	703	904
1962	11,622	7,249	4,322	1,804	2,122	396	-	1,207	1,720	781	939
1963	12,822	8,055	4,778	1,908	2,380	490	-	1,378	1,899	844	1,055
1964	14,490	9,025	5,232	2,181	2,455	596	-	1,693	2,100	939	1,161
1965	16,467	10,252	5,991	2,474	2,829	682	6	2,124	2,137	847	1,290
1966	18,239	11,298	6,542	2,696	3,045	782	19	2,304	2,452	1,046	1,406
1967	20,621	12,759	7,232	2,900	3,462	832	38	2,614	2,913	1,231	1,682
1968	23,091	14,128	8,021	3,445	3,593	947	36	2,932	3,175	1,268	1,907
1969	26,189	15,839	8,799	3,779	3,859	1,097	64	3,377	3,663	1,551	2,112
1970	29,872	17,639	9,787	4,131	4,313	1,236	107	3,681	4,171	1,668	2,503
1971	32,113	18,466	10,252	4,534	4,391	1,199	128	3,654	4,560	1,782	2,778
1972	33,369	18,412	9,876	4,478	4,103	1,128	167	3,704	4,832	1,881	2,951
PERCENT CHANGE											
1960-65 . .	68	69	58	50	54	125	-	170	44	32	53
1965-70 . .	81	72	63	67	52	181	1683	73	95	97	94
1962-72 . .	187	154	129	148	93	184	-	207	181	141	234

Note: Data cover aggregate U.S.A., including outlying territories (Puerto Rico, Virgin Islands, etc.).

SOURCE: National Science Foundation compilation of data from the National Center for Education Statistics Annual Survey, Earned Degrees Conferred.

Table 2.21 EARNED DOCTOR'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1980

(Percent Distribution)

Field of Science	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	Academic Year Ending																				
All Fields, Total . . .							100														
Total S&E	66.2	66.3	66.6	67.1	67.1	66.9	65.4	65.1	65.4	65.7	63.7	61.9	60.2	59.2	57.6	56.6	57.1	54.6	54.3	54.3	54.3
Natural Sciences . . .	30.3	32.7	35.1	37.0	36.9	37.1	35.5	35.7	35.3	35.2	33.3	32.5	30.0	29.7	28.7	25.3	24.9	25.6	25.1	25.3	25.3
Engineering	8.0	8.9	10.5	10.8	11.5	11.0	12.7	12.7	12.7	12.9	12.4	11.3	11.0	9.9	9.9	9.6	9.0	7.5	7.4	7.4	7.4
Social & Behavioral Sciences . . .	19.6	19.6	18.0	18.3	18.5	16.9	17.2	17.7	17.3	17.6	18.0	18.1	19.2	19.6	19.6	20.2	21.2	21.5	21.5	21.6	21.6
Science & Engineering, Total							100														
Life Sciences	25.5	23.6	24.7	23.3	23.6	23.5	23.2	22.2	23.7	23.2	22.6	21.8	21.6	22.4	21.5	21.5	21.3	21.8	21.7	21.8	21.5
Physical Sciences . .	28.7	29.4	27.4	27.6	25.2	25.7	25.2	25.4	21.8	22.8	22.7	22.1	20.4	21.4	20.8	19.3	19.2	18.6	18.5	18.5	18.5
Mathematics	4.7	4.9	5.1	5.7	6.3	6.2	6.5	6.1	6.3	6.5	6.5	6.0	5.6	5.2	5.1	4.9	4.6	4.1	4.1	4.1	4.1
Computer Sciences . .	-	-	-	-	-	-	0.2	0.3	0.2	0.4	0.6	0.6	0.9	1.1	1.4	1.7	1.9	2.1	2.1	2.2	2.2
Engineering	12.1	13.5	15.7	16.1	17.5	19.4	19.1	19.2	19.4	20.0	19.4	18.3	18.2	16.7	17.1	16.7	15.5	[illegible]	13.7	13.7	13.7
Psychology	9.8	10.0	10.1	9.3	9.7	7.6	8.6	8.7	8.2	8.9	8.5	9.0	9.4	9.2	10.1	10.9	12.1	[illegible]	12.5	11.5	12.5
Social Sciences . . .	19.7	19.5	17.0	17.5	17.9	17.6	17.3	18.0	18.5	18.2	19.8	20.2	22.5	23.9	23.9	24.7	25.0	[illegible]	25.2	[illegible]	26.2

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.19.

Table 2.22 EARNED DOCTOR'S DEGREES IN SCIENCE AND ENGINEERING: 1960-1972

(Percent Distribution)

Field of Science	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
	Academic Year Ending												
All Fields, Total	100												
Total S&E	61.6	61.8	62.4	62.8	[illegible]	62.2	61.9	61.9	61.2	60.5	59.0	57.5	55.2
Natural Science	38.5	37.6	37.2	37.3	36.1	36.4	35.9	35.1	34.7	33.6	32.8	31.9	29.6
Engineering	8.6	8.9	10.4	10.7	11.7	12.9	12.6	12.7	12.7	12.9	12.3	11.4	11.1
Social Sciences	15.1	15.2	14.8	14.8	[illegible]	13.0	13.4	14.1	13.7	14.0	14.0	14.2	14.5
Science & Engineering, Total . .	100												
Life Sciences	27.2	25.2	24.9	23.7	24.2	24.1	23.9	22.7	24.4	23.9	23.4	24.6	24.3
Physical Sciences	30.4	30.5	29.3	29.5	27.2	27.6	27.0	27.1	25.4	24.4	24.5	23.8	22.3
Mathematics	5.0	5.3	5.5	6.1	6.6	6.7	6.9	6.5	6.7	6.9	7.0	6.5	6.1
Computer Sciences	-	-	-	-	-	-	0.2	0.3	0.3	0.4	0.6	0.7	0.9
Engineering	13.0	14.4	16.7	17.1	16.8	20.7	20.4	20.5	22.5	21.3	20.9	19.8	20.1
Psychology	10.6	10.8	10.8	10.5	10.4	8.3	9.3	9.6	9.0	9.8	9.5	9.7	10.2
Social Sciences	13.9	[illegible]	13.0	13.1	12.9	12.6	12.4	13.2	13.5	13.3	14.2	15.0	16.0

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.20.

Table 2.23 SCIENTIFIC AND ENGINEERING DEGREES AS PERCENTAGE OF TOTAL DEGREES GRANTED, BY LEVEL: 1960-72[1] and 1960-1980[2]

(Percent)

Academic Year Ending	NSF			NCES		
	Bachelor	Master	Doctor	Bachelor	Master	Doctor
1960 . . .	31	27	62	38	30	66
1961 . . .	30	29	62	37	32	66
1962 . . .	30	30	62	40	37	67
1963 . . .	30	30	63	41	38	67
1964 . . .	30	30	62	41	38	67
1965 . . .	31	30	62	41	39	67
1966 . . .	31	27	62	42	37	66
1967 . . .	32	26	62	43	37	66
1968 . . .	32	26	61	43	35	65
1969 . . .	32	25	60	43	35	65
1970 . . .	32	24	59	43	34	64
1971 . . .	31	22	58	42	32	62
1972 . . .	30	21	55	41	32	60
1973 . . .	-	-	-	41	31	59
1974 . . .	-	-	-	41	31	58
1975 . . .	-	-	-	41	31	57
1976 . . .	-	-	-	40	31	57
1977 . . .	-	-	-	40	30	55
1978 . . .	-	-	-	41	30	54
1979 . . .	-	-	-	41	30	54
1980 . . .	-	-	-	42	30	54

1 Based on NSF compilation.

2 Based on NCES data.

SOURCE: Market Facts, Inc., Center for Quantitat[illegible] Sciences. Taken from Tables 2.14, 2.18, 2.22 and 2.13, 2.17, 2.21.

Table 2.24 SCIENTIFIC AND ENGINEERING DEGREES BY LEVEL[1] AND FIELD OF SCIENCE[2] AS PERCENTAGE OF TOTAL SCIENTIFIC AND ENGINEERING DEGREES. 1960-1980

Academic Year Ending	Life Sciences			Physical Sciences			Mathematics			Computer Sciences			Engineering			Psychology			Social Sciences		
	B	M	D	B	M	D	B	M	D	B	M	D	B	M	D	B	M	D	B	M	D
1960 . . .	16		26	11	14	28	8	8	5	-	-	-	26	31	12	6	6	10	34	26	20
1961 . . .	15	15	24	10	14	28	9	9	5	-	-	-	24	31	14	6	6	10	35	24	20
1962 . . .	15	13	25	10	12	27	9	8	5	-	-	-	23	27	16	6	6	10	36	34	17
1963 . . .	15	12	23	10	[illegible]	28	10	9	6	-	-	-	21	27	16	6	5	10	38	35	18
1964 . . .	15	12	24	9	11	25	10	9	6	-	-	-	19	27	18	7	5	10	40	36	18
1965 . . .	16	12	24	9	11	26	9	9	6	-	-	-	19	27	19	7	5	8	41	36	18
1966 . . .	16	12	23	8	10	25	[illegible]	[illegible]	6	-	-	-	17	26	19	8	5	9	43	38	17
1967 . . .	16	12	22	7	9	[illegible]	[illegible]	[illegible]	6	-	-	-	16	24	19	8	5	9	44	39	18
1968 . . .	15	12	24	7	9	24	[illegible]	[illegible]	5	-	-	-	15	24	19	9	5	8	45	40	18
1969 . . .	15	12	23	7	[illegible]	22	[illegible]	8	[illegible]	-	-	-	14	22	20	9	6	9	46	42	18
1970 . . .	14	11	[illegible]	[illegible]	8	23	8	[illegible]	[illegible]	-	-	-	15	22	19	10	6	8	46	42	20
1971 . . .	14	11	[illegible]	[illegible]	8	22	7	7	6	1	2	1	14	22	18	11	6	9	48	44	20
1972 . . .	14	11	23	6	8	20	6	7	6	1	2	1	14	21	18	12	7	9	48	44	22
1973 . . .	14	11	22	[illegible]	8	[illegible]	6	6	5	1	2	1	12	20	17	12	7	9	48	45	24
1974 . . .	14	11	22	[illegible]		21	6	6	5	1	2	1	12	20	17	13	7	10	48	46	24
1975 . . .	[illegible]	11	22	5	7	19	6	6	5	1	2	2	10	20	17	14	7	11	49	47	25
1976 . . .	14	11	21	5	7	19	6	6	5	1	2	2	9	19	16	14	7	12	50	47	25
1977 . . .	14	11	[illegible]	5	7	19	6	6	4	2	2	[illegible]	9	[illegible]	14	15	7	13	49	47	26
1978 . . .	14	11	22	[illegible]	7	18	6	6	4	2	3	2	10	19	4	15	7	14	49	48	26
1979 . . .	13	11	22	5	7	18	6	6	6	2	3	2	[illegible]	19	14	16	7	14	48	48	26
1980 . . .	13	11	22	[illegible]	7	18	[illegible]	6	[illegible]	2	2	2	[illegible]	18	14	16	7	14	48	48	26

1
B= Bachelor's
M= Master's
D= Doctor's

2
National Center for Education Statistics (NCES) [illegible]

SOURCE: Market Facts, Inc., Center for Quantitative [illegible]. Taken from Tables 2.13, 2.17 and 2.21.

Computer Sciences, Psychology and Social Sciences have accounted for increasing proportions of all science and engineering degrees at each of the three degree levels and these trends will continue through 1980. At the doctorate level, life sciences, physical sciences, and psychology account for higher proportions of degrees than they do at lower levels.

The multitude of factors which encourage or discourage students and prospective students from continuing their education, and which influence their decisions about field of specialization will only be touched upon here. Needless to say, they are incorporated into the projections (for degrees) provided by NCES and (for supply and utilization) by the Bureau of Labor Statistics.

Our rationale for examining data on educational attainment is twofold. First, the shifts between fields of science (or between scientific fields and others) need to be identified to project the total numbers of scientists and engineers for future years. Although recognition should be made of the fact that shifts in field of employment do occur after formal education is complete (at least temporarily), the educational process is still by far the largest supplier of new scientific talent. Field choices in post-secondary education particularly can be expected to reflect awareness (on the part of counsellors, as well as students) of changes in: national policy which in turn influences the job market, income levels and costs of education, the availability of financial support for educational expenses, social pressures relating to the relative importance to society of certain skills, etc.

2.1.3 Scientific & Engineering Labor Force

The data on the history of and the projections for the labor force of scientists and engineers, to a large extent, is qualified by the same types of inconsistencies that affect the educational data. Over time, definitions for science/engineering have included more or less of the social scientists, medical scientists and technicians. Computer scientists are often shifted between engineering and mathematical fields (or not counted at all). In addition, the prime sources of national data (BLS, Census, NSF) provide totals based upon different points of view. BLS statistics on labor force show the number of employees (by field or occupation) from the viewpoint of the employers. The total number of (employed) scientists and engineers thus identified is not necessarily compatible with the number who identify themselves as being scientists and engineers, nor with the number of labor force participants who have degrees in science and engineering.

The growth in the numbers of scientists (including social scientists) and engineers over the past decade has been from an estimated 1.1 million to 1.8 million in 1970 and ? 0 million in 1975. The rates of increase observed over the past two decades show a steadily slowing trend. Employment of natural scientists and engineers increased 46 percent from 1950 to 1955, 36 percent over the next five years, 24 percent in the first half of the 60's and 17 percent in the last part of that decade. NSF currently estimates an annual rate of increase of 2.4 percent annually or 13 p rcent between 1970 and 1975. S/E employment grew at a faster rate than total employment through 1970. The number of natural scientists and engineers per 10,000 civilian employees was less than 100 in 1950, 168 by 1960, and just over 200 in 1970. At NSF's projected rates of increase the ratio may be estimated at about the same through 1975 and then decreasing by 198 to roughly 185.

Both NSF and BLS projections for the decade 1975-1985 note that the supply of new scientists and engineers will exceed utilization. The net effect is an anticipated increase in the proportion of employed scientists and engineers with advanced degrees. Whether this amounts to enrichment of the field or to underutilization, the phenomenon is the same. In considering the generation of scientific and technical information, this phenomenon is particularly significant as it is generally believed that doctoral degree holders are more likely to produce more recorded information than those with less advanced degrees. However, the potential effect may be tempered by the fact that decreasing college enrollments also mean fewer academic jobs, and scientists/engineers employed in these positions also tend to be high producers of recorded information.

Employed natural scientists and engineers have made up about 2 percent of total employment since the mid-sixties and this proportion is projected to remain fairly constant through 1985. However, there are strong indications that scientists and engineers in the early 1980's will have more education than currently; more will have Ph.D's. There are presently approximately 2,000,000 employed scientists and engineers (depending somewhat upon which scientific fields are included).

Three primary sources of data are available from which to make estimates and projections. All three break out the fields of science somewhat differently and definitions and totals are not fully comparable. The first, which provides data for even years up through 1970, is the national Register of Scientific and Technical Personnel which was maintained by the National Science Foundation. Secondly, NSF supports the Roster of Doctoral Scientists and Engineers, maintained by the National Research Council. A survey of a sample of the 272,000 individuals on the Roster was conducted in 1973. In 1972 and 1974, the Census Bureau surveyed a sample of people who had been identified in the 1970 decennial census as being in specified scientific or engineering occupational groups. This survey is intended to be continued biennially.

The rates of growth of employment in scientific and engineering fields are compared here with rates of growth for total employment, and with employment of professional and technical workers. In addition, the availability of data for doctoral scientists allows special consideration of this group.

It appears to be generally true that each successive series of estimates and projections for employment in all of the categories mentioned in the proceeding paragraph, tend to be revised [illegible]ward. The same is true of estimates and projections for population (S[illegible] and II), college enrollment, degrees granted and labor force. Because all such estimates and projections are based partially upon assumptions about the trend in birth rates, they cannot be considered completely independent of each other in terms of magnitude of numbers of people involved in each category. However, relationships between the various subgroups of employed persons (for example, the proportion of total employment which consists of scientists and engineers) can still provide indications of trends.

Definitional problems become severe when attempts are made to compare data from different sources. The fields of scientific endeavor which are included in one set of data are not consistent with those covered in others. In addition, the assumptions concerning what constitutes a "scientist" (independent of field) vary, in some cases due to inconsistencies between training and employment categories. "Natural Scientists", a classification used by NSF, Census and BLS, only sometimes includes mathematics and statistics. In some series scientists and technicians are grouped together, in others scientists and engineers, while data on scientists alone may also be presented. In addition, data sources must be considered. Statistics collected from employers regarding the number of employees in certain occupations differ from those collected from employees themselves.

Any examination of trends in employment is necessarily coupled with trends in education and as a result leads to comments concerning anticipated "enrichment". Whether the expected increased educational level foreseen by scientific and technical personnel (including academicians) is in fact an improvement ("enrichment") or whether it is actually "underutilization" is a semantic argument as the phenomenon is the same. Consensus of opinion exists that it will occur over the next decade.

The process of creating estimates for S/E labor force for the eight (excluding "Other") NSF specific fields of science is a risky business. Generally, it is considered by manpower statisticians to be something which for valid reasons cannot be done. Shifts between fields are known to be occurring annually both in terms of the definitional boundaries used by different data series and also by the scientists and engineers themselves. Individual professional identity may not be the same as educational background or as current employment. Classifications used by surveys of employers and surveys of employees are based upon objectives sufficiently disparate as to preclude consistent definitions of scientific field. A reasonable assumption is that shifts between disciplines are more likely to occur between closely related sub-specialties or between specialties and multi-disciplinary fields. Very little study has been devoted to these shifts. The literature reveals a bias toward the belief that S/E's who move to a field of "non-S/E" do not return. We were unable to uncover documentation to support this belief, however.

In estimating S/E labor force between 1960 and 1980, a number of arbitrary decisions were applied to existing data. These are described below for each of the seven fields of science plus engineering. In all cases, the reader is referred to the source data for specific caveats, survey methodologies, and definitional distinctions which are sufficiently lengthy to make their full disclosure here impractical. The Bureau of Labor Statistics provides widely quoted data on employed natural scientists and engineers through 1970 (27). These data were used for the years 1960-1970 in the accompanying table (2.25). In addition, sub-fields were broken out of Physical Science and Life Science in order to create a category for "Environmental Science". This may well be an artificial discipline anyway and it should be noted that NSF in its educational statistics does not identify such a category. However, Census does in its current survey. The decision to create this category from a subset of geologists/geophysicists and other physical scientists may underestimate the category to the extent that chemists and physicists are involved in environmentally oriented occupations. The number of environmental scientists is the number of geologists/geophysicists listed by BLS plus 25 percent of other physical scientists. (The remaining 75 percent were added to physicists and chemists to obtain Physical Sciences estimates). That proportion was chosen to be in line with the number of meteorologists listed in NSF's National Register of Scientific and Technical Manpower (92, 93, 94, 95, 96). Although oceanographers were not counted separately for the decade 1960-70, the totals arrived at for 1970 carry forward into BLS 1972 data summing geologists, meteorologists and oceanographers. Also ignored in these totals are life scientists involved in environmental fields. For the years 1972-85, BLS '72 estimates and projected rates of increase were used.

The '60-'70 scientist and engineer population covered in the employment data above specifically excludes social scientists and psychologists, and also (with the likely exception of computer engineers) computer scientists. Data for the number of scientists and engineers between '72 and '80 are derived from the BLS estimates for 1972 and 1985 and average annual rates of increase. In most cases, a number of categories were summed to create groupings resembling the NSF fields of science and flat rates of increase applied through 1980. Thus any erratic changes between 1972 and 1980 are submerged by the methodology.

Table 2.25 SCIENTIFIC AND ENGINEERING LABOR FORCE ESTIMATES, BY FIELD OF SCIENCE: 1960-1980

(Thousands)

Year	Eng.	Natural Science[1] Total	Maths.	Life Sciences	Phys. [illegible]	[illegible][1]	Total Eng. & Nat. Sciences[1]	Comp. [illegible][2]	Soc. [illegible][3]	Psych.[3]	TOTAL
1960 . . .	801	303	34	97	146	26	1104	-	34	21	1159
1961 . . .	833	318	36	103	152	27	11[illegible]		36	23	1210
1962 . . .	873	337	40	112	159	27	1210	-	37	25	1272
1963 . . .	923	358	44	120	165	29	1281	-	39	26	1346
1964 . . .	946	382	47	130	174	30	1327	-	41	28	1396
1965 . . .	970	396	50	137	1[illegible]	32	1367	3	42	30	1442
1966 . . .	1000	415	54	147	184	34	1419	7	44	32	1501
1967 . .	1038	439	62	151		26	14[illegible]	16	50	35	1578
1968 . . .	1062	463	67	159	19[illegible]	37	1525	24	58	37	1649
1969 . .	1085	483	73	166	202	38	1568	55	61	41	1725
1970	1098	476	74	173	209	40	1595	94	64	44	1797
1971 . . .	1099	506	75	177	214	40	1605	98	80	51	1834
1972 . . .	1100	515	76	180	219	40	1615	103	96	57	1871
1973 . . .	1130	528	78	184	224	42	1658	108	95	59	1923
1974 . . .	1160	539	80	187	229	[illegible]	1[illegible]	113	100	61	1973
1975 . . .	1192	551	82	191	234	44	1743	118	102	63	2026
1976 . . .	1224	565	85	195	240	45	1789	123	104	65	2081
1977 . . .	1257	5[illegible]	87	199	2[illegible]	46	18[illegible]	129	107	68	2138
1978 . . .	1291	590	89	203	[illegible]	47	1881	135	109	70	2195
1979 . . .	1326	604	92	207	[illegible]	48	1930	141	[illegible]	73	2255
1980 . . .	1361	617	94	212	2[illegible]	49	1978	1[illegible]	[illegible]	75	2314
PERCENT CHANGE											
1960-65 .	21	31	47	41	21	23	24	-	20	4[illegible]	
1965-70 .	13	25	48	26	18	25	17	-	52	47	
1970-75 .	9	11	11	10	12	10	9	18	59	43	13
1975-80 .	14	12	15	10	12	11	13	25	11	19	14
1960-80 .	37	64	118	[illegible]	63	54	44	-	88	110	64

[1] Underestimated [illegible] the proportion of life scientists who should be included.

[2] 1960-70 computer scientists are estimated [illegible] of [illegible] [illegible] granted.

[3] Social Sciences [illegible] 1960-1970 [illegible] 1970 [illegible] increase [illegible] by the number of [illegible]

[4] 1965 [illegible] and Natural [illegible] Statistics figures [illegible] in NSF publications.

[illegible]

For some fields, especially Psychology and Social Sciences, the jump from 1970-1972 is probably more dramatic than reality warrants. Rather than the rate of increase being excessively large over the two year period, it is more reasonable to assume that either the '60-'70 data is underestimated, or the '72-'80 series is over stated. Almost the reverse appears to be true with engineering estimates, where growth from '70-'72 appears to be smaller than might reasonably be expected.

Number of Scientists and Engineers

Since scientists and engineers are both producers and users of scientific and technical publications we will show that the number of articles produced and the number of uses of these publications are highly correlated to the number of scientists and engineers. Thus, this number is significant for projecting future production and use since the number of scientists and engineers is not expected to grow as rapidly as in the past. This section provides estimates of the number of scientists and engineers by field from 1960 through 1975 and projections through 1980.

Our estimates of number of scientists and engineers are based on an analysis of secondary sources generated by the National Science Foundation, the U.S. Department of Labor, and the U.S. Census Bureau. There are discrepancies in coverage and in definition among these sources of data and, therefore, we have had to make judgments and adjustments to create reasonably consistent information.

Estimates of the number of scientists and engineers are given in Table 2.25 and Figure 2.5. The Natural Science fields (Mathematics, Life Sciences, Physical Sciences, Environmental Sciences) are given as a subtotal. This total is considered more accurate than that for the individual natural sciences. The overall total does not include field nine ("Other Sciences") except as these persons are distributed among the other fields. The projections of 1972 to 1980 data are made by summing Bureau of Labor Statistics projections for 1985 in sub-fields, and applying average annual rates of increase.

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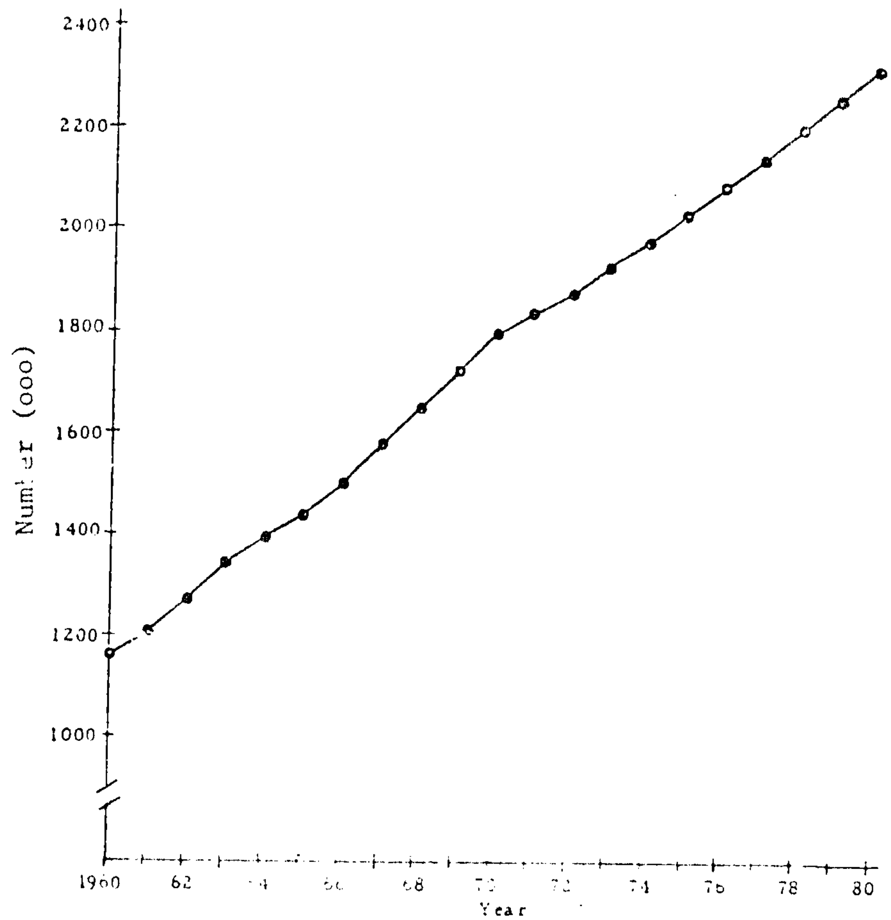
Figure 2.5: ESTIMATED NUMBER OF SCIENTISTS AND ENGINEERS: 1960-1980



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

The small, undetermined number of persons engaged in the field of Computer Sciences in 1960 had increased greatly to an estimated 118,000 persons by 1975. The fields of Mathematics and Psychology increased by over one hundred percent from 1960 to 1975. It is demonstrated in Section 3 that the rapid increase of scientists in these latter fields was not necessarily accompanied by a similar increase in published scientific and technical articles. Research and Development funding levels also had some influence on the production of published articles. The funding levels are discussed in Section 2.2.

R&D and non-R&D Employment

The proportions of total scientists and engineers who are employed in R&D is of primary importance as they are assumed to be producing the bulk of scientific and technical research information.

R&D scientists/engineers as a percent of total S/E's employed peaked between 1964 and 1967 at almost 38 percent. Decreasing percentages were then observed through 1970. However, these proportions, as reported by NSF, are based on "natural" scientists and engineers (thus excluding social scientists at least) and full-time equivalents. In addition, state and local government R&D employment is not included. Whether or not with the addition of social scientists, R&D employment would fail to show such a decrease remains unanswered. In order to provide estimates for total R&D employment, however, these proportions are applied to the Market Facts, Inc. estimate for the total S/E labor force in Table 2.26.

The National Science Board's Science Indicators 1972 (91) (an update of which is expected within the next few months) and NSF's National Patterns of R&D Resources (102) annual series address most of the trends in R&D employment particularly, and only highlights and some potential projections will be attempted here.

Although approximately one-third of all scientists and engineers are employed in R&D activities the proportion is higher, just over 50 percent in 1972 (97), for doctoral degree holders. In addition there are substantial differences among the fields of sciences for Ph.D's., but only minor differences among fields for non-Ph.D's. Of the 617,000 natural scientists and engineers employed in R&D in 1973, slightly less than 20 percent held doctorates. Two-thirds of all doctoral scientists were doing research.

Employment by Sector and Field of Science

The distribution of R&D scientists and engineers by type of employer has changed little over the past 15 years during which industry has been the major employer, accounting for more than two-thirds. Federal

Table 2.26 TOTAL SCIENTISTS AND ENGINEERS AND R&D SCIENTISTS AND ENGINEERS: 1960-1980

(Thousands)

Year	Total	R&D	R&D as Percent of Total*
1960 . . .	1,159	406	35.0
1961 . . .	1,210	431	35.6
1962 . . .	1,272	464	36.5
1963 . . .	1,346	499	37.1
1964 . . .	1,396	524	37.5
1965 . . .	1,442	541	37.5
1966 . . .	1,501	557	37.1
1967 . . .	1,578	592	37.5
1968 . . .	1,649	597	36.2
1969 . . .	1,725	604	35.0
1970 . . .	1,797	604	33.6
1971 . . .	1,834	607	33.2
1972 . . .	1,871	610	32.6
1973 . . .	1,923	617	32.1
1974 . . .	1,973	623	31.6
1975 . . .	2,026	630	31.1
1976 . . .	2,081	637	30.6
1977 . . .	2,138	644	30.1
1978 . . .	2,195	650	29.6
1979 . . .	2,255	656	29.1
1980 . . .	2,314	662	28.6

* 1960-1970 data from Science Indicators 1972, 1973 edition, National Science Board, National Science Foundation.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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employment ranged from 12 to 16 percent and academic institutions 10 to 13 percent. State governments employed about 4,900 S/E's in R&D activities in 1973.

Engineers made up more than two-thirds of the S/E labor force in 1960, and a slightly smaller proportion in 1970 and 1975. However, a much smaller, although growing, proportion of Ph.D's are engineers (8 percent in 1960, and 15 percent in 1970).

Distributions of the numbers of scientists and engineers by discipline are available from NSF for total population of S/E's, for total R&D employment, for R&D employment by sector, and by basic versus applied research versus development. Not all of the data can be combined in complete matrices as the definition of scientist may include only "natural" scientists or may specifically exclude social scientists. In some series psychology and social science are separated, while in others, they are combined. General trends, however, in terms of percent changes from year to year, are in agreement.

Other Factors Affecting Science & Engineering Labor Force

The size of scientist/engineer labor force, although primarily determined by the magnitude of the number of academic degrees granted, is also affected by field switching and immigration/emigration.

NSF estimates (105) indicate that approximately seven percent of net additions to doctorate science and engineering labor force consists of immigrants, and 12 percent of new science and engineering doctorate recipients intend to emigrate. What appears to be a net loss of S/E doctorate recipients is more than accounted for by the fact that one-fifth of these doctorate recipients are foreign citizens to begin with. In 1960, 8 percent of S/E's were doctorates, by 1970 the proportion had increased to 10 percent and is estimated for 1973 at 14 percent. The proportion is expected to continue to increase.

Field switching both internally within scientific and engineering fields and in and out of scientific fields is considerably more difficult to identify. Available data, for example, the results of the Census Bureau reports on the 1972 Professional, Technical and Scientific manpower survey (Technical Paper 33, Table 3.1) (20) indicates that something on the order of one-third of those in specified science and engineering occupations in 1970 indicated a professional identification two years later in a different field of science or engineering. One of the results of this finding, however, was a redefinition of scientists/engineers by field. The redefinition combined specified filtering criteria by field of education, employment and self-identification.

The precautions to be noted here are twofold. Degrees granted in a certain field provide only part of the new labor supply for that field and not all of the degree holders in a given field will pursue employment in that field. For most science and engineering fields, the higher the level of the degree obtained, the more likely that occupation and field of study will coincide.

In addition, in examining statistics on enrollments, degrees granted, employment, professional self-identification and so forth, it is absolutely necessary to be aware that not only do definitions of who is or is not a scientist/engineer vary according to a multitude of current definitions (and sources of data), but that the definitions from a given source vary over time. Part of this variation is, of course, due to the changing nature of science itself with emerging multi-discipline fields and subspecialties.

Salary Levels for Scientists and Engineers

The median salary for scientists and engineers in 1974 is estimated at $19,300 (23). This represents an increase since 1964 of 80 percent. Over the same decade, salaries for all (male) civilians increased 82 percent, while salaries for professional and technical workers rose by 91 percent during the same period.

The salaries of scientists and engineers have increased over the past 15 years even when stated in constant dollars. This phenomenon is probably due to the supply and demand of manpower in the scientific labor market. This may have a slight bearing on production of scholarly, scientific and technical articles when such production is related to research and development funding. Estimated median salaries for scientists in eight of the nine fields of science are given in Table 2.27 below. The table also gives projections to 1980 based on past rates of increase.

Median salaries of scientists and engineers more than doubled between 1960 and 1975. More significant, perhaps, is the fact that salaries have also increased after the Gross National Product (GNP) deflator has been applied. This increase is from $10,700 to $13,200 which is about 23 percent from 1960 to 1975. There does not appear to be a significant difference among the nine fields of science. The greatest increase was in psychology. The lowest salaries over the span of time appear to be in the life sciences.

1974, the most recent comprehensive data indicates that the fields of Engineering, Physical and Environmental Sciences, Mathematics, Psychology and Social Sciences all had medians higher than the scientific/engineering population on a whole. Estimates of individual fields for the 1960's are based upon the National Science Foundation American Science Manpower series (92, 93, 94, 95, 96). Estimates for Engineering, not included in the NSF series, are taken from Scientific and Technical Manpower Resources (110) for the early 1960's. The data is about ten percent higher than BLS salaries for technical engineers in 1962 and about five percent higher in 1972. For the years 1972 and 1974, data from the Census biennial surveys is used. There are obvious problems in combining data from several sources in this way, especially for individual fields of science. Each source tends to define inclusion within the field somewhat differently. In addition, an individual source frequently combines different specialties into scientific fields in a way which makes precise comparison over time difficult.

Some trends are apparent, nevertheless. If anything, salary increases shown here are on the conservative side. The assumption of conservatism is indicated by the fact that scientific and engineering salaries appear to have increased less over the last decade or so than have salaries for the total labor force.

Table 2.27 ESTIMATED MEDIAN SALARIES FOR SCIENTISTS AND ENGINEERS, BY FIELD OF SCIENCE: 1960-1980[1]

(Thousands of Dollars)

Year	Total Science & Engineering: Constant $[2]	Total Science & Engineering: Current $	Total Science & Engineering: Annual % Increase in Current $	Eng.	All Science	Math.	Comp. Sciences	Phys. Sciences	Environ. Sciences	Life Sciences	Psych.	Social Sciences
1960 . . .	10.7	9.4	-	9.6	9.0	9.0	8.8	9.9	8.9	8.8	8.0	9.5
1961 . . .	10.9	9.7	3.0	9.8	9.5	9.5	9.4	10.1	9.2	9.1	8.5	9.9
1962 . . .	11.1	10.0	3.1	10.0	10.0	10.0	9.9	10.3	9.6	9.3	9.0	10.4
1963 . . .	11.3	10.3	3.1	10.2	10.5	10.6	10.5	10.8	10.0	9.8	9.6	10.9
1964 . . .	11.5	10.6	3.1	10.5	11.0	11.1	11.2	11.3	10.4	10.3	10.3	11.4
1965 . . .	12.1	11.4	6.8	11.3	11.5	11.6	11.8	11.7	10.9	10.9	10.9	11.9
1966 . . .	12.5	12.1	6.8	12.2	12.0	12.1	12.6	12.2	11.5	11.5	11.5	12.5
1967 . . .	12.8	12.8	5.1	12.9	12.6	12.6	13.3	12.9	12.2	12.0	12.3	12.9
1968 . . .	12.9	13.4	5.1	13.5	13.2	13.2	14.1	13.6	12.9	12.6	13.2	13.3
1969 . . .	13.1	14.3	6.3	14.4	14.1	13.9	15.2	14.5	13.9	13.5	14.1	13.9
1970 . . .	13.1	15.1	5.9	15.2	15.0	14.6	16.5	15.5	14.9	14.5	15.0	14.5
1971 . . .	13.2	15.9	5.0	16.0	15.5	15.3	16.4	15.9	16.0	14.6	16.0	15.6
1972 . . .	13.4	16.6	4.7	16.9	16.1	16.1	16.2	16.4	17.3	14.7	17.0	16.3
1973 . . .	13.6	17.9	7.9	18.1	17.5	17.8	17.3	17.9	18.6	16.2	18.2	18.1
1974 . . .	13.3	19.3	7.8	19.4	19.1	19.8	18.4	19.5	20.1	17.8	19.4	20.2
PROJECTIONS												
1975 . . .	13.2	20.8	8.0	21.0	20.6	21.4	19.9	21.1	21.7	19.2	21.0	21.8
1976 . . .	13.3	22.4	7.5	22.5	22.2	23.0	21.4	22.6	23.3	20.7	22.5	23.3
1977 . . .	13.3	24.0	7.0	24.1	23.7	24.6	22.9	24.2	25.0	22.1	24.1	25.1
1978 . . .	13.3	25.5	6.5	25.7	25.3	26.2	24.3	25.8	26.6	23.5	25.7	26.7
1979 . . .	13.2	27.1	6.0	27.2	26.8	27.8	25.8	27.3	28.2	25.0	27.2	28.3
1980 . . .	13.1	28.6	5.5	28.7	28.3	29.3	27.2	28.9	29.7	26.3	28.7	29.9
PERCENT CHANGE												
1950-65 . .	13	21		18	28	29	34	18	22	24	36	25
1965-70 . .	8	32		35	30	26	40	32	37	33	38	22
1970-75 . .	1	38		38	37	47	21	36	46	32	40	50
1975-80 . .	-1	38		37	32	37	37	37	37	37	37	37
1964-74 . .	16	82		85	74	78	64	73	93	73	88	77

[1] Per capital disposable personal income is roughly proportional to S&E salaries over the entire period (20.5% in '60, 22.0% in '68, 23.0% in '72). BLS estimate of per capita DPI in 1980 is $6,146. At the 22% rate, S&E salaries would be $29.8 in 1980, and at 23%, $26.5.

[2] Using GNP implicit price deflator (1975-80, NPA) to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences, based upon NSF published data (except for projections).

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Projections through 1980 are likely to be even more conservative. For the initial projection year, 1975, a rate of increase of 8 percent is used, as other indicators of CPI and GNP appear to be of that magnitude. Discussion of anticipated economic activity and employment for the remainder of the current decade point fairly consistently to a slight tapering off of current levels of growth by the end of the decade. For this reason decreasing annual rates of increase are used to arrive at projected salaries for 1980. All fields of science are projected at the same rates, as patterns since 1962 do not indicate any consistent relationships or differences in rates of increase for different fields.

Rates of increase may be expected to differ over the last half of the decade, depending upon national direction and emphasis on such things as energy and environmental policy.

Median salary levels for Federally employed scientists and engineers are somewhat higher and those for educational institutions somewhat lower. Ph.D. salaries were about 6 percent higher in 1973. Salaries for Ph.D. scientists and engineers and/or for those employed by academic institutions may be of more interest in terms of the costs of generating information as these groups have a higher publishing rate than the overall group.

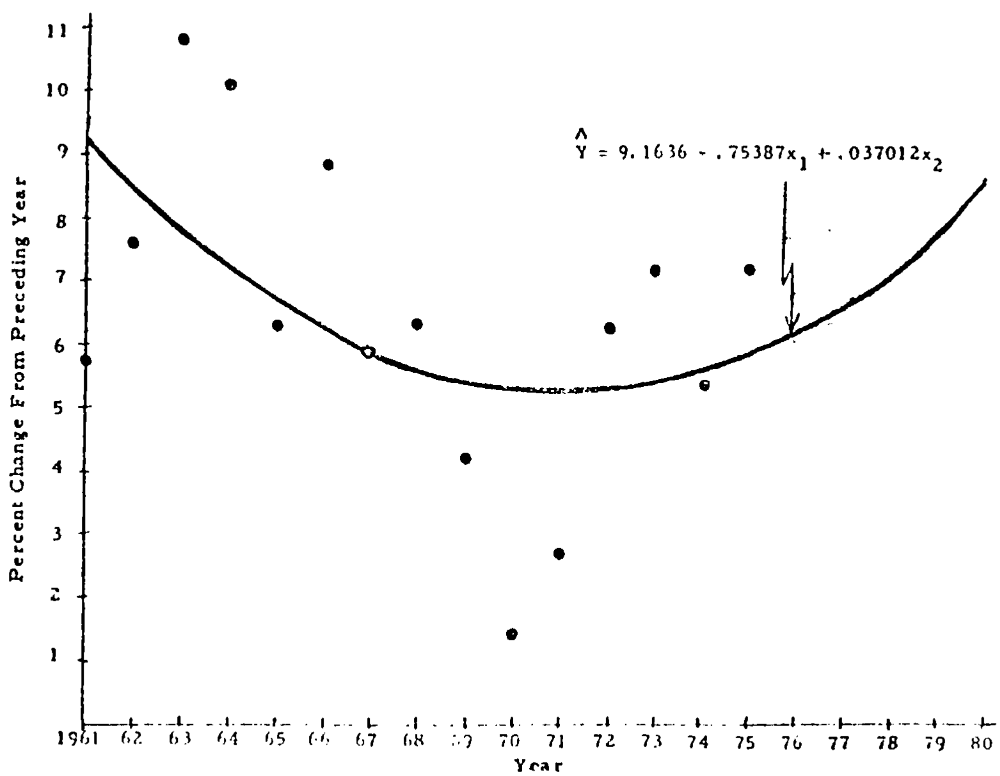
2.2 Financial Resources: Research and Development

NSF's own publications provide some of the best sources for trend data in terms of financial resources input to the generation of scientific and technical information. These are primarily R&D expenditures, since "...the increase in the bulk of publication correlates more nearly with research and development expenditures than with manpower figures" (59).

Funds for R&D constitute two to three percent of GNP. The peak of three percent was reached in 1964. Since then the percentage slowly but steadily declined to 2.3 percent in 1974. These data are provided for reference at the end of this section in Table 2.47 (see page 91).

Data on research and development funding in this section are in terms of actual current dollar funds and constant 1967-dollar funds. The GNP implicit price deflator is used as a basis for computing constant 1967 dollars. Tables 2.28 and 2.29 give funds (in current and constant dollars respectively) used for R&D and distributed to basic research, applied research and development. Projections through 1980 are also shown, as are rates of increase for five-year periods and for the most recent decade of data exclusive of the projected amounts. Both sets of data are plotted in Figure 2.7. The projections for 1976 through 1980 for total funds are based upon a time series analysis of the rates of increase for current dollars from 1960 through 1975. A second order polynomial model was used with one value of x. The result is shown in Figure 2.6 below (r=.5). Amounts for Basic and Applied Research and Development were then projected as constant percentages of the total, using the average over 1971-75. Thus the projections assume that the distribution will remain constant.

Figure 2.6: ANNUAL RATE OF INCREASE IN TOTAL R&D FUNDS: 1961-1980



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

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Table 2.28 FUNDS USED FOR RESEARCH AND DEVELOPMENT: 1960-1980

(Millions of Dollars)

Year	Total R&D $	Basic Research $	Basic Research %	Applied Research $	Applied Research %	Development $	Development %
1960 . . .	13,551	1,183	8.7	3,057	22.6	9,311	68.7
1961 . . .	14,346	1,378	9.7	3,115	21.7	9,853	68.7
1962 . . .	15,426	1,695	11.0	3,727	24.2	10,004	64.9
1963 . . .	17,093	1,974	11.5	3,825	22.4	11,294	66.1
1964 . . .	18,894	2,301	12.2	4,238	22.4	12,355	65.4
1965 . . .	20,091	2,572	12.8	4,470	22.2	13,049	64.9
1966 . . .	21,894	2,825	12.9	4,747	21.7	14,322	65.4
1967 . . .	23,205	3,029	13.1	4,968	21.4	15,208	65.5
1968 . . .	24,669	3,286	13.3	5,356	21.7	16,027	65.0
1969 . . .	25,686	3,378	13.2	5,533	21.5	16,775	65.3
1970 . . .	26,047	3,548	13.6	5,892	22.6	16,607	63.8
1971 . . .	26,745	3,544	13.3	6,047	22.6	17,154	64.1
1972 . . .	28,402	3,705	13.0	6,272	22.1	18,425	64.9
1973 . . .	30,427	3,800	12.5	6,839	22.5	19,788	65.0
1974[e] . .	32,045	3,991	12.5	7,460	23.3	20,594	64.3
1975[e] . .	34,345	4,035	11.9	7,950	23.3	22,270	64.8
PROJECTIONS*							
1976 . . .	36,469	4,595	12.6	8,315	22.8	23,559	64.6
1977 . . .	38,867	4,897	12.6	8,862	22.8	25,108	64.6
1978 . . .	41,605	5,242	12.6	9,486	22.8	26,877	64.6
1979 . . .	44,761	5,640	12.6	10,206	22.8	28,916	64.6
1980 . . .	48,432	6,102	12.6	11,042	22.8	31,287	64.6
PERCENT CHANGE							
1960-65 .	48	117		46		40	
1965-70 .	30	38		32		27	
1970-75 .	32	15		[illegible]		34	
1975-80 .	41	49		[illegible]		40	
1960-75 .	71	59		79		71	

[e] NSF estimate.

* Market Facts, Inc., Center for Quantitative Sciences.

Note: Total amounts shown in projections are based upon a static distribution among the three categories. These totals are not the same as those shown on other tables due to different assumptions.

SOURCE: National Science Foundation, National Patterns of R&D Resources, 1953-1975 (NSF 75-307).

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Table 2.29 FUNDS FOR RESEARCH AND DEVELOPMENT: 1960-1980

(Millions of Constant 1967 Dollars)*

Year	Total R&D	Basic Research	Applied Research	Development
1960 . . .	15,427	1,347	3,480	10,600
1961 . . .	16,125	1,549	3,501	11,075
1962 . . .	17,148	1,854	4,143	11,120
1963 . . .	18,755	2,166	4,197	12,392
1964 . . .	20,411	2,486	4,578	13,347
1965 . . .	21,310	2,728	4,741	13,841
1966 . . .	22,594	2,915	4,899	14,780
1967 . . .	23.205	3,029	4,968	15,208
1968 . . .	23,718	3,159	5,150	15,409
1969 . . .	23,561	3,099	5,075	15,387
1970 . . .	22,648	3,085	5,123	14,440
1971 . . .	22,249	2,948	5,030	14,270
1972 . . .	22,857	2,982	5,047	14,828
1973 . . .	23,186	2,896	5,211	15,079
1974 . . .	22,152	2,759	5,157	14,236
		PROJECTIONS		
1975 . . .	21.725	2,584	5,054	14,087
1976 . . .	21,615	2,723	4,928	13,963
1977 . . .	21,578	2,719	4,920	13,940
1978 . . .	21,610	2,723	4,927	13,960
1979 . . .	21,850	2,753	4,982	14,115
1980 . . .	22,221	2,800	5,066	14,354
		PERCENT CHANGE		
1960-65 .	38	103	36	31
1965-70 .	6	13	8	4
1970-75 .	-4	-16	-1	-2
1975-80 .	2	8	-	2
1965-75 .	2	-5	7	2

* Using GNP implicit price deflator (1975-1980 NPA).

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.28.

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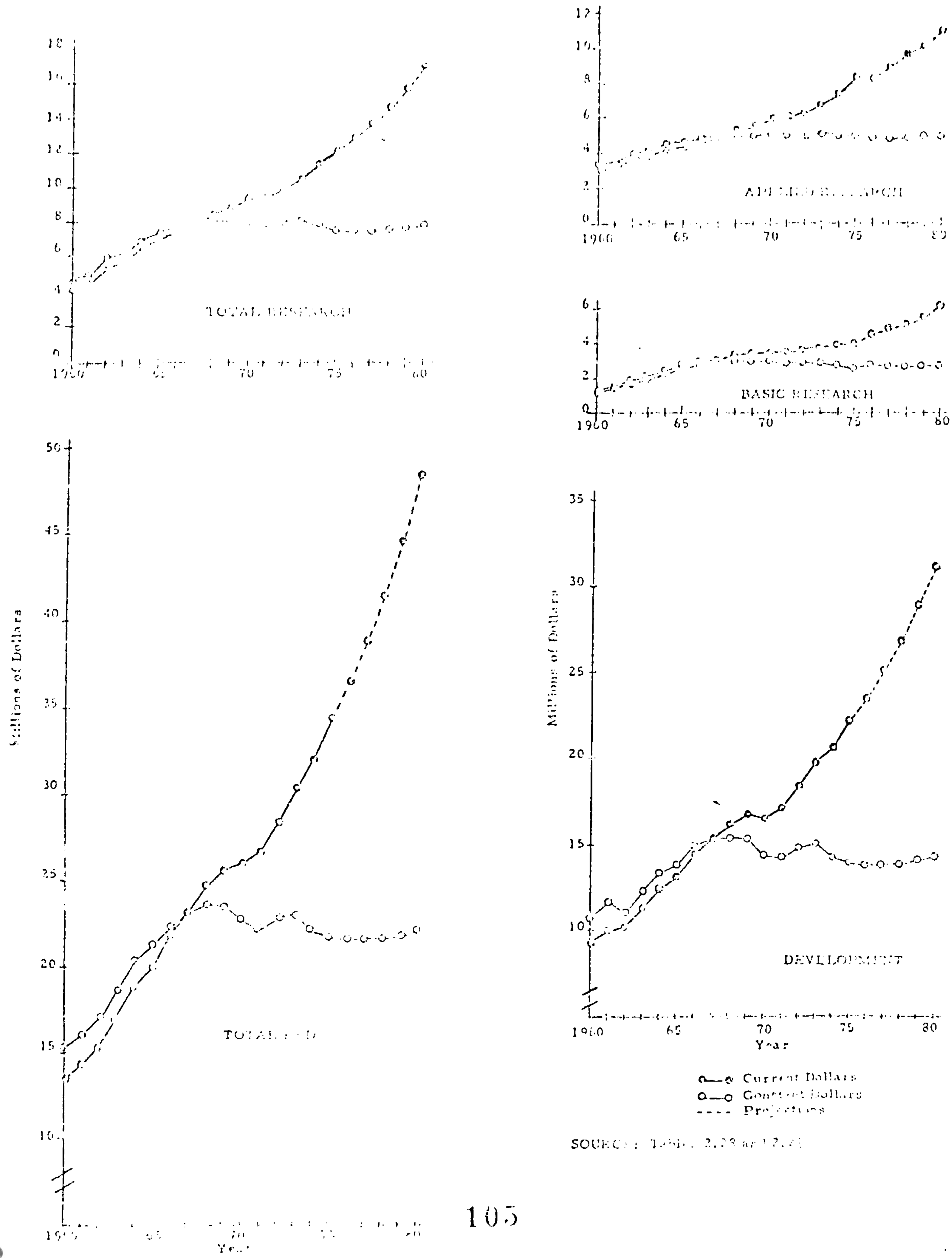
Figure 2.7 [illegible] AND DEVELOPMENT: 1960-1980



SOURCE: Tables 2.23 and 2.24

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Clearly the greatest increase in funding from 1965 to 1975 was in applied research. However, since 1970 all three areas have decreased in constant dollar funding, although these decreases are not projected to continue. The constant dollar total research and development funding level per R&D scientist/engineer has gone from $38,000 in 1960 down to $34,500 in 1975. Thus, funds available for scientists and engineers have decreased fairly dramatically. We feel that this factor may have had some impact on the number of articles produced per scientist and evidence would support this supposition. The problem is aggravated even more because salaries of scientists have increased faster than the GNP implicit price deflator. For example, median constant dollar salaries have risen from $10,700 in 1960 to about $13,200 in 1975.

2.2.1 Sources of Funds and Users of Funds

The relationship of sectoral source to use of funds illustrates the importance of the Federal government as the prime provider of research and development funds. Prior to 1969, Federal funds accounted for over 60 percent of R&D funding. By 1975 this proportion had decreased to 53 percent.

The data for R&D funding by sectoral use and source is shown in Table 2.30 in current dollars, in Table 2.31 in constant 1967 dollars and in Table 2.32, where the amounts provided and used are shown as percentages of total dollar funds. In order to provide projections for 1976 through 1980, we assumed that the changing distributions among sectors (for both source and use) would continue in the direction taken since 1966. The difference between the mean percent (from Table 2.32) for the two periods 1966-70 and 1971-75 was used as the projected increase for 1975-80. The projected percentage distributions were then applied to total R&D funds as previously projected by time analysis. The patterns of funding by sectors are not at all consistent and, therefore, must be considered independently if possible. Use patterns from 1960 to 1975 have also varied substantially by the different sectors. For example, funds used (constant dollar) by industry have increased less than one half of one percent over the decade 1965-1975 compared to funds used by universities and colleges which increased 14 percent although use in all sectors has decreased in the years 1970 to 1975.

Table 2.30 SOURCE OF FUNDS AND FUNDS USED FOR RESEARCH AND DEVELOPMENT, BY SECTOR: 1960–1980

(Millions of Dollars)

Year	Total	Federal Government Source	Federal Government Use	Industry Source	Industry Use	Universities & Colleges Source	Universities & Colleges Total Use	FFRDC[1] Use	Other Use	Other Nonprofit Institutions Source	Other Nonprofit Institutions Use
1960 . . .	13,551	8,752	1,726	4,535	[illegible]	147	1,006	360	646	142	310
1961 . . .	14,346	9,264	1,874	4,769	[illegible]	155	1,173	410	763	168	351
1962 . . .	15,426	9,926	2,035	5,114	[illegible]	[illegible]	1,374	470	904	201	490
1963 . . .	17,093	11,219	2,279	5,449	[illegible]	[illegible]	1,611	530	1,081	218	573
1964 . . .	18,894	12,553	2,835	5,880	[illegible]	235	1,904	629	1,275	226	640
1965 . . .	20,091	13,033	3,093	6,539	[illegible]	267	2,103	629	1,474	252	710
1966 . . .	21,894	13,930	3,220	7,317	[illegible]	[illegible]	[illegible]	630	1,715	284	781
1967 . . .	23,205	14,420	3,396	8,134	[illegible]	345	2,594	673	1,921	306	830
1968 . . .	24,669	14,952	3,493	8,997	[illegible]	[illegible]	2,868	719	2,149	329	979
1969 . . .	25,686	14,914	3,503	9,994	[illegible]	[illegible]	[illegible]	725	2,270	354	930
1970 . . .	26,047	14,764	3,855	10,434	[illegible]	461	3,072	737	2,335	388	1,058
1971 . . .	26,745	14,982	4,156	10,817	[illegible]	[illegible]	3,216	716	2,500	417	1,062
1972 . . .	28,402	15,875	4,482	11,508	[illegible]	576	3,439	764	2,675	443	1,110
1973 . . .	30,427	16,472	4,619	12,880	[illegible]	604	3,751	817	2,934	471	1,120
1974* . .	32,045	16,955	4,960	13,916	[illegible]	[illegible]	3,873	865	3,008	491	1,252
1975* . .	34,345	18,160	5,200	14,935	[illegible]	730	4,010	910	3,100	520	1,275
PROJECTIONS**											
1976 . . .	36,469	18,555	5,594	16,240	[illegible]	[illegible]	[illegible]	953	3,354	565	[illegible]
1977 . .	38,867	19,618	6,040	17,715	[illegible]	[illegible]	4,644	1,002	3,642	616	1,465
1978 . . .	41,605	20,532	6,649	19,399	[illegible]	[illegible]	5,028	1,058	3,970	675	1,579
1979 . . .	44,761	21,564	7,135	21,339	[illegible]	[illegible]	5,470	1,122	4,348	742	1,712
1980 . . .	48,432	22,764	7,817	23,596	[illegible]	1,252	5,984	1,196	4,788	820	1,866
PERCENT CHANGE											
1960–65 .	48	49	79	45	[illegible]	79	109	75	128	77	129
1965–70 .	30	[illegible]	25	60	[illegible]	73	46	17	58	54	49
1970–75 .	32	23	35	43	[illegible]	[illegible]	31	23	33	34	21
1975–80 .	41	25	50	58	[illegible]	72	49	31	54	58	46
1965–75 .	71	39	68	128	[illegible]	171	91	45	110	106	80

* NSF estimate.

** Market Facts, Inc., Center for Quantitative Sciences.

Note: Amounts shown for projections result from application of projections of distributions of funds by use and source.

[1] Federally Funded Research and Development Centers administered by universities and colleges. Expenditures administered by industry and other nonprofit institutions are included in the totals of their respective sectors.

SOURCE: National Science Foundation, National Patterns of R&D Resources [illegible]

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Table 2.31 SOURCE OF FUNDS AND FUNDS USED FOR RESEARCH AND DEVELOPMENT, BY SECTOR: 1960-1980

(Millions of Constant 1967 Dollars)*

Year	Total	Federal Government		Industry		Universities and Colleges				Other Nonprofit Institutions	
		Source	Use	Source	Use	Source	Total Use	FFRDC Use	Other Use	Source	Use
1960 . . .	15,427	9,964	1,965	5,132	11,964	170	1,145	410	735	162	353
1961 . . .	16,125	10,412	2,106	5,338	12,260	185	1,318	[illegible]	858	189	439
1962 . . .	17,148	11,034	2,332	5,685	12,743	206	1,527	522	1,005	223	543
1963 . . .	18,755	12,310	2,501	5,979	13,858	227	1,768	582	1,186	239	629
1964 . . .	20,410	13,561	3,066	6,352	14,597	254	2,057	679	1,377	244	691
1965 . . .	21,310	13,824	3,281	6,936	15,046	283	2,231	667	1,563	267	753
1966 . . .	22,594	14,438	3,323	7,551	16,045	313	2,420	650	1,770	293	806
1967 . . .	23,205	14,420	3,396	8,134	16,385	345	2,594	673	1,921	306	830
1968 . . .	23,718	14,376	3,358	8,650	16,757	376	2,757	691	2,066	316	845
1969 . . .	23,561	13,680	3,213	9,171	16,793	385	2,701	665	2,036	325	853
1970 . . .	22,648	12,837	3,352	9,072	15,705	401	2,671	641	2,030	337	920
1971 . . .	22,249	12,463	3,457	8,998	15,233	440	2,675	596	2,030	347	883
1972 . . .	22,857	12,776	3,607	9,261	15,589	464	2,768	615	2,153	357	893
1973 . . .	23,186	12,552	3,520	9,815	15,954	460	2,858	623	2,236	359	853
1974 . . .	22,152	11,721	3,387	9,620	15,226	472	2,677	598	2,079	339	865
1975 . . .	21,725	11,487	3,2[illegible]9	9,447	15,093	462	2,537	576	1,961	329	807
PROJECTIONS											
1976 . . .	21,615	11,175	3,316	9,625	14,938	479	2,553	564	1,988	335	808
1977 . . .	21,578	10,903	3,353	9,835	14,834	498	2,578	556	2,322	342	813
1978 . . .	21,610	10,664	3,453	10,076	14,776	519	2,612	549	2,062	351	820
1979 . . .	21,850	10,526	3,483	10,416	14,861	545	2,670	548	2,122	362	836
1980 . . .	22,221	10,444	3,586	10,826	15,033	574	2,745	549	2,197	376	856
PERCENT CHANGE											
1960-65 .	38	39	67	35	26	67	95	63	113	65	113
1965-70 .	6	-7	2	31	4	42	20	-4	30	26	22
1970-75 .	-4	-11	-2	4	-4	15	-5	-10	-3	-2	-12
1975-80 .	2	-9	9	15	-	24	8	-5	12	14	6
1965-75 .	2	-17	0	36	0	63	14	-14	25	23	7

* Using GNP implicit price deflator (1975-1980 NPA).

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.30.

Table 2.32 SOURCE OF FUNDS AND FUNDS USED FOR RESEARCH AND DEVELOPMENT: 1960-1980

(Percent Distribution)

Year	Total Dollars (Millions)	Federal Government		Industry		Universities and Colleges				Other Nonprofit Institutions	
		Source	Use	Source	Use	Source	Total Use	FFRDC Use	Other Use	Source	Use
1960 . . .	13,551	64.6	12.7	33.3	77.6	1.1	7.4	2.7	4.8	1.0	2.3
1961 . . .	14,346	64.6	13.1	33.1	76.0	1.2	8.2	2.9	5.3	1.2	2.7
1962 . . .	15,426	64.3	13.6	33.2	74.3	1.2	8.9	3.0	5.9	1.3	3.2
1963 . . .	17,093	65.6	13.3	31.9	73.9	1.2	9.4	3.1	6.3	1.3	3.4
1964 . . .	18,894	66.4	15.0	31.1	71.5	1.2	10.1	3.3	6.7	1.2	3.4
1965 . . .	20,091	64.9	15.4	32.5	70.6	1.3	10.5	3.1	7.3	1.3	3.5
1966 . . .	21,894	63.9	14.7	33.4	71.0	1.4	10.7	2.9	7.8	1.3	3.6
1967 . . .	23,205	62.1	14.6	35.1	70.6	1.5	11.2	2.9	8.3	1.3	3.6
1968 . . .	24,669	60.6	14.2	36.5	70.7	1.6	11.6	2.9	8.7	1.3	3.6
1969 . . .	25,686	58.1	13.6	38.9	71.3	1.6	11.5	2.8	8.6	1.4	3.6
1970 . . .	26,047	56.7	14.8	40.1	69.3	1.8	11.8	2.8	9.0	1.5	4.1
1971 . . .	26,745	56.0	15.5	40.4	68.5	2.0	12.0	2.7	9.3	1.6	4.0
1972 . . .	28,402	55.9	15.8	40.5	68.2	2.0	12.1	2.7	9.4	1.6	3.9
1973 . . .	30,427	54.1	15.2	42.3	68.8	2.0	12.3	2.7	9.6	1.5	3.7
1974 . . .	32,045	52.9	15.3	43.4	68.7	2.1	12.1	2.7	9.4	1.5	3.9
1975 . . .	34,345	52.9	15.1	43.5	69.5	2.1	11.7	2.6	9.0	1.5	3.7
PROJECTIONS											
1976 . . .	36,469	51.7	15.3	44.5	69.1	2.2	11.8	2.6	9.2	1.6	3.7
1977 . . .	38,867	50.5	15.5	45.6	68.7	2.3	11.9	2.6	9.4	1.6	3.8
1978 . . .	41,605	49.4	15.7	46.6	68.4	2.4	12.1	2.5	9.5	1.6	3.8
1979 . . .	44,761	48.2	15.9	47.7	68.0	2.5	12.2	2.5	9.7	1.7	3.8
1980 . . .	48,432	47.0	16.1	48.7	67.7	2.6	12.4	2.5	9.9	1.7	3.9

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.30.

Sources for R&D funds and funds used are further subdivided by type of research and by development in Tables 2.33 through 2.38. Projection methods were the same as those described for the preceeding set of tables. That is, the percent distributions were projected and the results applied to total R&D funds.

In terms of sources of funds, increasing proportions were allocated to basic research through 1970 by the Federal government and by universities and colleges. These increases were generally at the expense of funds for development. Industry and non-profit institutions other than universities and colleges showed opposite trends, with development funding tending to increase. There is a clear predominance of funding for development by the Federal government and by industry, while non-profit groups including educational institutions provide the largest proportion of their funds for basic research.

Tables 2.36 through 2.38 show the dollar amounts (current and constant) and distribution of funds used by sector for performance of research and development. Basic research activities clearly predominate only for universities and colleges, where they accounted for 53 percent in 1960 and peaked at 68 percent in 1971. Since then less emphasis appears to be placed on basic research and more emphasis on applied research, and this trend is projected to continue.

As might be expected industrial performance of R&D is heavily development oriented, with generally increasing proportions being applied to development primarily at the expense of basic research. The Federal government as a performer allocated an increasing proportion of the funds used to basic research between 1960 and 1970, although the proportion was not large, 17 percent in 1970. Projections to 1980 indicate that the decreasing proportion allocated to basic research since 1970 will account for only 11 percent by 1980, while both applied research and development will gain during the same period.

2.2.2 R&D Funding by Field of Science

The only consistent funding information by field of science is the Federal obligations for research and development. The data for R&D expenditures

Table 2.33 SOURCES OF FUNDS FOR BASIC RESEARCH, APPLIED RESEARCH AND DEVELOPMENT[1], BY SECTOR: 1960-1980

(Millions of Dollars)

Year	Federal			Industry			Universities and Colleges			Other Nonprofit Institutions		
	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel
1960 . . .	693	1,725	6,334	331	1,228	2,949	72	66	11	87	38	17
1961 . . .	841	1,804	6,619	350	1,197	3,202	85	69	11	102	45	21
1962 . . .	1,091	2,127	6,708	382	1,473	3,259	102	70	13	120	57	24
1963 . . .	1,310	2,205	7,704	414	1,487	3,543	121	72	14	129	61	28
1964 . . .	1,595	2,503	8,455	424	1,596	3,860	144	77	14	138	62	25
1965 . . .	1,817	2,653	8,563	448	1,638	4,433	164	88	15	143	71	38
1966 . . .	1,936	2,729	9,275	496	1,844	4,977	196	89	18	147	85	52
1967 . . .	2,173	2,874	9,373	477	1,895	5,762	223	102	20	156	97	53
1968 . . .	2,327	3,020	9,606	518	2,132	6,347	276	97	17	165	107	57
1969 . . .	2,336	2,982	9,546	519	2,327	7,152	298	105	17	175	119	60
1970 . . .	2,469	3,258	9,037	536	2,406	7,492	350	98	13	193	130	65
1971 . .	2,379	3,313	9,290	556	2,476	7,785	400	115	14	209	143	65
1972 . . .	2,528	3,387	9,960	528	2,601	8,379	428	132	16	221	152	70
1973 . . .	2,605	3,670	10,397	561	2,835	9,484	416	158	30	218	176	77
1974[e] . .	2,724	3,992	10,239	594	3,080	10,242	434	214	35	239	174	78
1975[e] . .	2,765	4,295	11,100	625	3,265	11,045	445	245	40	250	165	85
PROJECTIONS*												
1976 . . .	2,861	4,544	11,430	639	3,504	12,097	492	273	44	270	205	91
1977 . . .	3,011	4,321	11,806	653	3,772	13,290	544	305	48	292	227	97
1978 . . .	3,158	5,133	12,241	667	4,075	14,657	605	342	52	317	253	105
1979 . . .	3,328	5,488	12,745	681	4,422	16,237	674	384	58	346	283	113
1980 . . .	3,525	5,896	13,343	694	4,822	18,080	754	434	64	379	317	123
PERCENT CHANGE												
1960-65 . .	162	54	35	35	35	50	128	33	36	64	87	124
1965-70 . .	36	23	6	20	45	69	113	11	-13	35	83	71
1970-75 . .	12	32	23	17	36	47	27	250	208	30	42	31
1975-80 . .	27	37	20	11	48	64	69	77	60	52	71	45
1965-75 . .	52	62	30	40	97	149	171	178	167	75	161	124

[e] NSF estimate.

* Market Facts, Inc., Center for Quantitative Sciences.

Note: These projected amounts result from application of projection distribution shown on Table 2.35. Total amounts for Basic and Applied Research and Development do not add to projected amounts shown on other tables.

[1] See Table 2.30 for totals for R&D by sector.

SOURCE: National Science Foundation, National Patterns of R&D Resources, 1953-1975 (NSF 75-307).

Table 2.34 SOURCES OF FUNDS FOR BASIC RESEARCH, APPLIED RESEARCH AND DEVELOPMENT, BY SECTOR

(Millions of Constant 1967 Dollars)*

Year	Federal			Industry			Universities and Colleges			Other Nonprofit Institutions		
	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel
1960 . . .	789	1,964	7,211	377	1,398	3,357	82	75	13	99	43	19
1961 . . .	945	2,028	7,440	393	1,345	3,599	96	78	12	115	51	26
1962 . . .	1,213	2,364	7,457	425	1,637	3,623	113	78	14	133	63	27
1963 . . .	1,437	2,419	8,453	454	1,632	3,893	133	79	15	142	67	31
1964 . . .	1,723	2,704	9,134	458	1,724	4,170	156	83	15	149	67	28
1965 . . .	1,927	2,814	9,083	475	1,759	4,702	174	93	16	152	75	40
1966 . . .	2,050	2,816	9,572	512	1,903	5,136	202	92	19	152	88	54
1967 . . .	2,173	2,874	9,373	477	1,895	5,762	223	102	20	156	97	53
1968 . . .	2,237	2,904	9,236	498	2,050	6,102	265	93	16	159	103	55
1969 . . .	2,189	2,735	8,756	476	2,134	6,560	2[illegible]3	96	16	161	109	55
1970 . . .	2,147	2,833	7,858	466	2,092	6,514	304	85	11	168	113	57
1971 . . .	1,979	2,756	7,728	463	2,060	6,476	333	96	12	174	119	54
1972 . . .	2,034	2,726	8,015	425	2,093	6,743	344	106	13	178	122	56
1973 . . .	1,985	2,797	7,770	427	2,160	7,227	317	120	23	166	134	59
1974 . . .	1,883	2,760	7,078	411	2,129	7,030	300	148	24	165	120	54
1975 . . .	1,749	2,717	7,021	395	2,065	6,987	281	155	25	158	117	54
PROJECTIONS												
1976 . . .	1,708	2,693	6,775	379	2,077	7,170	292	162	26	160	122	54
1977 . . .	1,672	2,677	6,555	363	2,094	7,378	302	169	27	162	126	54
1978 . . .	1,640	2,666	6,358	346	2,117	7,613	314	178	27	165	131	55
1979 . . .	1,625	2,679	6,221	332	2,159	7,926	329	187	28	169	138	55
1980 . . .	1,617	2,705	6,122	318	2,212	8,295	346	199	29	174	145	56
PERCENT CHANGE												
1960-65	144	43	26	26	26	40	112	24	23	54	74	111
1965-70	11	43	13	-2	19	39	75	-9	-3[illegible]	11	51	43
1970-75	-19	-4	-11	-15	-1	7	-8	82	127	-6	4	-5
1975-80	-8	-	-13	-19	7	19	23	28	16	10	24	4
1965-75	-9	-3	-23	-17	17	49	62	67	56	4	56	35

*Using GNP implicit price deflator (1975-1980 NPA).

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.33

Table 2.35 SOURCES OF FUNDS FOR BASIC RESEARCH, APPLIED RESEARCH AND DEVELOPMENT, BY SECTOR: 1960-1980

(Percent Distribution)

Year	Federal (100)			Industry (100)			Universities and Colleges (100)			Other Nonprofit Institutions (100)		
	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel
1960 . . .	7.9	19.7	72.4	7.3	27.2	65.4	48.3	44.3	7.4	61.3	26.8	12.0
1961 . . .	9.1	19.5	71.4	7.4	25.2	67.4	51.5	41.8	6.7	60.7	26.8	12.5
1962 . . .	11.0	21.4	67.6	7.5	28.8	63.7	55.1	37.8	7.0	59.7	28.4	11.9
1963 . . .	11.7	19.7	68.7	7.6	27.3	65.1	58.5	34.8	6.8	59.2	28.0	12.8
1964 . . .	12.7	19.9	67.4	7.2	27.1	65.6	61.3	32.8	6.0	61.1	27.4	11.5
1965 . . .	13.9	20.4	65.7	6.8	25.4	67.8	61.4	33.0	5.6	56.7	28.2	15.1
1966 . . .	14.2	19.5	66.3	6.8	25.2	68.0	64.7	29.4	5.9	51.3	29.9	18.3
1967 . . .	15.1	19.9	65.0	5.9	23.3	70.8	64.6	29.6	5.8	51.0	31.7	17.3
1968 . . .	15.6	20.2	64.2	5.8	23.7	70.5	70.6	24.8	4.3	50.2	32.5	17.3
1969 . . .	16.0	20.0	64.0	5.2	23.3	71.5	71.0	25.0	4.0	49.4	33.6	16.9
1970 . . .	16.7	22.1	61.2	5.1	23.1	71.8	75.9	21.3	2.8	49.7	33.5	16.8
1971 . . .	15.9	22.1	62.0	5.1	22.9	72.0	75.6	21.7	2.6	50.1	34.3	15.6
1972 . . .	15.9	21.3	62.7	4.6	22.6	72.8	74.3	22.9	2.8	49.9	34.3	15.8
1973 . . .	15.8	22.3	61.9	4.4	22.0	73.6	68.9	26.2	5.0	46.3	37.4	16.3
1974 . . .	16.1	23.5	60.4	4.3	22.1	73.6	63.5	31.3	5.1	48.7	35.4	15.9
1975 . . .	15.2	23.7	61.1	4.2	21.9	74.0	61.0	33.6	5.5	48.1	35.6	16.3
PROJECTIONS												
1976 . . .	15.3	24.1	60.6	3.9	21.6	74.5	60.8	33.8	5.4	47.7	36.2	16.1
1977 . . .	15.3	24.6	60.1	3.7	21.3	75.0	60.7	34.0	5.3	47.4	36.8	15.8
1978 . . .	15.4	25.0	59.6	3.4	21.0	75.6	60.5	34.2	5.2	47.0	37.5	15.5
1979 . . .	15.4	25.5	59.1	3.2	20.7	76.1	60.4	34.4	5.2	46.6	38.1	15.3
1980 . . .	15.5	25.9	58.6	2.9	20.4	76.6	60.2	34.7	5.1	46.3	38.7	15.0

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.33.

Table 2.36 FUNDS USED FOR BASIC RESEARCH, APPLIED RESEARCH AND DEVELOPMENT[1], BY SECTOR: 1960-1980

(Millions of Dollars)

Year	Federal			Industry			Colleges & Universities: Total Universities and Colleges			Colleges & Universities: FFRDC[2]			Colleges & Universities: Other			Other Nonprofit Institutions		
	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel
1960 . . .	160	595	971	376	2,029	8,104	530	301	17	97	122	141	433	179	34	117	132	61
1961 . . .	206	634	1,034	395	1,977	8,536	651	327	[illegible]	115	135	160	536	192	35	126	177	88
1962 . . .	251	702	1,145	488	2,449	[illegible]	795	[illegible]	219	136	155	179	659	205	40	161	216	113
1963 . . .	299	730	1,250	522	2,457	[illegible]	[illegible]	[illegible]	241	159	170	201	814	227	40	180	241	152
1964 . . .	364	928	1,546	549	2,600	10,363	1,194	434	276	191	202	236	1,003	232	40	194	276	170
1965 . . .	[illegible]	1,030	1,639	592	2,658	10,935	1,348	483	274	208	204	217	1,138	279	57	210	299	201
1966 . . .	445	1,047	1,728	624	2,843	12,081	1,530	535	280	227	207	196	1,303	328	84	226	322	233
1967 . . .	472	1,102	1,822	629	2,915	12,841	1,707	593	294	250	219	204	1,457	374	90	[illegible]	358	251
1968 . . .	502	1,204	1,787	642	3,124	13,663	1,925	635	308	276	231	212	1,649	404	96	[illegible]	393	269
1969 . . .	565	1,201	1,737	618	3,287	14,403	1,982	616	347	275	210	240	1,707	406	107	[illegible]	429	288
1970 . . .	646	1,378	1,831	629	3,399	14,034	2,065	643	364	269	216	252	1,796	427	112	208	472	378
1971 . . .	535	1,477	2,144	610	3,384	14,317	2,174	684	358	260	210	246	1,914	474	112	[illegible]	502	335
1972 . . .	607	1,481	2,394	579	3,473	15,319	2,274	766	399	250	226	288	2,024	540	111	245	552	313
1973 . . .	585	1,613	2,421	605	3,759	16,573	2,355	931	465	297	226	294	2,058	705	171	255	536	329
1974[e] . .	635	1,834	2,431	640	4,025	17,355	2,442	1,005	426	291	271	303	2,151	734	[illegible]	274	596	382
1975[e] . .	655	1,955	2,590	660	4,370	18,830	2,490	1,060	460	305	280	325	2,185	780	135	280	605	390
PROJECTIONS*																		
1976 . . .	682	2,123	2,789	662	4,618	19,923	2,656	1,158	494	314	291	348	2,340	869	145	293	658	413
1977 . . .	712	2,315	3,014	664	4,898	21,157	2,843	1,268	533	325	303	374	2,515	971	156	307	719	440
1978 . . .	756	2,572	3,323	667	5,220	22,564	3,055	1,395	577	338	317	406	2,713	1,088	169	322	787	469
1979 . . .	782	2,786	3,566	672	5,586	24,188	3,299	1,542	628	352	332	438	2,940	1,224	184	341	867	504
1980 . . .	825	3,081	3,911	677	6,014	26,074	3,583	1,713	688	369	351	476	3,203	1,384	201	362	960	544
PERCENT CHANGE																		
1960-65 .	165	73	69	57	31	35	154	60	57	114	67	54	163	56	68	79	127	230
1965-70 .	52	34	12	6	28	28	53	33	33	29	6	16	58	53	96	-1	58	88
1970-75 .	1	42	41	5	29	34	21	65	26	13	30	29	22	83	21	35	28	3
1975-80 .	26	58	51	3	38	38	44	62	50	21	25	46	47	77	49	29	59	39
1965-75 .	54	90	58	11	64	72	85	119	68	47	37	50	92	180	137	33	102	94

[e] NSF estimate.

* Market Facts, Inc., Center for Quantitative Sciences.

Note: These projected amounts result from application of projection of distributions shown on Table 2.38. Total amounts for Basic and Applied Research and Development do not add to projected amounts shown on other tables.

[1] See Table 2.30 for totals for R&D by sector.

[2] Federally Funded Research and Development Centers administered by individual universities and colleges. Expenditures administered by Industry and other nonprofit institutions are included in the total of their respective sectors.

SOURCE: National Science Foundation, National Patterns of R&D Resources, 1953-1975 (NSF 75-307).

Table 2.37 FUNDS USED FOR BASIC RESEARCH, APPLIED RESEARCH AND DEVELOPMENT, BY SECTOR: 1960-1980

(Millions of Constant 1967 Dollars)*

Year	Federal			Industry			Colleges and Universities: Total Universities and Colleges			Colleges and Universities: FFRDC			Colleges and Universities: Other			Other Nonprofit Institutions		
	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel
1960 . . .	182	677	1,105	428	2,310	9,226	603	343	199	110	139	161	493	204	39	133	150	69
1961 . . .	237	713	1,162	444	2,222	9,594	732	368	219	129	152	180	602	216	39	142	199	99
1962 . . .	279	780	1,273	542	2,722	9,479	884	400	243	151	172	199	733	228	44	179	240	126
1963 . . .	328	891	1,372	573	2,696	10,569	1,067	436	264	174	187	221	893	249	44	197	264	167
1964 . . .	393	1,002	1,670	593	2,809	11,195	1,290	469	293	206	218	255	1,084	251	43	210	298	184
1965 . . .	450	1,092	1,738	628	2,819	11,598	1,430	512	291	221	216	230	1,207	296	60	223	317	213
1966 . . .	459	1 080	1,783	644	2,934	12,467	1,579	552	289	234	214	202	1,345	338	87	233	332	240
1967 . . .	472	1,102	1,822	629	2,915	12,841	1,707	593	294	250	219	204	1,457	374	90	221	358	251
1968 . . .	483	1,138	1,718	617	3,004	13,136	1,851	610	296	265	222	204	1,585	388	92	209	378	259
1969 . . .	518	1,102	1,593	567	3,015	13,211	1,818	565	318	252	193	220	1,566	372	98	195	394	264
1970 . . .	562	1,198	1,592	547	2,955	12,202	1,795	559	316	234	188	219	1,562	371	97	131	410	329
1971 . . .	445	1,229	1,784	507	2,815	11,910	1,808	569	298	216	175	205	1,592	394	93	187	418	279
1972 . . .	488	1,192	1,927	466	2,795	12,328	1,830	616	321	201	182	232	1,629	435	89	197	444	252
1973 . . .	446	1,229	1,845	461	2,864	12,629	1,795	709	354	226	172	224	1,568	537	130	194	408	251
1974 . . .	439	1,268	1,680	442	2,782	11,997	1,688	695	294	201	187	209	1,487	507	85	189	412	264
1975 . . .	414	1,237	1,638	417	2,764	11,911	1,575	671	291	193	177	206	1,382	493	85	177	383	247
PROJECTIONS																		
1976 . . .	404	1,258	1,653	392	2,737	11,608	1,574	696	293	186	172	206	1,387	515	86	174	390	245
1977 . . .	395	1,285	1,673	369	2,719	11,740	1,578	704	296	180	168	208	1,396	539	87	170	399	244
1978 . . .	393	1,336	1,725	346	2,711	11,720	1,587	725	299	176	165	210	1,409	565	88	167	409	244
1979 . . .	382	1,360	1,741	328	2,727	11,807	1,610	753	307	172	162	214	1,435	597	90	166	423	246
1980 . . .	379	1,414	1,794	311	2,759	11,963	1,644	786	316	169	161	218	1,470	635	92	166	440	250
PERCENT CHANGE																		
1960-65 . .	147	61	57	47	22	26	137	49	46	101	55	43	145	45	54	68	111	209
1965-70 . .	25	10	-8	-13	5	5	26	9	9	5	-13	-5	29	25	62	-19	29	55
1970-75 . .	-26	3	3	-24	-6	-2	-12	20	-8	-18	-6	-6	-12	33	-12	-2	-7	-25
1975-80 . .	-8	14	10	-25	-	-	4	17	9	-12	-9	6	6	29	8	-6	15	1
1965-75 . .	-8	13	-6	-34	-2	3	10	31	0	-13	-18	-10	15	67	42	-21	21	16

* Using GNP implicit price deflator (1975-[illegible] NPA).

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.[illegible].

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Table 2.38 FUNDS USED FOR BASIC RESEARCH, APPLIED RESEARCH AND DEVELOPMENT, BY SECTOR: 1960-1980

(Percent Distribution)

Year	Federal (100)			Industry (100)			Colleges and Universities: Total Universities and Colleges (100)			Colleges and Universities: FFRDC (100)			Colleges and Universities: Other (100)			Other Nonprofit Institutions (100)		
	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel	Basic	App'd	Devel
1960 . . .	9.3	34.5	56.3	3.6	19.3	77.1	52.7	29.9	17.4	26.9	33.9	39.2	67.0	27.7	5.3	37.7	42.6	19.7
1961 . . .	11.0	33.8	55.2	3.6	18.1	78.3	55.5	27.9	16.6	28.0	32.9	39.0	70.2	25.2	4.6	32.2	45.3	22.5
1962 . . .	12.0	33.5	54.6	4.2	21.4	74.4	57.9	26.2	15.9	28.9	33.0	38.1	72.9	22.7	4.4	32.9	44.1	23.1
1963 . . .	13.1	32.0	54.8	4.1	19.5	76.4	60.4	24.6	15.0	30.0	32.1	37.9	75.3	21.0	3.7	31.4	42.1	26.5
1964 . . .	12.8	32.7	54.5	4.1	19.2	76.7	62.7	22.8	14.5	30.4	32.1	37.5	78.7	18.2	3.1	30.3	43.1	26.6
1965 . . .	13.7	33.3	53.0	4.2	18.7	77.1	64.0	23.0	13.0	33.1	32.4	34.5	77.2	18.9	3.9	29.6	42.1	28.3
1966 . . .	13.8	32.5	53.7	4.0	18.3	77.7	65.2	[illegible]	11.9	36.0	32.9	31.1	76.0	19.1	4.9	28.9	41.2	29.8
1967 . . .	13.9	32.4	53.7	3.8	17.8	78.4	65.8	22.9	11.3	37.1	32.5	30.3	75.8	19.5	4.7	26.6	43.1	30.2
1968 . . .	14.4	34.5	51.2	3.7	17.9	78.4	67.1	22.1	10.7	38.4	32.1	29.5	76.7	18.8	4.5	24.7	44.7	30.6
1969 . . .	16.1	34.3	49.6	3.4	18.0	78.7	67.3	20.9	11.8	37.9	29.0	33.1	76.9	18.3	4.8	22.9	46.1	31.0
1970 . . .	16.8	35.7	47.5	3.5	18.8	77.7	67.2	20.9	11.8	36.5	29.3	34.2	76.9	18.3	4.8	19.7	44.6	35.7
1971 . . .	12.9	35.5	51.6	3.3	18.5	78.2	67.6	21.3	11.1	36.3	29.3	34.4	76.6	19.0	4.5	21.2	47.3	31.5
1972 . . .	13.5	33.0	53.4	3.0	17.9	79.1	66.1	22.3	11.6	32.7	29.6	37.7	75.7	20.2	4.1	22.1	49.7	28.2
1973 . . .	12.7	34.9	52.4	2.9	18.0	79.2	62.8	24.8	12.4	36.4	27.7	36.0	70.1	24.0	5.8	22.8	47.8	29.4
1974 . . .	13.0	37.4	49.6	2.9	18.3	78.8	63.0	25.9	11.0	33.6	31.3	35.0	71.5	24.4	4.1	21.9	47.6	30.5
1975 . . .	12.6	37.6	49.8	2.8	18.3	78.9	62.1	26.4	11.5	33.5	30.8	35.7	70.5	25.2	4.4	22.0	47.4	30.6
PROJECTIONS																		
1976 . . .	12.2	38.0	49.9	2.6	18.3	79.1	61.7	26.9	11.5	33.0	30.5	36.5	69.8	25.9	4.3	21.4	48.3	30.3
1977 . . .	11.8	38.3	49.9	2.5	18.3	79.2	61.2	27.3	11.5	32.4	30.2	37.4	69.0	26.6	4.3	20.9	49.1	30.0
1978 . . .	11.4	38.7	49.9	2.3	18.3	79.3	60.8	27.8	11.5	31.9	29.9	38.2	68.3	27.4	4.3	20.4	49.9	29.7
1979 . . .	11.0	39.1	50.0	2.2	18.3	79.4	60.3	28.2	11.5	31.4	29.6	39.0	67.6	28.2	4.2	19.9	50.7	29.4
1980 . . .	10.6	39.4	50.0	2.1	18.4	79.6	59.9	28.6	11.5	30.8	29.3	39.8	66.9	28.9	4.2	19.4	51.5	29.2

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.36.

over time appear in National Patterns of R&D Resources; Funds and Manpower in the United States 1953-1975 (102). Federal Funds for Research, Development and Other Scientific Activities, Detailed Statistical Tables (99, 100) gives obligated funds, over time, by field of science. These data cover "all" performers, including: a) industry, b) intramural, c) universities and colleges, d) FFRDC's (Federally Funded R&D Centers), and e) other non-profit groups (which include state and local R&D performers, usually a very small percentage). Also included in the Detailed Statistical Tables are trends in basic research funding obligations and applied research funding obligations. In these statistics, unfortunately, "computer science" is subsumed by mathematics. This is one category which might be of particular interest because it could include R&D in the development of scientific and technical information services.

The first source above describes expenditures while the second reports obligations. Obligated funds are not necessarily spent in the same year, especially for programs stretching over several years. Federal obligations are used in this section to examine trends by field of science. The trends observed may be expected to be not too different from trends for overall R&D expenditures considering that Federal funds constitute more than half of all R&D funds. Other sources of data by scientific discipline which may be of interest are described below for comparison.

Data on industry R&D by field of science is found in Research and Development in Industry 1973 (107). These figures reflect expenditures, rather than obligations, for basic research only. The field of science categories here are somewhat different than those in Federal funding obligations described previously, again without a separate category for "computer science and engineering". Applied research and development data are also provided but by major industrial product group rather than by discipline. Such a breakdown does not appear to be applicable to STI. The Standard Industrial Classification (SIC) Manual classification used might be correlated with factors other than publishing volume within specific fields and provide indicators of commercial interest in the information field. However, this would take us outside the realm of STI itself into, perhaps, the commercial viability of information industry activities.

Resources for Scientific Activities at Universities and Colleges (109) includes statistics for R&D expenditures at institutions of higher education. It shows current dollar expenditures for R&D by field of science. These figures do not distinguish between basic and applied research, since the survey which collected this data did not make this distinction. From the standpoint of impact on STI, this distinction for college and university R&D appears to be crucial. *Resources* also presents some current expenditures for instruction in the sciences and engineering by field of science and by type of institution (i.e., those granting doctorate, master's, bachelor's, and no degrees).

R&D expenditures by state government agencies are described in *Research and Development in State Government Agencies* (108). For the years of these surveys, state government agency expenditures for R&D were increasing. It is uncertain how state R&D funding trends might impact the generation of STI, since state agencies may not place the same emphasis on publishing as colleges and universities, nor would they be influenced by the proprietary nature of R&D in industry. In addition, approximately 50 percent of state funds for R&D are provided by the Federal government, with about nine percent of state and R&D expenditures going to state colleges and universities. One of the impacts of the "new federalism" might be to increase the correlation between state and Federal expenditures to the extent that little additional information would be gained by observing state expenditures separately. It should also be noted that a large proportion of state R&D expenditures is concentrated in a relatively few states. The ratio of applied to basic R&D expenditures has changed significantly for states during the last 10 years with basic research loosing ground, a factor which may impact on publishing growing out of this sector.

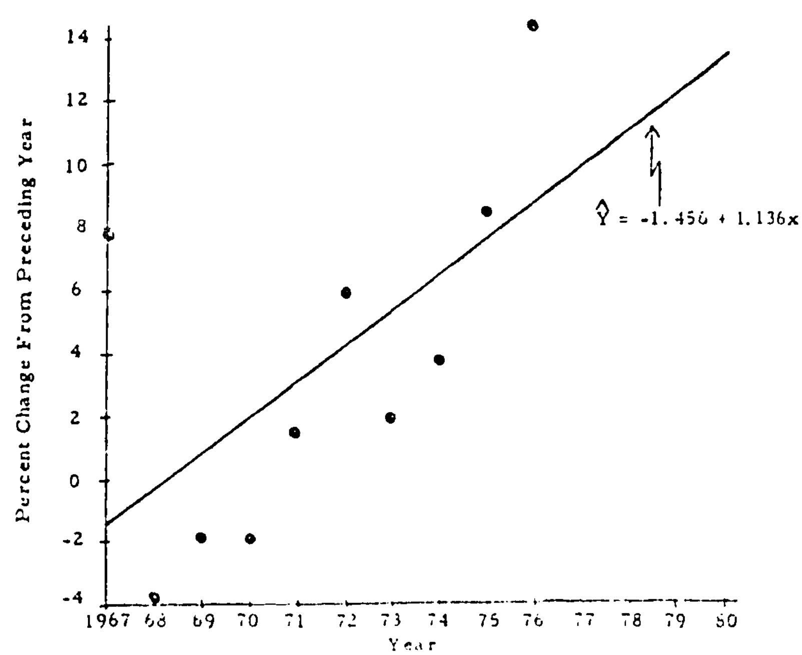
A common problem area in using available, published statistics can be described as definitional. First, definitional categories used by data collectors may differ from year to year. Second, the interpretations of questionnaire respondents of these categories may not be consistent. Both of these problems in interpreting existing data on scientific activities are discussed at length in the National Research Council's *Physics in Perspective* (89).

Federal Obligations by Field of Science

Data on Federal obligations for development and research by field of science are given in Table 2.39 and 2.40 for current and constant dollars respectively. The data are graphed in Figure 2.9. The most dramatic funding increase in research occurred in Social Sciences where total research funding (in constant dollars) increased 23 percent from 1966 to 1976. An even larger relative increase was observed for this field for applied research than for total research. Applied research as a whole increased more than basic research during the period, but the difference was not large, 62 percent and 46 percent respectively in current dollars. Constant dollars show decreases for both applied and basic research.

Projections (1977-1980) of total R&D ob gations are based upon a time series analysis of the rates of increase in ent dollars. Rates of increase generally declined through 1968, therefo shorter period (1967-1976) was selected to provide a more reasonable, although probably still conservative, estimate. The data and regression equation are shown in Figure 2.8 below.

Figure 2.8 ANNUAL RATES OF INCREASE IN FEDERAL OBLIGATIONS FOR R&D:1967-1980



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

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Table 2.39 FEDERAL OBLIGATIONS FOR RESEARCH & DEVELOPMENT, BY FIELD OF SCIENCE: 1960-1980

(Millions of Dollars)

Item	1960	1961	19	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Research & Development	7,552	9,059	10,290	12,495	14,225	14,614	15,320	16,529	15,921	15,641	15,340	15,574	16,512
Total Research	1,941	2,620	3,273	4,041	4,464	4,854	5,271	5,273	5,361	5,228	5,597	6,074	6,557
Life Sciences	511	629	810	922	1,045	1,167	1,301	1,451	1,538	1,499	1,533	1,673	1,982
Physical Sciences[2]	608	860	1,029	884	931	1,029	1,077	1,074	1,132	1,169	1,012	1,042	1,139
Environmental Sciences[2]				455	671	676	749	664	656	538	575	677	783
Mathematics	25	40	64	87	93	105	123	130	119	115	102	120	136
Engineering	690	864	1,059	1,445	1,450	1,576	1, 82	1,561	1,572	1,509	1,990	2,047	1,965
Psychology	38	51	57	72	95	103	100	108	98	104	114	116	126
Social Sciences	35	45	63	80	102	127	166	189	195	215	209	304	310
Other Sciences	33	132	190	97	77	70	74	95	52	80	72	103	116
Basic Research	610	825	1,106	1,389	1,367	1,690	1,840	2,004	2,056	2,077	2,042	2,132	2,411
Life Sciences	172	238	313	380	424	487	552	612	612	569	576	596	729
Physical Sciences[2]	319	443	604	515	564	639	667	713	731	819	704	743	783
Environmental Sciences[2]				252	310	263	291	315	342	339	341	393	454
Mathematics	18	21	26	42	52	57	60	65	67	57	59	52	63
Engineering	76	82	116	137	135	147	168	178	185	185	234	220	235
Psychology	17	21	28	36	47	58	53	60	55	55	57	49	58
Social Sciences	8	11	18	25	34	37	44	57	61	72	65	70	80
Other Sciences	-[3]	8	2	2	2	2	4	4	4	11	4	10	9
Applied Research	1,331	1,796	2,166	2,652	2,898	3,164	3,431	3,269	3,304	3,151	3,555	3,942	4,146
Life Sciences	340	391	498	542	621	680	749	839	925	930	956	1,077	1,253
Physical Sciences[2]	289	417	425	369	367	390	410	361	401	350	307	298	356
Environmental Sciences[2]				203	361	413	458	349	314	230	234	284	329
Mathematics	7	19	38	45	41	48	62	65	53	57	43	68	74
Engineering	614	781	943	1,308	1,316	1,429	1,514	1,382	1,387	1,324	1,746	1,821	1,730
Psychology	21	30	29	35	48	46	47	48	44	49	56	67	68
Social Sciences	27	34	45	55	68	90	121	132	133	143	144	234	231
Other Sciences	33	124	139	95	75	68	69	92	47	69	68	92	107
Development	5,611	6,438	7,017	8,454	9,761	9,760	10,050	11,256	10,561	10,413	9,743	9,490	9,955

(Continued)

Table 2.39 (cont.) FEDERAL OBLIGATIONS FOR RESEARCH & DEVELOPMENT, BY FIELD OF SCIENCE: 1960-1980

(Millions of Dollars)

Item	1973	1974	1975[e]	1976[e]	1977*	1978*	1979*	1980*	Percent Change* 1960-65	1965-70	1970-75	1975-80	1966-76
Research & Development[1]	16,821	17,438	18,905	21,652	23,796	26,424	29,641	33,587	94	5	23	78	41
Total Research	6,500	7,173	7,737	8,241	9,447	10,490	11,767	13,334	150	15	38	72	56
Life Sciences	2,059	2,389	2,471	2,348	2,938	3,262	3,660	4,147	128	31	61	68	80
Physical Sciences[2]	1,126	1,182	1,315	1,476	1,625	1,804	2,024	2,293	n.a.	-2	30	74	37
Environmental Sciences[2]	791	876	960	1,028	1,152	1,280	1,436	1,627	n.a.	-15	67	69	37
Mathematics	126	127	143	157	179	199	224	253	320	-3	40	77	28
Engineering	1,760	2,003	2,202	2,545	2,730	3,032	3,401	3,854	128	26	11	75	51
Psychology	116	143	132	137	170	189	212	240	[illegible]	11	16	82	37
Social Sciences	296	291	343	356	416	462	518	587	[illegible]	65	64	71	114
Other Sciences	226	160	171	193	227	252	282	320	112	3	138	87	167
Basic Research	2,420	2,465	2,596	2,689	3,284	3,647	4,090	4,635	177	21	27	79	46
Life Sciences	758	843	822	753	1,021	1,134	1,272	1,441	183	18	43	75	36
Physical Sciences[2]	796	797	[illegible]	1,000	1,113	1,236	1,387	1,571	n.a.	10	28	75	50
Environmental Sciences[2]	445	447	[illegible]	499	601	667	748	848	n.a.	30	36	83	71
Mathematics	57	49	55	59	76	84	94	107	217	4	-7	95	-2
Engineering	206	189	210	218	276	306	344	389	93	59	-10	85	30
Psychology	51	49	47	48	66	73	82	93	241	-2	-18	98	-9
Social Sciences	78	73	82	91	105	117	131	148	363	76	26	80	107
Other Sciences	28	16	19	21	23	26	29	32	-	100	375	68	425
Applied Research	4,080	4,708	5,141	5,551	6,139	5,817	7,647	8,665	138	12	45	69	62
Life Sciences	1,301	1,546	1,649	1,595	1,909	1,809	2,378	2,695	100	41	72	63	113
Physical Sciences[2]	330	385	418	476	510	483	635	719	n.a.	-21	36	72	16
Environmental Sciences[2]	346	428	497	529	546	518	681	771	n.a.	-43	112	55	16
Mathematics	69	78	88	98	104	99	130	147	586	-10	105	67	58
Engineering	1,554	1,814	1,992	2,327	2,443	2,315	3,044	3,449	133	22	167	73	54
Psychology	66	93	85	90	104	99	130	147	119	22	52	73	91
Social Sciences	218	218	260	265	313	297	390	442	233	60	81	70	119
Other Sciences	197	144	151	171	203	192	252	286	106	-	122	89	148
Development	10,321	10,265	11,168	13,411	14,349	15,934	17,874	20,253	74	-	15	81	33

e NSF estimate.

* Market Facts, Inc., Center for Quantitative Sciences.

1 Excludes R&D Plant.

2 Physical Sciences and Environmental Sciences not separately identified prior to 1963.

3 Less than $500,000.

SOURCE: National Science Foundation, Detailed Statistical Tables, Federal Funds for Research, Development, and Other Scientific Activities.
1960-1963 data: Volume XXI, 1972.
1964 data: Volume XXII, 1973.
1965-1976 data: Volume XXIV, 1975.

Table 2.40 FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT, BY FIELD OF SCIENCE: 1960-1980

(Millions of Constant 1967 Dollars)*

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Research & Development[1] . . .	8,597	10,182	11,438	13,710	15,367	15,501	15,810	16,529	15,307	14,347	13,338	12,536	13,288
Total Research	2,210	2,945	3,638	4,434	4,822	5,148	5,440	5,273	5,154	4,795	4,867	5,053	5,277
Life Sciences	582	707	900	1,012	1,129	1,238	1,343	1,451	1,538	1,375	1,333	1,392	1,595
Physical Sciences[2] . . .	692	967	472	970	1,006	1,091	1,111	1,074	1,088	1,022	888	867	917
Environmental Sciences[2] .				499	725	717	773	664	631	493	500	563	630
Mathematics	28	45	71	95	100	111	127	130	114	105	89	100	109
Engineering	786	971	1,177	1,585	1,566	1,672	1,736	1,561	1,511	1,384	1,722	1,697	1,581
Psychology	43	57	63	79	103	109	103	108	94	95	99	96	101
Social Sciences	40	51	70	88	110	115	171	189	187	197	182	253	249
Other Sciences	38	148	211	106	83	74	76	95	50	73	63	85	91
Basic Research	695	927	1,229	1,524	1,693	1,793	1,899	2,004	1,977	1,905	1,775	1,774	1,940
Life Sciences	196	268	348	417	458	517	570	612	583	522	501	496	557
Physical Sciences[2] . .	363	498	671	565	609	678	688	713	703	751	612	618	630
Environmental Sciences[2] .				276	335	279	300	315	329	283	296	327	365
Mathematics	20	24	29	46	56	60	62	65	64	52	51	43	51
Engineering	87	92	129	150	146	156	173	178	178	170	203	183	189
Psychology	19	24	31	39	51	62	55	60	53	50	50	41	47
Social Sciences	9	12	20	27	37	39	45	57	59	66	57	58	64
Other Sciences	-[3]	9	2	2	2	2	4	4	4	10	4	8	7
Applied Research	1,515	2,019	2,408	2,910	3,131	3,356	3,541	3,269	3,177	2,890	3,091	3,279	3,337
Life Sciences	387	439	554	595	671	721	773	839	889	853	831	896	1,038
Physical Sciences[2] . .	329	469	472	405	396	414	423	361	386	271	267	248	286
Environmental Sciences[2] .				223	390	438	473	349	302	211	203	236	265
Mathematics	8	21	42	49	44	51	64	65	51	52	37	57	69
Engineering	699	878	1,048	1,435	1,422	1,516	1,562	1,382	1,334	1,214	1,518	1,515	1,392
Psychology	24	34	32	38	52	49	49	48	42	45	49	56	55
Social Sciences	31	38	50	60	73	95	125	132	128	131	125	195	186
Other Sciences	38	139	210	104	81	72	71	92	45	63	59	77	86
Development	6,388	7,237	7,800	9,276	10,544	10,352	10,372	11,256	10,154	9,551	8,471	7,895	8,011

(Continued)

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Table 2.40 (cont.) FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT, BY FIELD OF SCIENCE: 1960-1980

(Millions of Constant 1967 Dollars)*

Item	1973	1974	1975	1976	1977	1978	1979	1980	Percent Change 1960-65	1965-70	1970-75	1975-80	1966-75
Research & Development[1]	12,818	12,054	11,958	12,833	13,211	13,725	14,469	15,410	80	-14	-10	29	-19
Total Research	4,953	4,959	4,894	4,884	5,245	5,449	5,744	6,110	133	-5	1	25	-10
Life Sciences	1,569	1,651	1,563	1,392	1,631	1,694	1,787	1,903	113	8	17	22	4
Physical Sciences[2] . . .	858	817	832	875	902	937	988	1,052	n.a.	-19	-5	26	-21
Environmental Sciences[2] .	603	606	607	609	640	665	701	746	n.a.	-30	21	23	-21
Mathematics	96	88	90	93	99	103	109	116	296	-20	1	29	-27
Engineering	1,341	1,385	1,393	1,508	1,516	1,575	1,660	1,768	113	3	-19	27	-13
Psychology	88	99	83	81	94	98	103	110	153	-9	-16	33	-21
Social Sciences	226	201	217	211	231	240	253	269	233	35	19	24	22
Other Sciences	172	111	108	114	126	131	138	147	95	-15	71	35	50
Basic Research	1,844	1,704	1,642	1,594	1,823	1,894	1,996	2,127	158	-1	-7	30	-16
Life Sciences	578	563	520	446	567	539	621	661	164	-3	4	27	-22
Physical Sciences[2] . . .	607	551	568	593	618	642	677	721	n.a.	-10	-7	27	-14
Environmental Sciences[2] .	339	309	293	296	334	346	365	389	n.a.	6	-1	33	-1
Mathematics	43	34	35	35	42	44	46	49	200	-15	-31	40	-44
Engineering	157	131	133	129	153	159	168	178	79	30	-34	34	-25
Psychology	39	34	30	28	37	38	40	43	226	-19	-40	43	-49
Social Sciences	59	50	52	54	50	61	64	68	333	46	-9	31	20
Other Sciences	21	11	12	12	13	14	14	15	-	100	200	25	200
Applied Research	3,109	3,255	3,252	3,290	3,408	3,021	3,733	3,976	122	-0	5	22	-7
Life Sciences	997	1,069	1,043	945	1,060	940	1,161	1,236	86	15	26	19	22
Physical Sciences[2] . . .	251	266	264	282	283	251	310	330	n.a.	-36	-1	25	-33
Environmental Sciences[2] .	264	296	314	314	303	269	332	354	n.a.	-54	55	13	-34
Mathematics	53	54	56	53	58	51	63	67	538	-27	51	20	-9
Engineering	1,184	1,234	1,260	1,379	1,356	1,202	1,486	1,582	117	-	-17	26	-12
Psychology	50	64	54	53	58	51	63	67	104	-	10	24	8
Social Sciences	166	151	164	157	174	154	190	203	206	32	31	35	23
Other Sciences	150	100	96	101	113	100	123	131	89	-10	63	36	42
Development	7,865	7,095	7,064	7,949	7,966	8,276	8,725	9,292	62	-28	-17	32	-23

*Using GNP implicit price deflator (1975-1980 NPA).

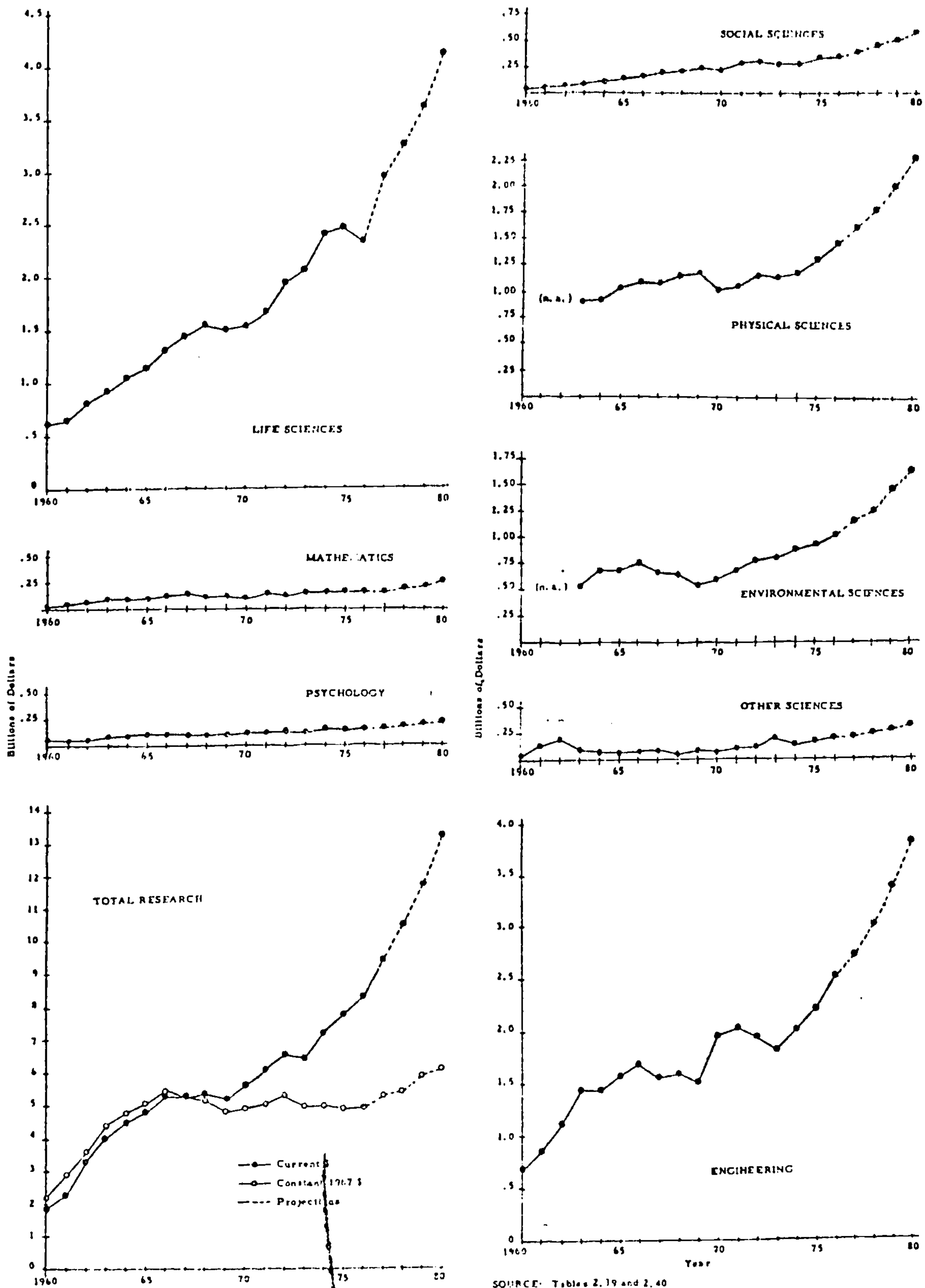
[1] Excludes R&D Plant.

[2] Physical Sciences and Environmental Sciences not separately identified prior to 1963.

[3] Less than $500,000.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.39.

Figure 2.9 FEDERAL OBLIGATIONS FOR R&D, BY FIELD OF SCIENCE: 1960-1980



SOURCE: Tables 2.39 and 2.40

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Individual projections for development and research by field of science were then calculated using a 5-year average (1972-1977) of distribution of total obligations, thus producing a static distribution for all projection years. The resulting percentages were applied to projected total R&D obligations.

The relative importance of scientific discipline is shown on Table 2.41 where Federal obligations are shown in a percent distribution. In 1975, Life Sciences and Engineering clearly predominate total research, accounting for approximately 30 percent each. Predominance of these two fields is maintained in applied research, where Engineering actually takes the lead, not unexpectedly. In terms of basic research, Life Sciences, although still accounting for nearly 32 percent, takes second place to Physical Sciences. Environmental Sciences accounts for 18 percent, ahead of Engineering's 8 percent.

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Table 2.41 FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT, BY FIELD OF SCIENCE: 1960–1980

(Percent Distribution)

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Research & Development[1]											100										
Development	74.3	71.1	68.2	67.7	68.6	66.8	65.6	65.1	66.3	66.6	63.5	60.7	60.3	61.4	58.9	59.1	61.9	60.3	60.3	60.3	60.3
Total Research	25.7	28.9	31.8	32.3	31.4	33.2	34.4	31.9	33.7	33.4	36.5	39.3	39.7	38.6	41.1	40.9	38.1	39.7	39.7	39.7	39.7
Basic Research	8.1	9.1	10.7	11.1	11.0	11.6	12.0	12.1	12.9	13.3	13.3	13.7	14.6	14.4	14.1	13.7	12.4	13.8	13.8	13.8	13.8
Applied Research	17.6	19.8	21.0	21.2	20.4	21.6	22.4	19.8	20.8	20.1	23.2	25.3	25.1	24.3	27.0	27.2	25.6	25.8	25.8	25.8	25.8
Total Research											100										
Life Sciences	26.3	24.0	24.7	22.8	23.4	24.0	24.7	27.5	28.7	28.7	27.4	27.5	30.2	31.7	33.3	31.9	28.5	31.1	31.1	31.1	31.1
Physical Sciences[2]	31.3	32.8	31.4	21.9	20.9	21.2	20.4	20.4	21.1	22.4	18.1	17.2	17.4	17.3	16.5	17.0	17.9	17.2	17.2	17.2	17.2
Environmental Sciences[2]				11.3	15.0	13.9	14.2	12.6	12.2	10.3	10.3	11.1	11.9	12.2	12.2	12.4	12.5	12.2	12.2	12.2	12.2
Mathematics	1.3	1.5	2.0	2.2	2.1	2.2	2.3	2.5	2.2	2.2	1.5	2.0	2.1	1.9	1.8	1.8	1.9	1.9	1.9	1.9	1.9
Engineering	35.5	33.0	32.4	35.8	32.5	32.5	31.9	29.6	29.3	23.9	35.4	33.5	30.3	27.1	27.9	28.5	30.9	28.9	28.9	28.9	28.9
Psychology	2.0	1.9	1.7	1.8	2.1	2.1	1.9	2.0	1.8	2.0	2.0	1.9	1.9	1.8	2.0	1.7	1.7	1.8	1.8	1.8	1.8
Social Sciences	1.8	1.7	1.9	2.0	2.3	2.6	3.1	3.6	3.6	4.1	3.7	5.3	4.7	4.6	4.1	4.4	4.3	4.4	4.4	4.4	4.4
Other Sciences	1.7	5.0	5.8	2.4	1.7	1.4	1.4	1.8	1.3	1.5	1.3	1.7	1.8	3.5	2.2	2.2	2.3	2.4	2.4	2.4	2.4
Basic Research											100										
Life Sciences	28.2	28.8	28.3	27.4	27.0	28.8	30.0	30.5	29.3	27.4	29.2	26.0	30.2	31.3	34.2	31.7	28.0	31.1	31.1	31.1	31.1
Physical Sciences[2]	52.3	53.7	54.6	37.1	36.0	37.8	36.2	35.6	35.6	29.4	34.5	34.8	32.5	22.9	32.3	34.6	37.2	33.9	33.9	33.9	33.9
Environmental Sciences[2]				18.1	19.8	15.6	15.8	15.7	16.6	14.9	16.7	[illegible]	19.8	18.4	15.1	17.8	15.6	18.3	18.3	18.3	18.3
Mathematics	3.0	2.5	2.4	3.0	3.3	3.4	3.3	3.2	3.3	2.7	2.9	2.2	2.6	2.4	2.0	2.1	2.2	2.3	2.3	2.3	2.3
Engineering	12.5	9.9	10.5	9.9	8.6	8.7	9.1	8.9	9.0	8.9	11.5	10.3	9.7	8.5	7.7	8.1	8.1	8.4	8.4	8.4	8.4
Psychology	2.8	2.5	2.5	2.6	3.0	3.4	2.9	3.0	2.7	2.6	2.8	2.3	2.4	2.1	2.0	1.8	1.8	2.0	2.0	2.0	2.0
Social Sciences	1.3	1.3	1.6	1.8	2.2	2.2	2.4	2.8	3.0	3.5	3.2	3.3	3.3	3.2	3.0	3.2	3.4	3.2	3.2	3.2	3.2
Other Sciences	–[3]	1.0	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.5	0.2	0.5	0.4	1.2	0.6	0.7	0.8	0.7	0.7	0.7	0.7
Applied Research											100										
Life Sciences	25.5	21.8	23.0	20.4	21.4	21.5	21.8	25.7	25.0	29.5	26.9	27.2	30.2	31.9	32.8	32.1	28.7	31.1	31.1	31.1	31.1
Physical Sciences[2]	21.7	23.2	19.6	13.9	12.7	12.3	11.9	11.0	12.1	11.1	8.6	7.6	8.6	8.1	8.2	8.1	8.6	8.3	8.3	8.3	8.3
Environmental Sciences[2]				7.7	12.5	13.1	13.3	10.7	9.5	7.3	6.6	7.2	7.9	8.5	9.1	9.7	9.5	8.9	8.9	8.9	8.9
Mathematics	0.5	1.1	1.8	1.7	1.4	1.5	1.8	2.0	1.6	1.8	1.2	1.7	1.5	1.7	1.7	1.7	1.8	1.7	1.7	1.7	1.7
Engineering	46.1	43.5	43.5	49.3	45.4	45.2	44.1	42.3	42.0	42.0	49.1	46.2	41.7	38.1	35.5	38.7	41.9	39.8	39.8	39.8	39.8
Psychology	1.6	1.7	1.3	1.3	1.7	1.5	1.4	1.5	1.3	1.6	1.6	1.7	1.6	1.6	2.0	1.7	1.6	1.7	1.7	1.7	1.7
Social Sciences	2.0	1.9	2.1	2.1	2.3	2.8	3.5	4.0	4.0	4.5	4.0	5.9	5.6	5.3	4.6	5.1	4.8	5.1	5.1	5.1	5.1
Other Sciences	2.5	6.9	8.7	3.6	2.6	2.1	2.0	2.8	1.4	2.2	1.9	2.3	2.6	4.8	3.1	2.9	3.1	3.3	3.3	3.3	3.3

[1] Excludes R&D Plant.

[2] Physical Sciences and Environmental Sciences not separately identified prior to 1963.

[3] Less than $500,000.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.39.

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Federal Obligations for Scientific and Technical Information

The same NSF source (100) that provides Federal obligations for R&D by field of science, includes data for Federal obligations for scientific and technical information. These data, because they indicate trends at least in the Federal establishment, are presented in Tables 2.42 and 2.43 in current and constant dollars respectively. Fairly steady increases were observed between 1960 and 1975, during which time obligations increased more than 500 percent in current dollars. In constant dollars, increases were observed through 1968, amounts were fairly constant through 1973 and then began to decrease. Almost half of Federal obligations for scientific and technical information are allotted to documentation.

In contrast to these data, collected by NSF as part of the annual Federal R&D funds survey, another source of statistics on Federal obligations for STI is found in a report for COSATI (148) which covers the years 1969-1973 only. The contrast occurs not only in the magnitude of the total dollar amounts, but in the rate of increase. For 1973, the COSATI (148) study has a total of 93[illegible] million dollars, more than double the NSF total of only 438 million. In addition, over the five years of the COSATI data, a 38 percent increase was experienced, while the increase for the NSF source was only 21 percent. The COSATI data is tabulated on Table 2.44, which also shows amounts allocated to two sets of sub-functions and activities. These breakdowns are difficult to compare with NSF's four categories and quite obviously are based upon different definitions for the various categories.

Both sets of Federal STI data are plotted in Figures 2.10 and 2.11 showing trends for both current constant dollars and increase over the five year period.

Table 2.42 FEDERAL OBLIGATIONS FOR SCIENTIFIC AND TECHNICAL INFORMATION: 1960-1980

(Millions of Dollars)

Year	Total	Publication and Distribution $	Publication and Distribution %	Documentation $	Documentation %	Audiovisual and Symposia $	Audiovisual and Symposia %	R&D in Information Science $	R&D in Information Science %
1960 . . .	75.9	37.0	48.7	28.4	37.4	7.6	10.0	2.9	3.8
1961 . . .	91.6	48.7	53.2	29.0	31.7	6.7	7.3	7.2	7.9
1962 . . .	128.5	55.7	43.3	42.4	33.0	17.0	13.2	13.3	10.4
1963 . . .	164.5	67.7	41.2	64.0	38.9	21.0	12.8	11.9	7.2
1964 . . .	203.2	59.9	29.5	90.8	44.7	22.7	11.2	12.6	6.2
1965 . . .	224.7	68.2	30.4	102.0	45.4	32.0	14.2	22.5	10.0
1966 . . .	277.7	82.7	29.8	124.6	44.9	22.5	8.1	48.0	17.3
1967 . . .	324.4	87.1	26.8	152.5	47.0	31.7	9.8	53.1	16.4
1968 . . .	359.2	100.7	28.0	165.6	46.1	34.1	9.5	58.8	16.4
1969 . . .	362.5	96.0	26.5	170.9	47.1	31.8	8.8	63.7	17.6
1970 . . .	386.8	98.9	25.6	198.1	51.2	32.6	8.4	62.1	16.0
1971 . . .	397.6	106.0	26.7	193.8	48.7	32.8	8.2	65.0	16.3
1972 . . .	419.4	116.6	27.8	196.5	46.9	36.5	8.7	69.7	16.6
1973 . . .	437.9	122.6	28.0	198.0	45.2	37.9	8.7	79.4	18.1
1974 . . .	442.8	129.1	29.2	199.4	45.0	35.0	7.9	79.3	17.9
1975[e] . .	464.2	140.7	30.3	211.4	45.5	37.7	8.1	74.4	16.0
1976[e] . .	492.0	151.2	30.7	220.5	44.8	38.0	7.7	82.3	16.7
PROJECTIONS*									
1977 . . .	518.3	151.3	29.2	235.8	45.5	42.5	8.2	88.6	17.1
1978 . . .	547.2	159.8	29.2	249.0	45.5	44.9	8.2	93.6	17.1
1979 . . .	579.1	169.1	29.2	263.5	45.5	47.5	8.2	99.0	17.1
1980 . . .	614.2	179.3	29.2	279.5	45.5	50.4	8.2	105.0	17.1
PERCENT CHANGE									
1960-65 .	196	84		259		321		676	
1965-70 .	72	45		94		2		176	
1970-75 .	20	42		7		16		20	
1975-80 .	32	27		32		34		41	
1966-76 .	77	83		77		69		71	

[e] NSF estimate.

* Market Facts, Inc., Center for Quantitative Sciences.

[1] Total includes $17.2 million for management, which was reported separately from other categories in 1964 only.

SOURCE: National Science Foundation, Detailed Statistical Tables, Federal Funds for Research, Development, and Other Scientific Activities, Fiscal Years 1974, 1975, 1976, Volume XXIV (NSF 75-323).

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Table 2.43 FEDERAL OBLIGATIONS FOR SCIENTIFIC AND TECHNICAL INFORMATION: 1960-1980

(Millions of Constant 1967 Dollars)*

Year	Total	Publication and Distribution	Documentation	Audiovisual and Symposia	R&D in Information Science
1960 . . .	86.4	42.1	32.3	8.7	3.3
1961 . . .	103.0	54.7	32.6	7.5	8.1
1962 . . .	142.8	61.9	47.1	18.9	14.8
1963 . . .	180.5	74.3	70.2	23.0	13.1
1964 . . .	219.5	64.7	98.1	24.5	13.6
1965 . . .	238.3	72.3	108.2	33.9	23.9
1966 . . .	286.6	85.3	128.6	23.2	49.5
1967 . . .	324.4	87.1	152.5	31.7	53.1
1968 . . .	345.4	96.8	159.2	32.8	56.5
1969 . . .	332.5	88.0	156.8	29.2	58.4
1970 . . .	336.3	86.0	172.2	28.3	54.0
1971 . . .	330.8	88.2	161.2	27.3	54.1
1972 . . .	337.5	93.4	158.1	29.4	56.1
1973 . . .	333.7	93.4	150.9	28.9	60.5
1974 . . .	306.1	89.2	137.8	24.2	54.8
1975 . . .	239.6	89.0	133.7	23.8	47.1
1976 . . .	291.6	89.6	130.7	22.5	48.8
PROJECTIONS					
1977 . . .	287.8	84.0	130.9	23.6	49.2
1978 . . .	284.2	83.0	129.3	23.3	48.6
1979 . . .	282.7	82.5	128.6	23.2	48.3
1980 . . .	281.8	82.3	128.2	23.1	48.2
PERCENT CHANGE					
1960-65 .	176	72	235	290	624
1965-70 .	41	19	59	-17	126
1970-75 .	-13	3	-22	-16	-13
1975-80 .	-4	-8	-4	-3	2
1966-76 .	2	4	2	-3	-1

* Using GNP implicit price deflator (1975-1980 NPA).

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 2.42.

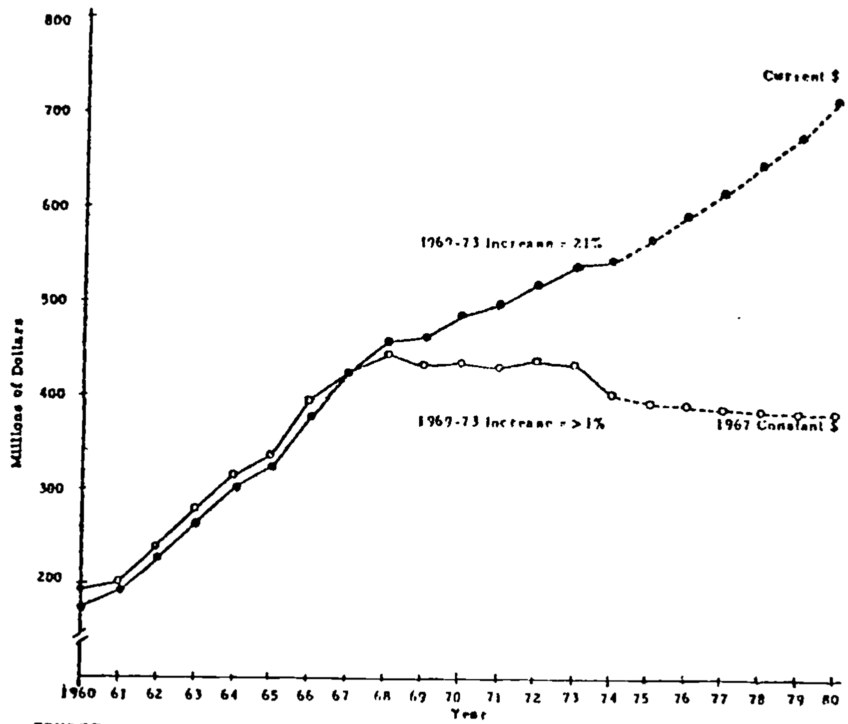
Table 2.44 FEDERAL OBLIGATIONS FOR MANAGEMENT, PROCESSING AND TRANSFER OF SCIENTIF AND TECHNICAL INFORMATION, DATA AND TECHNOLOGY*: 1969-1973

Item	1969		1970		1971		1972		1973		1969-73 Percent Change
	$	%	$	%	$	%	$	%	$	%	
Documentation.	130.3	19.2	147.1	19.8	170.6	20.1	178.8	19.6	185.5	19.8	42
Research and Technical Work Information	28.6	4.2	31.2	4.2	35.0	4.1	38.7	4.2	31.5	3.4	10
Information Analysis Centers.	52.9	7.8	57.3	7.7	71.7	8.4	82.2	9.0	83.3	8.9	57
Scientific and Technical Library.	71.8	10.6	73.5	9.9	83.9	9.9	90.1	9.9	92.9	9.9	29
Technical Data	202.7	29.9	213.1	28.8	228.4	26.9	230.3	25.2	232.0	24.8	14
Information Service Center .	63.4	9.4	71.1	9.6	94.4	11.1	107.2	11.7	115.3	12.3	82
Foreign Exchange	5.1	0.8	5.9	0.8	8.6	1.0	10.3	1.1	11.0	1.2	116
Technology Transfer.	21.9	3.2	32.7	4.4	33.3	3.9	36.5	4.0	42.7	4.6	95
Other.	101.2	14.9	109.2	14.7	123.4	14.5	140.1	15.3	140.9	15.1	39
TOTAL.	677.9	100.0	740.9	100.0	849.3	100.0	914.3	100.0	935.1	100.0	38
Management and Administration	149.5	22.1	167.7	22.6	179.2	21.1	196.2	21.5	205.4	22.0	37
Input.	213.2	31.4	231.1	31.2	282.7	33.3	310.2	33.9	319.8	34.2	50
Output	163.5	24.1	179.5	24.2	205.4	24.2	212.9	23.3	220.7	23.6	35
Support.	77.6	11.4	84.4	11.4	103.4	12.2	112.2	12.3	112.5	12.0	45
Conferences and Symposia . .	16.0	2.4	17.2	2.3	19.5	2.3	20.3	2.2	19.5	2.1	22
Research and Development in STI	55.4	8.2	59.8	8.1	57.3	6.7	60.5	6.6	56.4	6.0	2

* Includes Intramural.

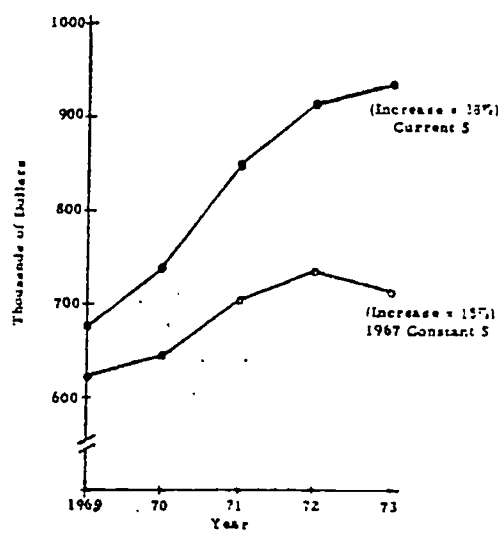
SOURCE: Federal Council for Science and Technology, Committee on Scientific and Technical Information, Report of the AD Hoc Group: Federal Agency Obligations for Management, Processing and Transfer of Scientific and Technical Information, Data and Technology (FY 1969-1973).

Figure 2.10 FEDERAL OBLIGATIONS FOR SCIENTIFIC AND TECHNICAL INFORMATION: 1960-1980



SOURCE: Tables 2.42 and 2.43.

Figure 2.11 FEDERAL OBLIGATIONS FOR MANAGEMENT, PROCESSING AND TRANSFER OF SCIENTIFIC AND TECHNICAL INFORMATION, DATA AND TECHNOLOGY: 1969-1973



SOURCE: Table 2.44

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Agencies Contributing Largest Amounts of Federal R&D Funds

The R&D expenditures of five agencies alone account for about 90 percent of all Federal expenditures for R&D. The Department of Defense itself spends almost 50 percent of the Federal R&D dollar. The next largest contributor is NASA, although both agencies appear to be contributing slightly decreasing percentages currently than two years ago as shown in Table 2.45 below. The other agencies are DHEW, ERDA and NSF.

Table 2.45 FEDERAL EXPENDITURES FOR RESEARCH AND DEVELOPMENT, SELECTED AGENCIES: 1974-1976

(Percent Distribution)

Year	Federal Total	Selected Agencies					
		Total	DOD	DHEW	ERDA	NASA	NSF
1974	100	91	50	11	8	18	3
1975[e]	100	90	48	11	10	17	3
1976[e]	100	90	48	11	11	16	3

[e] NSF estimate.

SOURCE: Federal Funds for Research, Development and Other Scientific Activities, Fiscal Years 1973, 1974 and 1975; Appendix: Detailed Statistical Tables, Volume XXIV (NSF 75-323).

The same five agencies provide most of Federal obligations for research, 83 percent. The proportion is even higher for Physical Sciences, Mathematics, Psychology, Engineering, and Other Sciences. The dollar amounts (estimates prepared by NSF) and percent distribution by field of science for 1975 are displayed in Table 2.46. As might be expected, the data shows that DHEW obligates the largest proportion of the Life Sciences, Psychology and Social Sciences obligations; ERDA and NASA of Physical Sciences, and DOD of Engineering. Thus, the policies of these individual agencies and any shifts in emphasis by them among scientific discipline is likely to substantially affect total R&D funding for those disciplines. The only field for which this might

Table 2.46 FEDERAL OBLIGATIONS FOR RESEARCH FOR SELECTED AGENCIES, BY FIELD OF SCIENCE: 1976 [e]

(Millions of Dollars)

Field of Science	Federal Total	Selected Agencies Total	DOD	DHEW	ERDA	NASA	NSF
Total	8,241	6,822	1,986	1,730	713	1,741	652
Life Sciences	2,348	1,838	147	1,396	127	53	115
Physical Sciences . .	1,476	1,341	223	44	431	479	164
Environmental Sciences	1,028	820	125	-	29	510	156
Mathematics	157	145	85	19	6	2	33
Psychology	137	130	51	61	-	10	8
Social Sciences . . .	356	191	8	136	-	1	46
Other Sciences	193	182	82	55	-	6	39
Engineering	2,545	2,174	1,265	19	121	679	90
PERCENT DISTRIBUTION							
Total	100	83	24	21	9	21	8
Life Sciences	100	78	6	59	5	2	5
Physical Sciences . .	100	91	15	3	29	32	11
Environmental Sciences	100	80	12	-	3	50	15
Mathematics	100	92	54	12	4	1	21
Psychology	100	95	37	45	-	7	6
Social Sciences . . .	100	54	2	38	-	-	13
Other Sciences . . .	100	94	42	28	-	3	20
Engineering	100	85	50	1	5	27	4

[e] NSF estimate.

SOURCE: National Science Foundation, Detailed Statistical Tables, Federal Funds for Research, Development and Other Scientific Activities, Fiscal Years 1974, 1975 and 1976, Volume XXIV (NSF 75-323).

not hold true is Social Sciences, where over 45 percent of federal obligations from agencies other than these five.

2.3 Gross National Product (GNP) and Price Deflators

Since 1960, Total R&D Funding has been at a level of between two and three percent of GNP. The higher level was reached in 1964. The current level (1973-75) is 2.3 percent. R&D funds are projected to continue to account for a decreasing proportion of GNP.

For reference purposes the GNP implicit price deflators used throughout this report are combined on Table 2.47 with total GNP and the R&D percentage.

Table 2.47 GROSS NATIONAL PRODUCT, PERCENT R&D FUNDS AND GNP IMPLICIT PRICE DEFLATORS: 1960-1980

Year	GNP[1,2] (Billions of Dollars)	Total R&D Funds as % of GNP[3]	GNP Implicit Price Deflator	
			1958=100[1,2]	1967=100[3]
1960 . . .	503.7	2.7	103.29	87.84
1961 . . .	520.1	2.8	104.62	88.97
1962 . . .	560.3	2.8	105.78	89.96
1963 . . .	590.5	2.9	107.17	91.14
1964 . . .	632.4	3.0	108.85	92.57
1965 . . .	684.9	2.9	110.96	94.28
1966 . . .	749.9	2.9	113.94	96.90
1967 . . .	793.9	2.9	117.59	100.00
1968 . . .	864.2	2.9	122.30	104.01
1969 . . .	930.3	2.8	128.20	109.02
1970 . . .	977.1	2.7	135.24	115.01
1971 . . .	1,054.9	2.5	141.35	120.21
1972 . . .	1,158.0	2.5	146.12	124.26
1973 . . .	1,294.9	2.3	154.31	131.23
1974 . . .	1,396.7	2.3	170.11	144.66
1975 . . .	1,475.2	2.3	185.9	158.09
1976 . . .	1,680.5	2.2	198.4	168.72
1977 . . .	1,878.3	2.1	211.8	180.12
1978 . . .	2,065.2	2.0	226.4	192.53
1979 . . .	2,273.6	2.0	240.9	204.86
1980 . . .	2,499.1	1.9	256.3	217.96

SOURCE: [1] 1960-1974, *Economic Report of the President*, February 1975 GNP.
[2] 1975-1980, National Planning Association.
[3] Market Facts, Inc., Center for Quantitative Sciences.

SECTION 3

TRENDS IN PUBLISHING SCIENTIFIC AND TECHNICAL INFORMATION

This is a major section of the report because it deals with the composition, recording, reproduction and initial distribution functions of scientific and technical information as depicted in Figure 1.1. In this section we are primarily concerned with statistical indicators that deal with quantity and cost of primary publications in science and technology. Secondary publications such as abstract journals are covered in Section 5 of the report, Organization and Control.

This section is subdivided into four sub-sections dealing with the growth of the literature, and two sub-sections discussing costs associated with publishing scientific and technical information. The documenting forms covered in these sections include books, journals, technical reports, and other items. A final sub-section deals with numeric data bases, another informational medium.

The literature of science is growing and growing very rapidly. It is an important function of this report to present data that reliably indicate the magnitude of this growth. Data on literature growth have, of course, been presented by many other writers. Unfortunately, many of these data have been conflicting. Some studies of literature growth, too, have concentrated exclusively on a single documentary form (e.g., the scientific journal) while others have produced estimates of the growth of the primary literature that are derived largely from observations on the growth of the secondary literature. Anderla's (5) figures for literature growth, for example, are largely based on figures for the growth rate of some major abstracting and indexing services, those organizations that are members of the National Federation of Abstracting and Indexing Services (NFAIS). But these figures are not necessarily reliable indicators of the growth of the primary literature. Use of figures for growth of secondary publications as an indicator of the growth of primary publications pre-supposes that the former are growing at the same rate as the latter. One cannot necessarily assume this. In fact, an extremely important statistical indicator would be one that revealed a discrepancy between these two rates of growth.

In the NFAIS annual statistics the data base is not constant, because additional members have been added over the years. These statistics cannot be used as a reliable indicator of the growth of even the secondary publications unless they are corrected to account for the addition of new services in the NFAIS membership. The Anderla figures are not based on such a correction factor. It is our belief that Anderla intended the use of these data to be illustrative of statistical indicators, however, there is a tendency for others to use the data as fact because better data concerning growth of the journal literature are not available.

There are different dimensions to the growth of the scientific and technical literature as well as different documentary components in this rate of growth. There are at least three dimensions to be considered:

1. The number of items published
2. The number of copies of items published
3. The size of the items published

The importance of these three dimensions varies somewhat from one documentary form to another. In considering the growth of the book publishing industry, for example, we are concerned both with the number of items (titles) published and with the number of copies of these titles that are sold, but not on the size of each book in number of pages published. In considering the growth of the science journal, however, we are interested in the growth of each journal (in number of pages published per year) as well as in the growth of the periodical literature in terms of number of titles published. Furthermore, the number of articles published may be the most important indicator of all. The number of copies of each title that are sold each year (i.e., the number of subscribers) is also presented.

The growth figures presented in this section of the report are, we believe, the best that are available for various documentary forms and for various dimensions of literature growth. Although some of these data are more reliable than others, collectively they seem to form an accurate composite picture of the rate of literature growth.

3.1 Growth of the Book Literature

3.1.1 Number of Books Published Worldwide

The UNESCO Statistical Yearbook (145) presents estimates of world book production based on reports submitted by member countries. One problem with the UNESCO figures is that different countries may interpret the term "book" in various ways, although UNESCO does provide guidelines on this. The U. S. figures, for example, include Federal Government publications for only certain of the years and completely exclude publications of state and local governments. The UNESCO figures give an overall indication, however, of the growth in the number of book titles published on a worldwide basis. The figures for the thirteen year period 1960-1972 are presented in Table 3.1 for overall book production only. The UNESCO overall figures represent an average annual growth, in number of titles published, of about 3.7 percent for this period. That is, about 54 percent more titles were published in 1972 than were published in 1960. Although UNESCO does publish a subject breakdown, from which it would be possible to extract figures for science and technology, these figures cannot be used as good indicators of growth because the base (i.e., number of countries included) varies from year to year.

According to UNESCO guidelines, the figures for book production are supposed to include all printed non-periodical publications of the type that would appear in national bibliographies, including government publications, textbooks, theses, offprints, publications in series, and volumes of illustrations. The UNESCO guidelines exclude trade catalogs and other advertising publications, timetables, telephone directories, almanacs, musical scores, maps and charts. UNESCO defines book as a printed non-periodical publication of at least 49 pages, exclusive of cover pages. It is contrasted with the term pamphlet, which is defined as a printed non-periodical publication of at least five pages but not more than 48 pages. Clearly, this distinction is somewhat arbitrary.

It is likely, however, that certain national figures for book production will be more accurate than these international figures because of greater control and standardization in data collection. In particular, good figures are gathered by the publishing industry in the United States and in

Great Britain. These statistics are given in Table 3.2. Even these numbers must be viewed with some caution, however, because, at least in the U. S., changes have been made in the way in which the counts are made. The U. S. figures indicate an average annual increase in publication rate of about 7.4 percent in the period 1960-1974. That is, in 1974 about 172 percent more titles were being published than were published in 1960. In Britain the average annual increase in publication rate appears somewhat less: about 3.1 percent a year for the period 1960-1973. There are many fluctuations, however; the 1973 output was 6.4 percent greater than the 1972 output in Great Britain. By comparison, the 1972-1973 increase in output was about five percent in the United States. In the field of science and technology the rate of publication increase in the U. S. was 327 percent in the 1960-1974 period, which represents about a 10.9 percent increase per year during this period.

As the rate of publication increases one would also expect that the number of books available at any one time (i.e., in print) would also be increasing. Some evidence of this is available from the London firm of J. Whitaker & Sons. The Whitaker bibliography Scientific and Technical Books in Print (134) listed 8,800 titles in 1965; 11,285 in 1966: 13,507 in 1967; 14,981 in 1968; 25,589 in 1969; and 34,000 in 1972. The Whitaker compilation, then, indicates that in 1972 almost four times as many scientific and technical books were in print and available in England than were in print and available in 1965.

The statistical indicators for the Soviet printing industry were compiled from data in the report "Printing Activity in the USSR in 1972", published by the "Kniga" (Book) Publishing House, Moscow, 1974. It is the latest available issue of yearly publications on this subject.

The numerical data were compiled on the basis of the deposited copies of publications sent to the central "Palace of Books" and to similar agencies in the constituent republics. Every separately identified edition of a book or brochure, every volume of a collective series, every issue of a newspaper, journal, bulletin, sheet music, map, reproduction, etc. has been taken into account.

The statistical data are part of the governmental census; therefore, all types of publications are included, regardless of whether they are intended

Table 3.1 NUMBER OF BOOK TITLES PUBLISHED WORLDWIDE: 1960-1972

(Thousands)

Year	All Fields
1960 . . .	364
1961 . . .	380
1962 . . .	388
1963 . . .	399
1964 . . .	408
1965 . . .	450
1966 . . .	460
1967 . . .	478
1968 . . .	487
1969 . . .	496
1970 . . .	546
1971 . . .	548
1972 . . .	561

SOURCE: United Nations Educational, Scientific, and Cultural Organization, Statistical Yearbook, 1964-1972.

Table 3.2 NUMBER OF NEW BOOK TITLES AND EDITIONS PUBLISHED: 1960-1974

Year	Number of New Book Titles and Editions		
	U.S. All Fields	U.S. Science/Technical*	Great Britain: All Fields
1960	15,012	3,[illegible]79	23,783
1961	18,060	5,062	24,893
1962	21,904	6,153	25,079
1963	25,784	7,411	26,023
1964	28,451	8,871	26,154
1965	28,595	8,808	26,358
1966	30,050	9,808	28,883
1967	28,762	8,993	29,619
1968	30,387	9,613	31,420
1969	29,579	9,645	32,393
1970	36,071	11,659	33,489
1971	37,692	12,595	32,538
1972	38,053	13,042	33,140
1973	39,951	13,522	35,254
1974	40,846	14,442	-

* Based on Table 3.7, figures include science, medicine, sociology/economics and half of agriculture and philosophy/psychology.

Note: The figures are for trade publications and exclude government publications and university theses.

SOURCE: The Bowker Annual of Library and Book Trade Information, R.R. Bowker Company, 1962-1975.

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for the general public or are restricted to internal official distribution only. On the other hand, certain categories of official documents and instructions issued by lower bureaucratic levels and publications of clearly ephemeral interest are excluded. Certain other criteria, such as the minimum volume of the output and the involved printing technique, are also applied to eliminate publications from coverage. Thus, material reproduced by non-typographic methods, publications less than four pages and 100 copies, books in Braille, and so on, are usually not included in the compilation.

For comparison purposes, the tabulations contain references to earlier years, specifically 1940, 1950, 1960, 1965 and 1970.

The scientific and technical literature is not identified as a single item but is distributed among several categories. Popular science is shown as a separate class. As was to be expected, political education and propagandists' sheets (actually "agitator's notes") are emphasized. Technology is distributed among several headings.

Thus, the scientific and technical material is given as part of the overall printing effort of the USSR; the volume may be compiled by examining the columns which give the number of copies, the size of individual issues and the total number of pages printed during the year.

During 1972 a total of 82,795 books and brochures were printed. The 1,505,999,000 copies of these publications amounted to 15,639,515,000 printed pages, representing a total sales price of 663,356,000 roubles. (The current official change rate is one rouble = $1.45). There were also printed during the year 111,092 minor publications, broadsides, and so on, which as mentioned above, are not subject to bibliographic control and are not sent to depository libraries, involving 634,963,000 copies; 27,967 authors' abstracts of dissertations; 13 tear-off calendars, 14,005 drawings; 1,810 titles of sheet music and 304 cartographic publications.

The cumulated volume of publications in the Soviet Union during the 1918 to 1972 period amounted to 2,524,539 books and brochures, representing 39,581,000,000 copies and 337,253,500,000 pages. The average output per title was 15,700 copies.

Table 3.3 presents the output of books and brochures in the Soviet Union since 1940.

Table 3.3 NUMBER OF BOOK TITLES AND BROCHURE TITLES PUBLISHED IN THE USSR: 1940-1972

Year	Books & Brochures	Copies (Millions)	Pages Printed (Millions)	Average No. of Copies Per Item (000)	Average No. of Pages Per Item
1940. . .	45,830	462.2	2,848.3	10.1	6.2
1950. . .	43,060	820.5	6,980.3	19.0	8.5
1960. . .	76,064	1,239.6	12,461.1	16.3	10.1
1965. . .	76,101	1,279.3	12,994.5	16.8	10.2
1970. . .	78,875	1,309.6	13,953.5	16.6	10.7
1972. . .	82,795	1,506.0	15,639.5	18.2	10.4

SOURCE: Printing Activity in the USSR in 1972, "Kniga" (BOOK) Publishing House, Moscow, 1974.

During 1972 the average number of copies per individual title was 18200 and the average length amounted to 10.4 pages. This low number is probably due to the fact that books and brochures are reported as a unit.

The average daily publication rate in 1972 amounted to 4,126,000 copies of all books and brochures; this corresponds to 606 copies of books and brochures per 100 inhabitants during the year.

Information is available about the distribution of the publications among freely distributed and "for pay" items, and about the publishing authority (State Central Committees, government departments and agencies, institutes, ministries, consistuent republics of the Union, and "others", such as specialized publishing agencies).

It is of interest to note that the 82,795 separate titles have been published in a great variety of languages. As expected, the greatest number was published in one of the national languages of the Soviet Union (79,132 items), including 63,448 in Russian and 62 other languages. Among the 3,663 titles in non-Soviet languages, English was leading with 1,356 items. The rest included Amhara and Gujarati and most of Western European and the Soviet-Bloc languages but also Japanese and Chinese. French (485), German (459) and Spanish (274) were the most popular languages after English.

In addition to original papers, many translations were also published. The 8,818 items included 6,787 translated from the Soviet national languages, including 5,074 from Russian. In addition 663 translations from English, 281 from German and 167 from French were also published.

The subject matter of the 82,795 books and brochures is classified as given in Table 3.4.

Table 3.4 NUMBER OF BOOK TITLES AND BROCHURE TITLES PUBLISHED IN THE USSR BY SUBJECT: 1972

Subject Classification		Number of Titles
Political and Socio-Economic Literature		11,529
Natural Sciences and Mathematics		8,553
Technology, Industry, Transportation, Communication, Municipal Services		29,244
Agriculture		6,597
Commerce, Purchasing, Supply Activities		815
Health Protection and Medicine		3,396
Physical Education and Sports		713
Cultural and Educational Activities, Science		4,130
Linguistics		2,311
Literary Studies		1,230
Fiction, including Children's Literature		7,225
Russian	3,142	
Other USSR Nationalities	3,324	
Foreign Countries	759	
Art		2,214
Printing, Book Trade, Bibliography		2,833
TOTAL		82,795

SOURCE: Printing Activity in the USSR in 1972, "Kniga" (BOOK) Publishing House, Moscow, 1974.

Detailed information is available concerning the number of copies printed in the individual categories, the total number of pages, the average number of copies per title and the average number of pages per item. The data are also compared with those from 1940, 1950, 1960, 1965 and 1970.

An interesting communication indicator is the extent of international trade in publications. Figures for book imports/exports to and from the United States are given in Table 3.5. It is interesting to note from this table that the number of new editions and titles imported into the United States has been erratic and, in fact, the total imported in recent years is actually less than the total imported in the mid 1960's. Nevertheless, the total dollar value of book imports has increased regularly over the years (an increase in value of about 400 percent between 1961 and 1973) and the dollar value of imports has been increasing more rapidly than the dollar value of exports. Note, however, that these figures represent only shipments valued at $250 or more and that they refer to book shipments in general and not just shipments in science and technology. The dollar figures also reflect inflationary trends and cannot be used as precise indicators of the amount of trade in number of copies. Comparative figures for imports and exports will also fluctuate considerably with changes in rates of foreign exchange.

It is noted that the imports for science and technology has grown substantially more from 1960 to 1974 than imports for all new titles and editions. These two figures are 389 percent and 61 percent increases respectively. The proportion of science and technology books in 1960 to the total number of books in 1960 was about 19 percent and this number grew to 58 percent in 1974. Further discussion concerning books publications in the United States is given in the following sections.

3.1.2 Number of Scientific and Technical Books Published in the United States

The principal source of information concerning the growth of scientific and technical book publishing is the Bowker Annual (18). The total number of scientific and technical book titles from this source is based on the following classifications (with Dewey Decimal Numbers): Agriculture (630-639; 712-719); Medicine (610-619); Philosophy and Psychology (100-199); and Technology (600-609, 620-629, 660-699). Only half of the titles in Agriculture and Philosophy and Psychology were included. The total number of book titles published in science and technology according to these calculations is given in Table 3.6, with the breakdown by field shown in Table 3.7.

Table 3.5 IMPORT AND EXPORT OF BOOKS: 1960-1974

Number of Books	U.S. Imports, All Fields ($ millions)	U.S. Exports, All Fields ($ millions)	U.S. Imports (new titles & editions)	U.S. Imports (science & technology)
1960	-	-	2158	411
1961	26.763	62.876	-	-
1962	33.447	70.733	2051	928
1963	38.747	77.746	2161	956
1964	43.898	88.642	4797	1931
1965	48.767	99.322	4670	1986
1966	61.525	120.803	6347	2785
1967	69.242	143.193	4852	2172
1968	68.392	151.623	4307	1905
1969	78.353	166.141	4103	1836
1970	92.023	174.937	4459	1977
1971	100.994	176.662	3882	1777
1972	136.937	172.115	3850	1930
1973	133.861	194.516	3283	1758
1974	-	-	3478	2008

Note: Data on dollar value of shipments is based only on shipment valued at $250 or more. It has been estimated by industry economists that the total values may be low by about 10% to 25% for imports and by about 50% for exports.

SOURCE: The Bowker Annual of Library and Book Trade Information, R. R. Bowker Company, 1962-1975.

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TABLE 3.6 NUMBER OF SCIENTIFIC AND TECHNICAL BOOK TITLES PUBLISHED IN THE UNITED STATES: 1960-1980

Year	Number of Titles Published[1]	Number of Scientists and Engineers[2] (Millions)	Number of Titles Per S/E[3] (10^{-3})	Number of Titles Per S/E Lagged 3 Years[3] (10^{-3})
1960	3,379	1.159	2.92	3.35
1961	5,062	1.210	4.18	4.83
1962	6,153	1.272	4.84	5.52
1963	7,411	1.346	5.51	6.39
1964	8,871	1.396	6.36	7.33
1965	8,808	1.442	6.11	6.92
1966	9,808	1.501	6.53	7.29
1967	8,993	1.578	5.70	6.44
1968	9,613	1.649	5.83	6.67
1969	9,645	1.725	5.59	6.43
1970	11,659	1.797	6.49	7.39
1971	12,595	1.834	6.87	7.64
1972	13,042	1.871	6.97	7.56
1973	13,522	1.923	7.03	7.52
1974	14,442	1.973	7.32	7.87
		PROJECTIONS		
1975	14,277	2.026	7.05	7.63
1976	14,753	2.081	7.09	7.67
1977	15,228	2.138	7.12	7.72
1978	15,798	2.195	7.20	7.80
1979	16,274	2.255	7.22	7.82
1980	16,884	2.314	7.30	7.90
		PERCENT CHANGE		
1960-65	161	24	109	107
1965-70	32	25	6	7
1970-75	22	13	9	3
1975-80	18	14	4	4

SOURCE: [1]Based on Table 3.7: Agriculture x.5, Sociology & Economics, Medicine, Science, Technology, and Philosophy & Psychology x.5.

[2]Taken from Table 2.25.

[3]Market Facts, Inc., Center for Quantitative Sciences.

Table 3.7 NUMBER OF BOOK TITLES PUBLISHED BY SIX CLASSIFICATIONS OF SCIENCE: 1960-1980

Year	Agriculture	Sociology and Economics	Medicine	Science	Technology	Philosophy and Psychology
1960 . . .	156	754	520	1,089	698	480
1961 . . .	231	1,613	776	1 [illegible]4	781	565
1962 . . .	283	2,059	952	1,743	931	653
1963 . . .	286	2,487	1,054	2,211	1,157	719
1964 . . .	285	3,272	1,211	2,738	1,125	766
1965 . . .	270	3,242	1,218	2,562	1,153	979
1966 . . .	287	3,482	1,446	2,958	1,333	892
1967 . . .	287	3,611	1,189	2,367	1,252	863
1968 . . .	249	4,070	1,277	2,407	1,262	946
1969 . . .	260	4,462	1,190	2,353	1,035	951
1970 . . .	265	5,912	1,476	2,358	1,141	1,280
1971 . . .	324	6,095	1,655	2,697	1,309	1,354
1972 . . .	390	6,415	1,839	2,586	1,425	1,164
1973 . . .	382	6,565	2,002	2,714	1,347	1,406
1974 . . .	391	6,640	2,281	3,049	1,593	1,368
			PROJECTIONS*			
1975 . . .	400	6,858	1,932	3,148	1,507	1,319
1976 . . .	447	7,109	1,714	3,501	1,582	1,334
1977 . . .	426	7,285	1,680	3,576	1,765	1,261
1978 . . .	412	7,310	1,956	3,580	1,834	1,308
1979 . . .	495	7,413	1,929	3,859	1,957	1,256
1980 . . .	460	7,740	2,055	4,114	2,109	1,332
			PERCENT CHANGE			
1960-65 .	73	330	134	135	65	104
1965-70 .	-2	82	21	-8	-1	31
1970-75 .	51	16	31	34	32	3
1975-80 .	15	13	6	31	40	1

* Market Facts, Inc., Center for Quantitative Sciences.

SOURCE: The Bowker Annual of Library and Book Trade Information, Editions 8-20. R. R. Bowker Company, 1962-1975.

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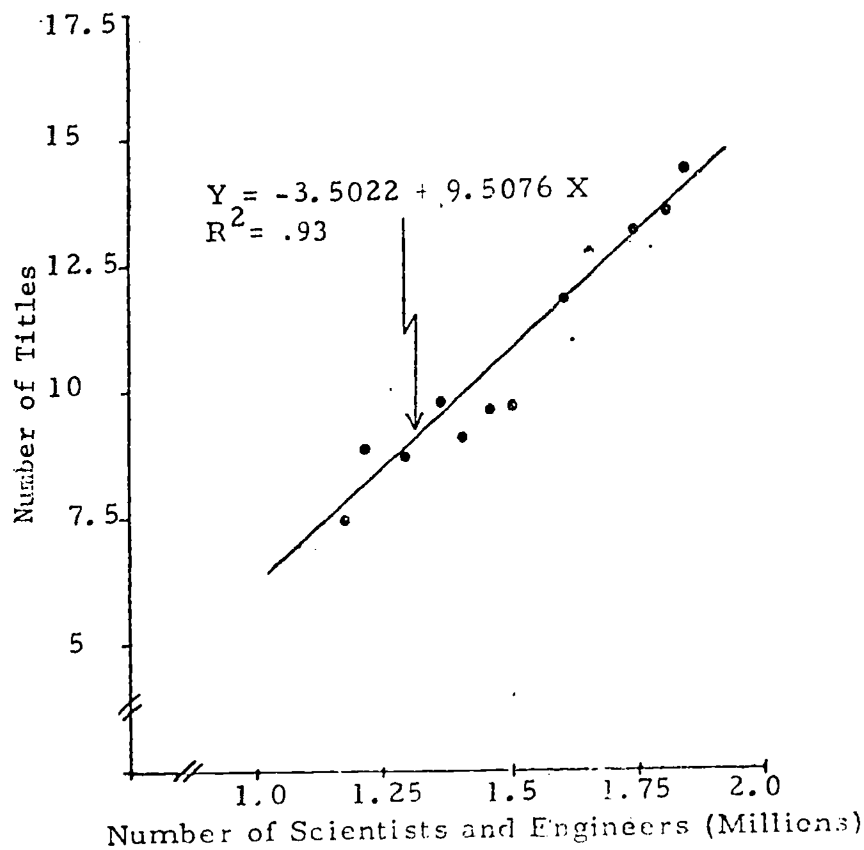
In Table 3.6, the number of scientists and engineers and the number of titles per scientist and engineer are also given along with forecasts made for the years 1975 through 1980. The forecasts of the number of titles are based on the number of scientists and engineers. It was assumed that it takes about three years to write and publish a book so that it makes sense to use a three year lag for the purpose of forecasting.* That is, the number of titles published in 1960 is based on the number of scientists and engineers in 1957 (1 million), 1961 titles on 1958 scientists and engineers (1.05 million), 1962 titles on 1959 scientists and engineers (1.11 million) and so on. The number of titles published are plotted against the number of scientists and engineers (lagged three years) in Figure 3.1.

Figure 3.1 NUMBER OF U. S. SCIENTIFIC AND TECHNICAL BOOK TITLES AS A FUNCTION OF SCIENTISTS AND ENGINEERS (LAGGED THREE YEARS)



SOURCE: Market Facts, Inc.
Center for Quantitative Sciences

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*Other intervals of time up to six years were tested but the best fit of the data was a ghree year period.

A linear model was fit to the data in order to provide a means of forecasting number of book titles published in the future. The model is as follows:

$$\hat{Y} = -3.50 + 9.51X$$

where: $\hat{Y}$ is the estimated number of book titles published (in thousands)

X is the number of scientists and engineers three years hence (in millions)

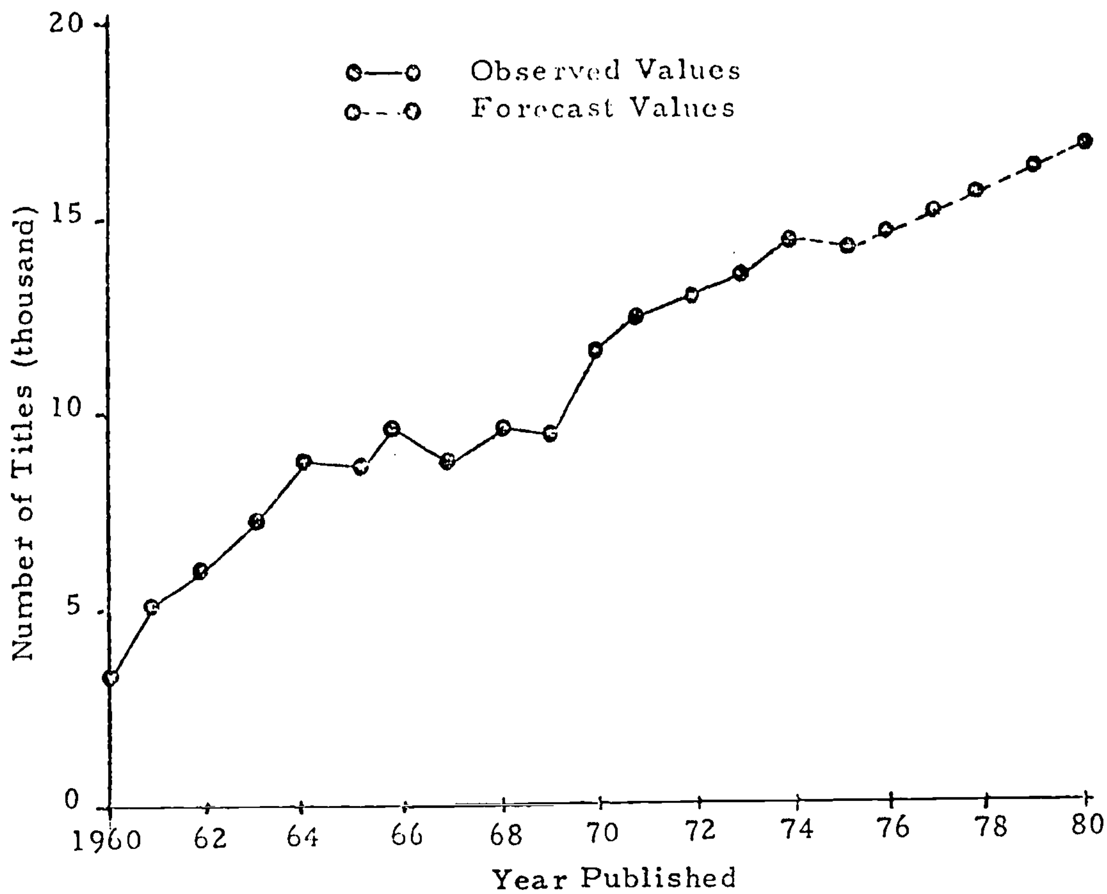
It is noted that the model is one that is merely fit to the data by a method of least squares and that it cannot be interpreted literally. For example, the model implies that there would be a negative number of book titles published if the number of scientists and engineers were fewer than 0.37 million persons. The model does illustrate, however, that both absolute and relative book productivity by scientists and engineers is increasing.

The actual productivity is expressed in Table 3.6 by the number of book titles produced per scientist and engineer. There was a very large increase from 1960 to 1964, followed by an extended period of levelling off. The forecast through 1980 suggests a gradual increase in book titles per scientist and engineer. The number of titles published is expected to increase about 18 percent from 1975 to 1980 and the productivity per scientist and engineer is anticipated to increase about four percent.

If the above model is applied to forecast the number of book titles published from 1975 through 1980, the figures given in Table 3.6 are obtained. These data are in Figure 3.2, along with the number of book titles published from 1960 up to 1974.

The rate of increase of the number of book titles published is expected to increase steadily over the 1975 to 1980 period at about 3.2 to 3.7 percent per year.

Figure 3.2 NUMBER OF SCIENTIFIC AND TECHNICAL BOOK TITLES PUBLISHED IN U. S.: 1960-1980



SOURCE: Table 3.6.

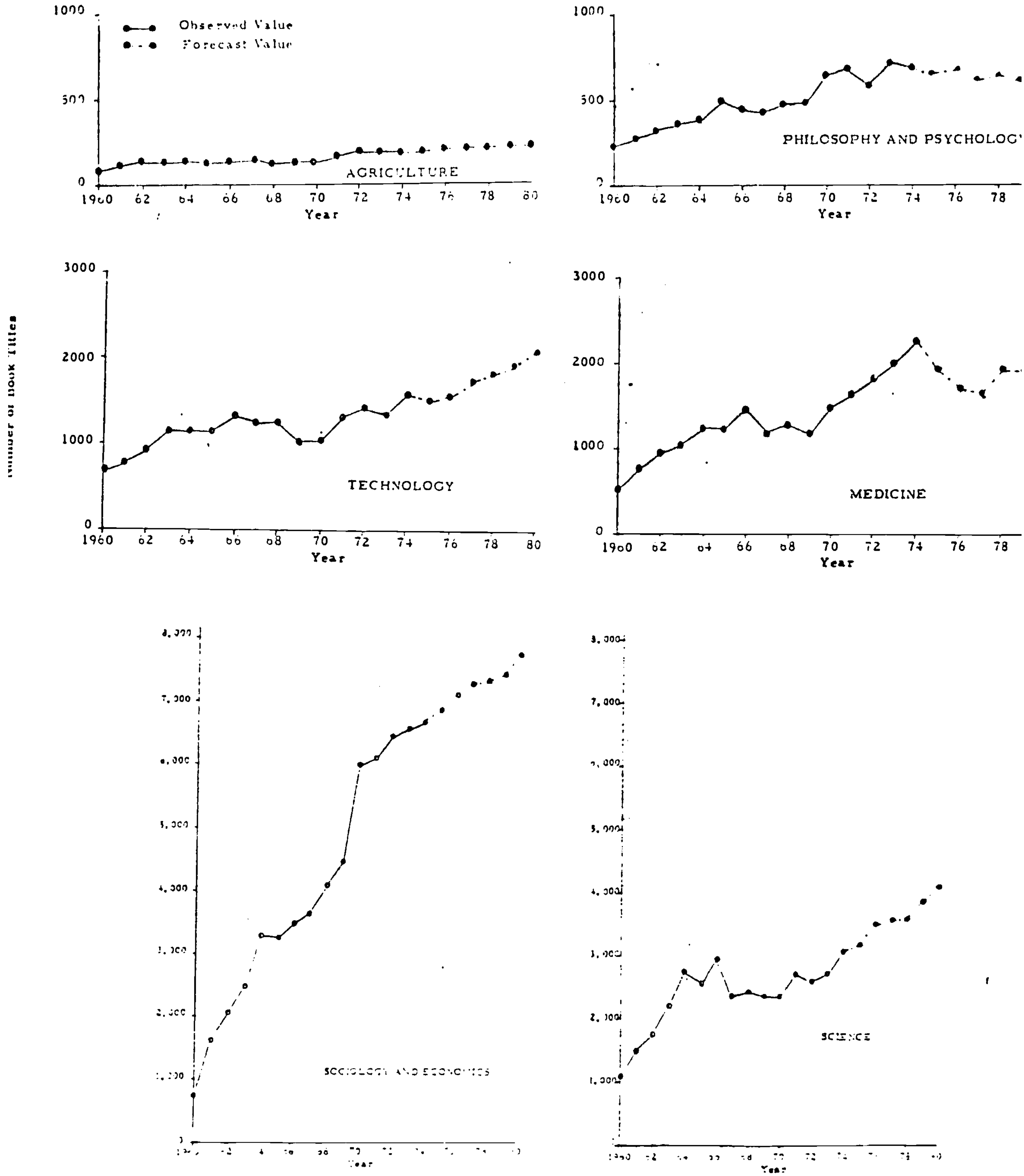
Data on books published do not exist for the nine specific fields of science of interest to us. However, the classification used by Bowker can be manipulated to roughly approximate six of the fields of science. The number of book titles published in those fields is shown in Table 3.7. It is noted that there are substantial differences among the fields in the number of book titles published as well as the rate of growth. The rate of growth for sociology and economics, nearly ten fold in the past fifteen years, is clearly the greatest. The pattern of growth from 1960 to the present seems to be fairly consistent among the six fields of science. The growth from 1960 to 1965 was very large, ranging from 65 percent in technology up to 330 percent in sociology and economics. The next five years (1965-1970) dampened out considerably, however. The growth (or decline) ranged from -8 percent in science to 82 percent in sociology and economics. The next five year period resulted in a recovery and moderate growth in all classes except philosophy and psychology, where the increases went from 104 to 31 down to four percent over the three five year periods. The remaining classes ranged in growth from 17 percent in sociology and economics up to 52 percent in agriculture. It is interesting to note that the science class of sociology and economics is overwhelmingly the largest class in terms of magnitude as well as growth. However, as will be shown later, this class of science makes moderate contributions to the journal literature.

In order to forecast the number of book titles published in each of the six classes, we ran a stepwise multiple regression on data from each class. The independent variables used for each class included number of scientists (lagged three years), number of Ph.D's., Federal obligations for research (lagged six years), and Federal obligations per scientist and engineer (lagged three years). Where there was a substantial amount of colinearity, some of these variables were discarded in our final equations. Correlation coefficients for the six classes ranged from .89 in engineering to .99 in sociology and economics. The results of the forecasts made (shown in Figure 3.3) indicate moderate growth over the 1975 to 1980 period, ranging from five percent in philosophy and psychology to 46 percent in technology.

3.1.3 Distribution and Price of the Book Literature

There is not a really good sour :e for determining the distribution of books in terms of number of copies. Thus, we have derived this number by dividing the average price into the receipts reported by Bowker. Though not an entirely satisfactory procedure, this does provide a reasonable indicator of trends in the number of copies distributed, average number of copies per title and average number of copies distributed per scientist and engineer. The average price of scientific and technical books was derived from the average prices reported for each of the six scientific classes mentioned above. The average was found by summing the product of prices and number of book titles published annually over the six classes and dividing the total number of book titles published annually. It is noted that the estimat of average price up to 1970 were based on titles published from 1971 on copies sold. However, this does not appear to distort the trend over time in either

Figure 3.3 NUMBER OF SCIENTIFIC AND TECHNICAL BOOK TITLES PUBLISHED BY SIX CLASSIFICATIONS: 1960-1980



SOURCE: R.R. Bowker Company (1960-1974)
Market Facts, Inc., Center for Quantitative Sciences (1975-1980)

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the overall average price or for individual classes of science (given later). The overall average prices and the remaining information related to book distribution are given in Table 3.8. The average price in current dollars increases steadily from 1960 to 1974, but in constant dollars the increases have not been quite so dramatic. The average price in current dollars is plotted in Figure 3.4 with an exponential curve fit to the observations. This curve is as follows:

$$\log \hat{Y} = 0.903 + .023X$$

where: $\hat{Y}$ is the estimated average price

X is the year published (0 is 1960, 1 is 1961 . . . .)

Even though the 1975 forecast may be low, the overall trend appears to be reasonable based on the past observations. If this trend holds, one would expect average prices in current dollars to increase about 31 percent from 1975 to 1980 and decrease slightly in constant dollars. This forecast, however, is highly tenuous since it is subject to the vagaries of the nation's economy and inflation.

Total receipts for book sales are also shown in Table 3.8, and plotted in Figure 3.5. The trend is computed to be:

$$\hat{Y} = 53.3 + 10.8X$$

wher :

$\hat{Y}$ is the estimated total receipts in millions of dollars

X is the year published (0 is 1960, 1 is 1962 . . . .)

Receipts have increased steadily since 1960, and this trend is expected to continue. However, when one looks at the receipts per title the picture takes on a new appearance.

The total receipts per title figure was derived by dividing the total receipts by the number of book titles published as shown in Table 3.8.

Table 3.8 AVERAGE PRICE, RECEIPTS, AND NUMBER OF COPIES OF SCIENTIFIC AND TECHNICAL BOOKS PUBLISHED IN THE U.S.: 1960-1980

Year	Number of Titles[1]	Average Price[2] (Current $)	Average Price (Constant $)	Receipts[3] (Millions $)	Receipts/ Title[4] (Thousands $)	Number of Copies[4] (Millions)	Average Copies/ Title[4]	Number of Scientists & Engineers[5] (Millions)	Average Copies/ S&E[4]
1960 . . .	3,379	8.54	9.72	69.1	20.44	8.09	2,394	1.159	6.98
1961 . . .	5,062	8.51	9.56	73.1	14.44	8.59	1,697	1.210	7.10
1962 . . .	6,151	8.84	9.83	77.2	12.55	8.73	1,419	1.272	6.86
1963 . . .	7,411	10.13	11.11	81.2	10.96	8.02	1,082	1.346	5.96
1964 . . .	8,871	9.67	10.45	90.4	10.19	9.35	1,051	1.394	6.70
1965 . . .	8,808	10.60	11.24	95.2	10.72	8.98	1,019	1.442	6.73
1966 . . .	9,808	10.86	11.15	109.6	11.17	10.10	1,079	1.501	6.73
1967 . . .	8,993	10.81	10.81	124.3	13.82	11.51	1,279	1.578	7.29
1968 . . .	9,613	11.12	10.69	134.8	14.02	12.12	1,260	1.649	7.35
1969 . . .	9,645	11.20	10.27	149.6	15.51	13.36	1,385	1.725	7.75
1970 . . .	11,657	13.92	12.10	158.3	13.58	11.37	975	1.797	6.33
1971 . . .	12,595	16.84	14.01	174.7	13.87	10.37	823	1.834	5.65
1972 . . .	13,047	16.45	13.24	168.8	14.48	11.48	880	1.671	6.13
1973 . . .	13,522	14.20	10.82	199.2	14.73	14.03	1,037	1.923	7.30
1974 . . .	14,442	18.43	12.74	210.0	14.54	11.39	789	1.973	5.77
				PROJECTIONS[4]					
1975 . . .	14,277	17.89	11.37	215.9	15.12	12.07	845	2.026	5.96
1976 . . .	14,753	18.88	11.19	226.7	15.37	12.01	814	2.081	5.77
1977 . . .	15,728	19.93	11.06	237.6	15.60	11.92	783	2.138	5.58
1978 . . .	15,798	21.02	10.92	248.4	15.72	11.82	748	2.195	5.38
1979 . . .	16,274	22.19	10.83	259.3	15.93	11.69	718	2.255	5.18
1980 . . .	16,884	23.39	10.73	270.1	16.00	11.55	684	2.314	4.99
				PERCENT CHANGE					
1960-65 .	161	24	16	38	-48	11	-57	24	-11
1965-70 .	32	24	8	66	27	8	-4	25	2
1970-75 .	22	29	-6	36	11	2	-13	13	-6
1975-80 .	18	31	-5	25	6	-4	-19	14	-16

*GNP price deflator (1975-1980 MPA) used to obtain 1967 Constant Dollars.

SOURCE: [1]Based on Table 3.7; figures represent science, medicine, sociology/economics and half of agriculture and philosophy/psychology.

[2]Based on Table 3.9.

[3]The Bowker Annual of Library and Book Trade Information, Editions 8-20, R.R. Bowker Company, 1962-1975. (Note: Adjusted to exclude vocational books.)

[4]Market Facts, Inc., Center for Quantitative Sciences.

[5]Taken from Table 2.25.

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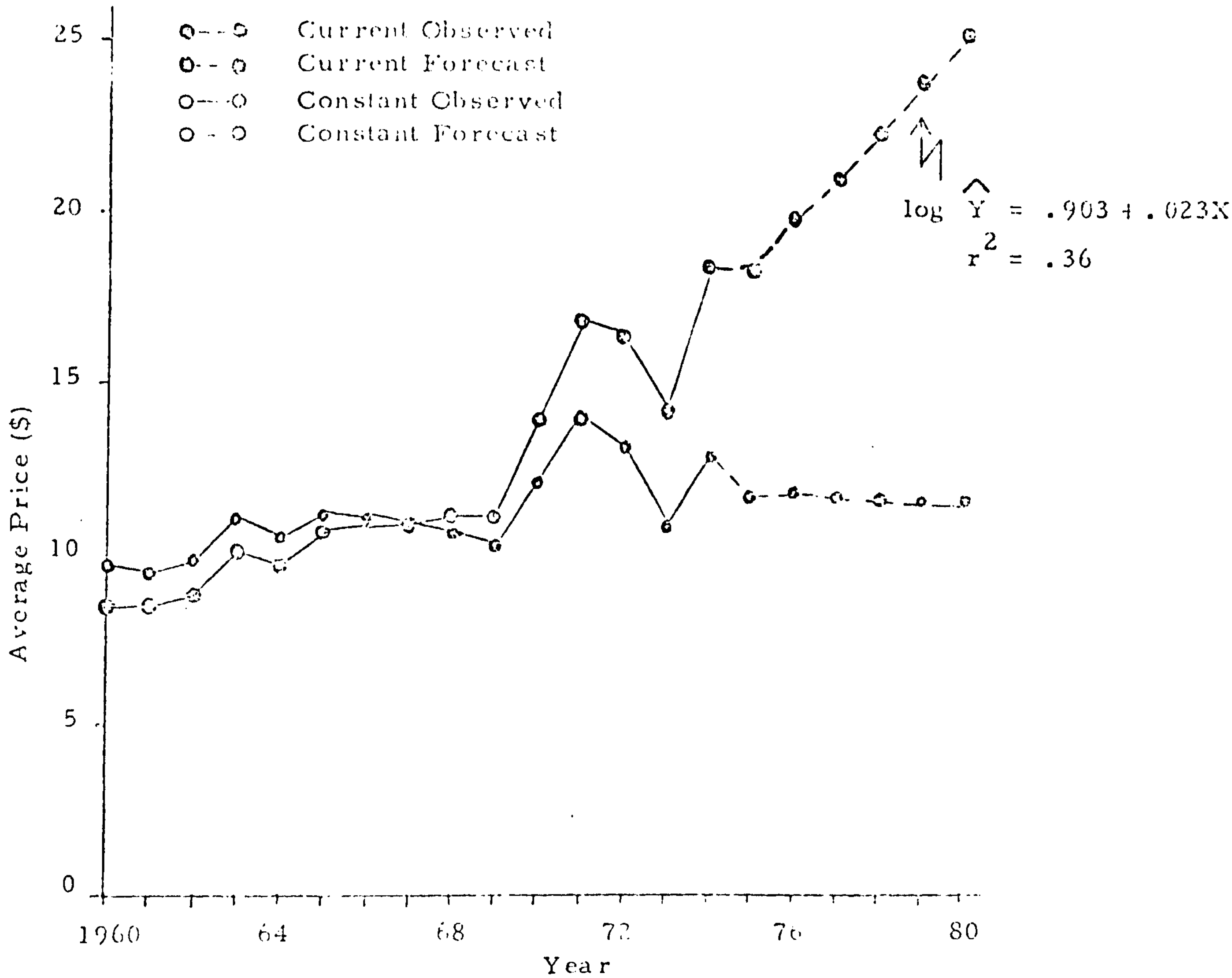
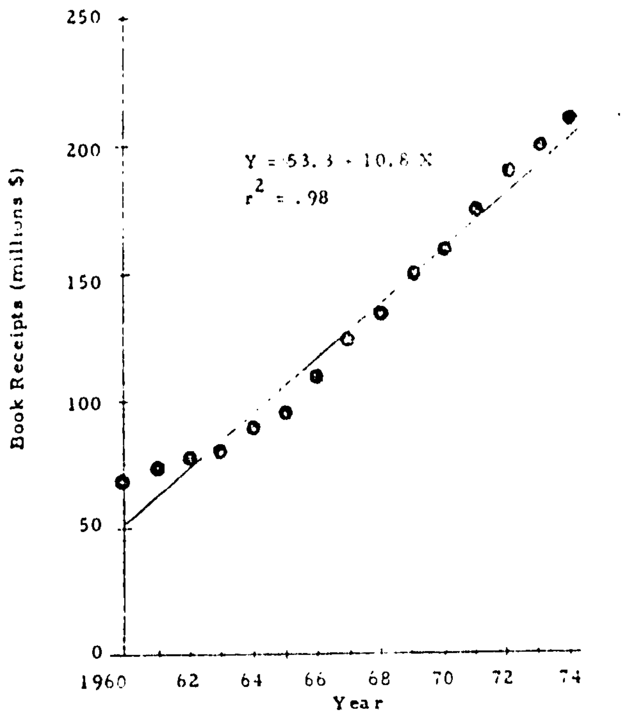
Figure 3.4 PRICE PER SCIENTIFIC AND TECHNICAL BOOK TITLE: 1960-1980



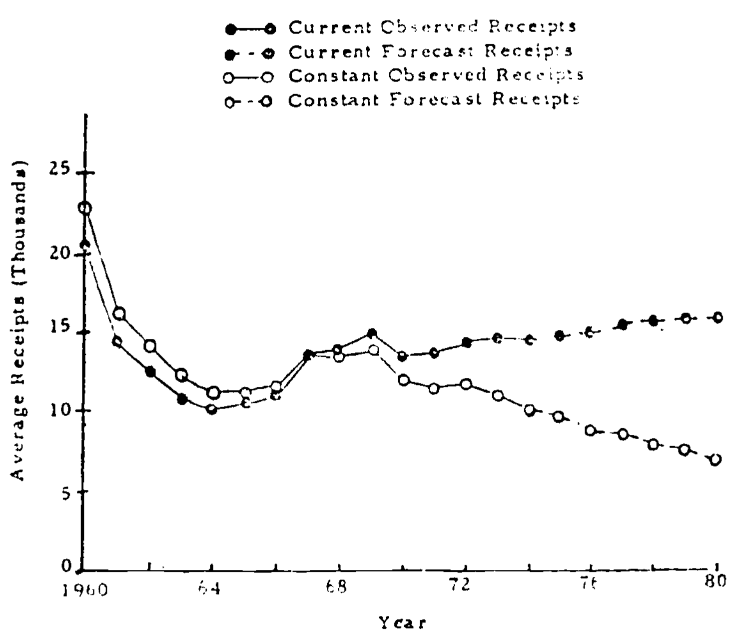
SOURCE: Table 3.8

Figure 3.5 TOTAL RECEIPTS FOR SCIENTIFIC AND TECHNICAL BOOK TITLES AS A FUNCTION OF TIME



SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Figure 3.6 RECEIPTS PER SCIENTIFIC AND TECHNICAL BOOK TITLE: 1960-1980



SOURCE: Table 3.8.

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These figures are in the $10,000 to $15,000 range and have remained fairly stable over the years. Current and constant dollar receipts per title are shown in Figure 3.6. These indicate a substantial decline in constant terms, and are quite significant. If the constant dollar cost of producing books does not also decline over the years (for example, due to reduced number of pages per book), the book publishers will be hurt by reduced profits or possibly even losses. Data are not available from secondary sources to verify this hypothesis but it is anticipated that the publishing study underway by the New York University (73) will address this phenomenon in more detail.

One reason that the receipts per title are down apparently is that, as shown in Table 3.8, fewer copies per title are being sold. The average number of copies sold per title has decreased rather steadily over the entire period of time from 1960 to 1974. Overall, the figure has decreased 67 percent. We note over the same time period the number of titles produced per scientist and engineer has increased 151 percent while the number of copies sold per scientist and engineer has decreased by 17 percent.

Computations of the average number of copies sold per scientist and engineer for 1975 to 1980 show a continued decline, down to five by 1980. One also might project this figure based on the expected negative correlation with average constant dollar price. The equation in this case (shown in Figure 3.7) would be:

$$\log \hat{Y} = 1.10 - .025X$$

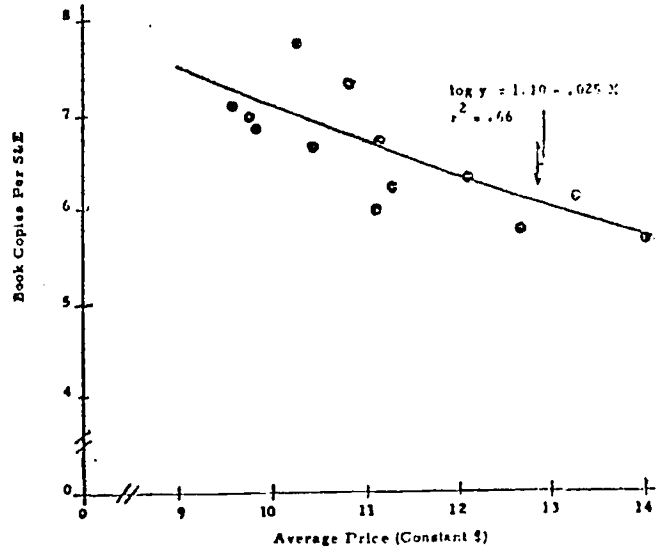
where:

$\hat{Y}$ is the estimated number of copies per scientist and engineer

X is the average constant dollar price

The correlation coefficient obtained is 0.8_. Projections based on this equation indicate a slightly increasing number of copies per scientist to 1980, going from 5.96 copies in 1975 to 6.82 copies in 1980. These figures appear less reliable than our earlier calculations.

Figure 3.7 NUMBER OF S&T BOOK COPIES SOLD PER SCIENTIST AND ENGINEER AS A FUNCTION OF THE AVERAGE PRICE OF A BOOK IN CONSTANT DOLLARS



SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

The magnitude of the number of books published per scientist seems, to us, to be quite high. It appears that there are about eight copies distributed for each scientist and this number is low since it represents only hard copy book volumes. Many of the copies are purchased by libraries to be used by a community of scientists. Thus, it would seem that many more copies of books are distributed than are likely to be read by scientists so that a further shakedown may occur in the book industry. We feel that two things are likely to happen. First fewer books will be accepted by the publishers and secondly either drastic cost reduction will take place or prices will have to increase in which case demand will be reduced further.

Table 3.9 shows the average prices for books published in the six classes of science designated by Bowker. Again, it is noted that there are substantial differences among classes in both the magnitude of the average prices and in the rate of increase. The total average price of books has increased 116 percent in current dollars and 31 percent in constant dollars over the 1960 to 1974 period. These increases are equivalent to average annual increases of 5.6 and 2.0 percent respectively.

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Table 3.9 AVERAGE PRICE OF SCIENTIFIC AND TECHNICAL HARDCOVER BOOKS: 1960-1980

Year	Agriculture		Social Science & Economics		Medicine		Science		Technology		S&T Total[1]	
	Current $	Constant $	Current $	Constant $	Current $	Constant $	Current $	Constant $	Current $	Constant $	Current $	Constant $
1960 . . .	5.96	6.79	6.19	7.05	8.41	9.57	10.21	11.62	8.89	10.12	8.54	9.72
1961 . . .	7.66	8.61	6.75	7.59	9.40	10.56	9.06	10.18	10.38	11.67	8.51	7.57
1962 . . .	6.39	7.10	6.59	7.33	9.87	10.97	10.30	11.44	10.46	11.62	8.84	9.83
1963 . . .	7.60	8.33	8.70	9.54	10.98	11.50	11.22	12.31	10.69	11.72	10.13	11.11
1964 . . .	7.69	8.31	7.63	8.24	11.22	12.12	10.99	11.87	11.02	11.90	9.67	10.45
1965 . . .	8.04	8.53	8.43	8.94	11.88	12.60	12.13	12.87	12.30	13.05	10.60	11.24
1966 . . .	8.37	8.63	9.08	9.37	12.37	12.77	11.72	12.09	12.51	12.91	10.86	11.21
1967 . . .	8.90	8.90	8.65	8.65	12.78	12.78	12.15	12.15	12.86	12.86	10.81	10.81
1968 . . .	10.23	9.84	9.68	9.31	12.55	12.07	11.90	11.44	12.93	12.43	11.12	10.69
1969 . . .	8.97	8.[illegible]	9.65	8.85	13.89	12.74	11.96	10.97	13.37	12.26	11.20	9.74
1970 . . .	10.42	9.06	12.38	10.76	18.05	15.69	14.95	13.00	14.91	12.96	13.92	12.10
1971 . . .	13.64	11.35	17.47	14.53	17.58	14.62	15.94	13.26	15.28	12.71	16.84	14.01
1972 . . .	10.94	8.50	16.93	13.62	16.19	13.03	16.05	12.92	16.11	12.96	16.45	13.24
1973 . . .	11.79	8.98	12.22	9.31	15.92	12.13	17.34	13.21	15.38	11.72	14.20	10.92
1974 . . .	13.21	9.13	17.47	12.08	18.92	13.08	20.83	14.40	17.74	12.27	18.43	12.74
PROJECTIONS[1]												
1975 . . .	13.16	8.32	17.30	10.94	18.91	11.36	21.28	13.46	17.42	11.02	18.40	11.64
1976 . . .	13.64	8.08	18.92	11.21	19.61	11.62	22.68	13.44	17.97	10.65	19.75	11.71
1977 . . .	14.12	7.84	20.32	11.28	20.31	11.26	24.17	13.42	18.52	10.28	20.96	11.64
1978 . . .	14.60	7.58	21.88	11.36	21.01	10.91	25.75	13.37	19.07	9.90	22.25	11.56
1979 . . .	15.08	7.36	23.50	11.47	21.71	10.60	27.44	13.39	19.62	9.58	23.63	11.53
1980 . . .	15.56	7.14	25.23	11.58	22.40	10.28	29.24	13.42	20.17	9.25	25.09	11.51
PERCENT CHANGE												
1960-65 .	35	26	36	27	41	32	19	11	38	29	24	16
1965-70 .	30	6	47	20	52	25	23	1	21	-1	31	8
1970-75 .	26	-8	40	2	5	-24	42	4	17	-15	32	0
1975-80 .	18	-14	46	6	18	-14	37	0	16	-16	36	-1

* Used GNP implicit price deflator (1975-1980 NSA) to obtain 1967 Constant Dollars.

[1] Market Facts, Inc., Center for Quantitative Sciences.

SOURCE: The Bowker Annual of Library and Book Trade Information, Editions 9-20, R. R. Bowker Company, 1967-1975. Price Data 1960-1970 based on Average Price Per Title, 1971-1974 based on Average Price Per Volume Sold.

3.2 Growth of the Scientific and Technical Journal Literature

One of the most elusive estimates that we have dealt with in this study is the total number of scientific and technical journals published in the world and in the United States. The difficulties encountered with making these estimates are twofold. First, there is a major question of definition as to what publications should be included or excluded in terms of their scientific and technical content, scholarly quality, and periodicity of publication. Secondly, many of the estimates that have been made in the past are based on available information from existing holdings and these data are not reliable because they do not exclude journals that have become extinct. The reason, of course, that they do not purge these journal titles from their lists is that the lists serve as a reference tool. In order to cope with the definitional difficulties encountered with making estimates of the number of journals, we present two estimates of scientific and technical journals published in the United States. The first is a narrow definition that includes only scholarly journals and the other is all-inclusive.

The next two sections provide estimates of the number of scientific and technical journals published worldwide and in the United States. Further sections concerning journals deal with the time required to publish journal articles (3.2.3), and journal distribution methods and prices (3.2.4 - 3.2.8).

3.2.1 Number of Scientific and Technical Journals Published Worldwide

To illustrate the exponential growth of scientific journals, Price (121) showed the number of journals from approximately the years 1660 to 2000. He estimated that there were nearly 50,000 journals in existence by the beginning of the present century. However, he warned that this figure represents the total number of journals ever published, and therefore, also includes those which have become extinct. He estimated live worldwide journals published in 1963 to be about 30,000.

Bourne (17), writing in 1962, estimated this population to be in the range of 30,000 to 35,000 titles. Other estimates of 30,000 to 40,000 journals appear to be based on the World List of Scientific Periodicals (154), which lists approximately 60,000 entries for 1960. However, according to Gottschalk and Desmond (55), at least 33 percent of this 1960 figure consists of deceased titles. Barr (9) feels that e mortality rate is even higher and that only about 40 percent of the 1960 figure (i.e., 24,000) represents actual live titles. In addition to the inclusion of deceased journals, the World List of Scientific Periodicals represents an inflated figure because of a loose interpretation of the term "scientific serial". Its definition extends to house organs, manuals, reviews, p e-prints, research papers, other technical report literature, and so Therefore, it is probable that the number of live titles included in the 1960 figure is considerably less than 24,000.

In a study for the Science and Technology Division of the Library of Congress, published in 1962, Gottschalk and Desmond (55) attempted to produce an accurate count of scientific and technical periodicals. In defining "scientific and technical serial"*, they tried to be as unrestrictive as possible. A serial or periodical was defined as "a publication intended to be continued indefinitely," but they omitted such categories as promotional literature or house journals, technical report literature, and proceedings (conferences) of international organizations. Also excluded were cover to cover translations, publishers' series (which are actually monographs), administrative reports of organizations, college bulletins (devoid of significant scientific and technical content) and other publications considered of little value to science and technology.

For purposes of the Gottschalk and Desmond study, science and technology comprised the natural, physical, and engineering sciences. Social sciences were excluded, but the behavioral science of psychology was included, and so were some borderline subjects. For example, a journal covering the historical aspects of anthropology was excluded, but a journal devoted to anthropology was included.

To conduct their census, Gottschalk and Desmond decided to comb the most comprehensive and recent serial listings of each country for current titles. For the United States they covered:

* In keeping with the writings of other authors and those mentioned in this section, the term "serial" will be used interchangeably with "periodical" throughout this discussion.

- *Ayers Directory*
- *Monthly Catalog of United States Government Publications*,
- *Monthly Checklist of State Publications*, and
- *Scientific and Technical Societies of the United States and Canada.*

Gottschalk and Desmond identified the main publishing countries of scientific and technical periodicals in 1961 as:

United States	6200 titles
Germany (East and West)	3500
Japan	2800
France	2800
USSR	2200
United Kingdom	2200
. . . . World	35000 ± 10%

Six years after the Gottschalk and Desmond census, K. P. Barr of the then National Lending Library (NLL) wrote an article (9) contesting the "Worldwide Census" figure of 35,000. Barr suggested that a more realistic figure was 26,000 titles. This estimate was based on the number of journals "currently received or on order" by the National Lending Library in Great Britain, whose goal is to collect all periodicals "which contain at any time matter of interest to practicing scientists and technologists."

Like Gottschalk and Desmond, the NLL defined a serial as a "publication to be continued indefinitely." They also defined science and technology as comprising the natural, physical, and engineering sciences and borderline subjects; the only real difference being that the NLL covered only experimental psychology, and therefore, may have had fewer psychology titles than the "Worldwide Census". This was offset, however, by the fact that the NLL covers certain aspects of management, business methods, and economics.

In his 1967 article, Barr stated that the NLL excluded only two of the categories which were excluded in the Gottschalk and Desmond report, house journals and publishers' series. Nevertheless, the NLL had a lower coverage of titles than the "Worldwide Census" indicating that the higher figure cannot be due to covering a larger field. By the end of 1965, the NLL had 22,600 titles currently received and about 3,600 on order for a total of 26,200 titles. This figure is considerably under the "Worldwide Census" figure of 35,300.

In 1971, the NLL Review (147) reported 36,599 titles received and another 3,668 on order for a total of 40,267 journal titles published worldwide. By this time the counts included social science publications which had been excluded in the 1967 figures. The total number of publications reported for the United States was 8,006 titles which included 7,285 titles currently received and 721 titles on order.

According to an article appearing in the September/October 1975 issue of the UNESCO Bulletin (38), the British Library Lending Division (BLLD), formerly the NLL, now collects material worldwide from the following categories:

- all significant serials in all subjects and languages (44,000 titles currently received)
- all significant English language monographs (55,000 volumes per year)
- report literature from over 90 countries (over one million reports in total currently held - mostly in microfiche)
- all types of conference proceedings and symposia, including those which appear in serial form (about 9,000 per year).

Judging from the August 1971 table of serial titles currently received and on order by the NLL, the last three mentioned categories are excluded from the "all significant serials" total of 44,000.*

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* This observation appears to conflict with the exclusion categories stated in Barr's 1967 article. The figures listed in the 1965 table of serial titles included in the article also seem to conflict with Barr's exclusion categories, indicating that in reality the NLL does exclude basically the same categories from their serial totals as did Gottschalk and Desmond.

There is another, somewhat gross, figure that might serve as a check on the NLM statistics. The number of titles listed in Ulrich's International Periodicals Directory (142) increased from 28,000 in 1966 to 55,000 in 1974, a growth of 96 percent in an eight year period, or an average annual growth of 8.8 percent. Even though this directory is known to be incomplete, and is not restricted to the sciences, the growth in the directory is presumably a reasonable reflection of the growth in the number of periodicals available.

In 1970, however, a task group of the National Academy of Sciences (59) estimated the current birth rate of new journals to be about 2.5 percent a year, although this was thought to be a "slight" underestimate. At that time the birth rate of new commercial journals, at about 8 percent a year, was found to be much greater than the birth rate of nonprofit journals (about 1.4 percent). Mortality was found to be negligible so that the rate of increase in the number of journals available was essentially the same as the birth rate.

Price, writing in 1961 (121), reported a doubling of number of journals over a time of about 15 years and that this rate of growth had been remarkably constant for centuries. A doubling rate of 15 years represents a growth rate of about 5 percent a year.

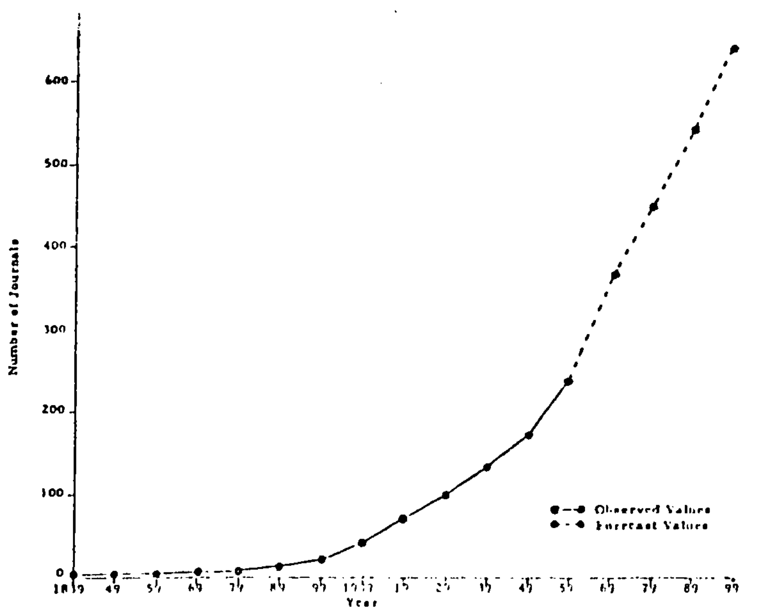
Clearly there is a wide discrepancy between growth of periodicals as reflected by the holdings of NLM and the lists of Ulrich, on the one hand, and the estimates of Price and the National Academy of Sciences (NAS) on the other. The Price compound growth rate of 5 percent a year is equivalent to about one half of the growth rate reflected in the NAS and Ulrich figures.

Further data on the evolution of science journals are available in two publications of the International Council of Scientific Unions (ICSU) (63, 128). The ICSU data, for the entire period 1910 - 1960, suggests an average annual rate of growth of about 12 percent a year on the physical sciences and about 5.5 percent a year in the biological sciences.

3.2.2 Number of Scientific and Technical Journals Published in the United States

There is ·ome evidence in the literature concerning the amazing growth of the number of journals in the United States over its history. The National Science Foundation (98) gives the picture of this growth up to 1959 based on a sample of journals. If we apply our observations of growth since 1960 as derived later in this section, t _ complete picture up to date appears as shown in Figure 3.8.

Figure 3.8 GROWTH OF U. S. JOURNALS



SOURCE: National Science Foundation, Characteristics of Scientific Journals, 1949-1959, August, 1964.
Market Facts, Inc., Centre for Quantitative Sciences.

A time series model was fit to this curve to forecast into the future. The equation used, as shown in Figure 3.8, was the following:

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$$\hat{Y} = 3.19 - 2.06X + .172X^3 - .002X^4$$

where:

$\hat{Y}$ is the estimated number of U. S. S&T journals

X is the year (1 is 1849, 2 is 1859, . . .)

This growth based on this curve appears to be dampening out somewhat. For example, the increase over ten years at the turn of the Century was 91 percent, in 1950 the increase was 38 percent and in 1980 it is projected to be 22 percent. Derek de Solla Price (124) emphasizes that this is to be expected in developed countries such as the United States. In fact he has demonstrated a high correlation between growth of developing countries (as measured by electrical power) and scientific output as measured by scientific and technical journals. Thus, one can reasonably predict by this means the growth of science and scientific output of developing countries as well as the more highly developed countries.

For recent years, we have chosen to present two estimates of the number of scientific and technical journals published in the United States The first estimate is based on the broad definition of scientific and technical journals as applied by the British National Lending Library (now called BLLD). The second estimate is based on a narrower definition of serials used by the Indiana University Graduate Library School in a 1974 study (48) conducted for the National Science Foundation. The Indiana University study covered only scholarly journals in pure sciences, applied sciences, humanities and social sciences. In all of our estimates we have excluded the humanities journals. Other exclusions involve trade journals, government publications, secondary journals and all other serials not defined as scholarly journals. A precise definition of their basis for inclusion and exclusion is given in Appendix IV.

According to our broad definition of scientific and technical journals, estimates for the numbers of scientific and technical journals published worldwide, including in the United States, are given in Table 3.10. We were told that the Gottschalk and Desmond figures included some extinct publications and that this was estimated to be about 33 percent of the total. Thus, this estimate was used for 1961. In 1963 through 1974, BLLD data were used for the number of worldwide journals that were published. The proportion of U. S. titles in 1971 was 19.1 or 8,020 journals. Because this figure includes social science journals not included earlier and excludes the humanities journals added later, we used it as the basis of our U. S. estimates. Separate growth rates for social sciences and the remainder of the sciences were then derived from a Bath University study (41) and our journal tracking study. These rates were applied to the 1971 figure to obtain the estimates presented in Table 3.11. As shown, the increase in the number of U. S. journals between 1960 and 1974 was 33.5 percent, equivalent to an average annual increase of 2.1 percent.

In 1973 or 1974, the Indiana University study identified 2,563 scholarly journals. We carefully scanned their list and deleted the scholarly humanities journals and some others to arrive at 1,945 scholarly scientific and technical journals. A sample of 191 of these journals were then tracked back to 1962 to identify journal births during the period.* We then took a sample of 178 of the journals from Ulrich's or New Serial Titles (114) listing in 1962. These titles were tracked forward to determine death rates.** From these observations we were able to estimate rates of change within each of the nine fields of science.***

By the process stated above, estimates of the number of scholarly scientific and technical journals published in the United States were found. These estimates are shown in Table 3.11. The results were extended to 1980 using a linear regression model based on the number of scientists and engineers. (See Figure 3.9). The estimated number of journal titles increased by about 46 percent over the period from 1960 to 1974. This increase yields an annual average of 2.6 percent increase. The five year increases appear fairly constant over the entire twenty year period.

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* Changes in titles were not considered a birth, but a journal that split into two journals was considered a birth of one of them.

** A merger of two journals was considered to be a death of one of the journals.

*** It is noted that the birth and death of the same journal between 1962 and 1974 would not have been observed by using our procedure.

Table 3.10: ESTIMATES OF THE NUMBER OF SCIENTIFIC AND TECHNICAL JOURNALS PUBLISHED WORLDWIDE AND IN THE UNITED STATES: 1960-1974

Year of Publication	No. of Journals Worldwide[1]	No. of Journals U.S.[2]
1960 . . .	18,800	6,335
1961 . . .	23,600	6,465
1962 . . .	23,100	6,614
1963 . . .	26,462	6,780
1964 . . .	25,573	6,950
1965 . . .	26,235	7,120
1966 . . .	30,110	7,290
1967 . . .	34,594	7,500
1968 . . .	37,182	7,670
1969 . . .	39,674	7,830
1970 . . .	40,431	7,920
1971 . . .	41,930	8,020
1972 . . .	44,676	8,170
1973 . . .	47,657	8,330
1974 . . .	49,440	8,460

SOURCES: [1] 1961: Gottschalk, C.M. and Desmond, W.F.. "Worldwide Census of Science and Technology Serials." American Documentation, 14:3 (July 1963).

1963-1974: Line, Maurice B. and Wood, D.N.. "The Effect of a Large-Scale Photocopying Service on Journal Sales." Journal of Documentation (scheduled for publication).

[2] 1971: Davey, J.S. and Smith, E.S.. "The Overseas Services of the British Library Lending Division." Unesco Bulletin 29:5 (September-October 1975).

Market Facts, Inc., Center for Quantitative Sciences.

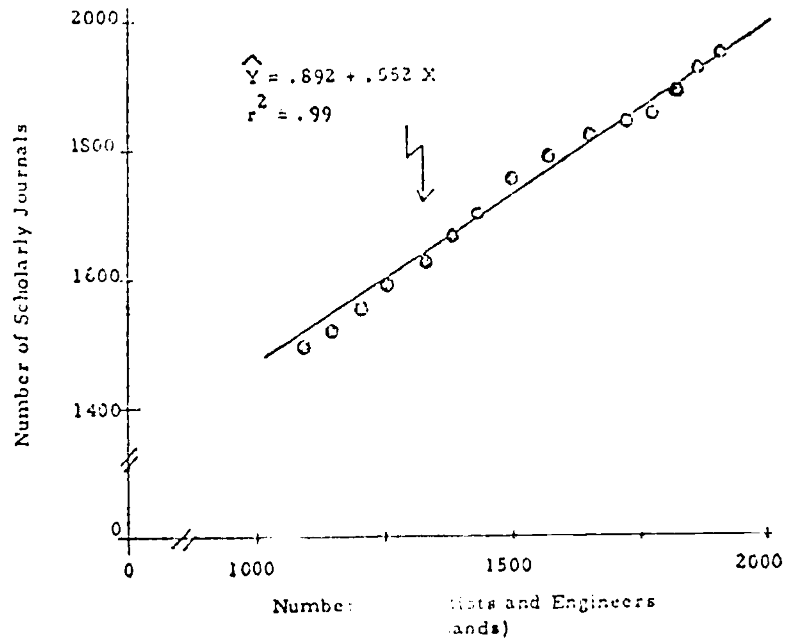
Table 3.11 ESTIMATES OF THE NUMBER OF SCHOLARLY SCIENTIFIC AND TECHNICAL JOURNAL TITLES PUBLISHED IN THE UNITED STATES: 1960-1980

Year	Number of Journals Published
1960 . . .	1,492
1961 . . .	1,520
1962 . . .	1,553
1963 . . .	1,591
1964 . . .	1,628
1965 . . .	1,667
1966 . . .	1,702
1967 . . .	1,752
1968 . . .	1,787
1969 . . .	1,823
1970 . . .	1,837
1971 . . .	1,856
1972 . . .	1,887
1973 . . .	1,919
1974 . . .	1,945
PROJECTIONS*	
1975 . . .	1,980
1976 . . .	2,013
1977 . . .	2,041
1978 . . .	2,074
1979 . . .	2,106
1980 . . .	2,140
PERCENT CHANGE	
1960-65 .	12
1965-70 .	10
1970-75 .	8
1975-80 .	8

* Market Facts, Inc., Center for Quantitative Sciences.

SOURCE: Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

Figure 3.9 NUMBER OF U. S. S&T SCHOLARLY JOURNALS AS A FUNCTION OF NUMBER OF SCIENTISTS AND ENGINEERS



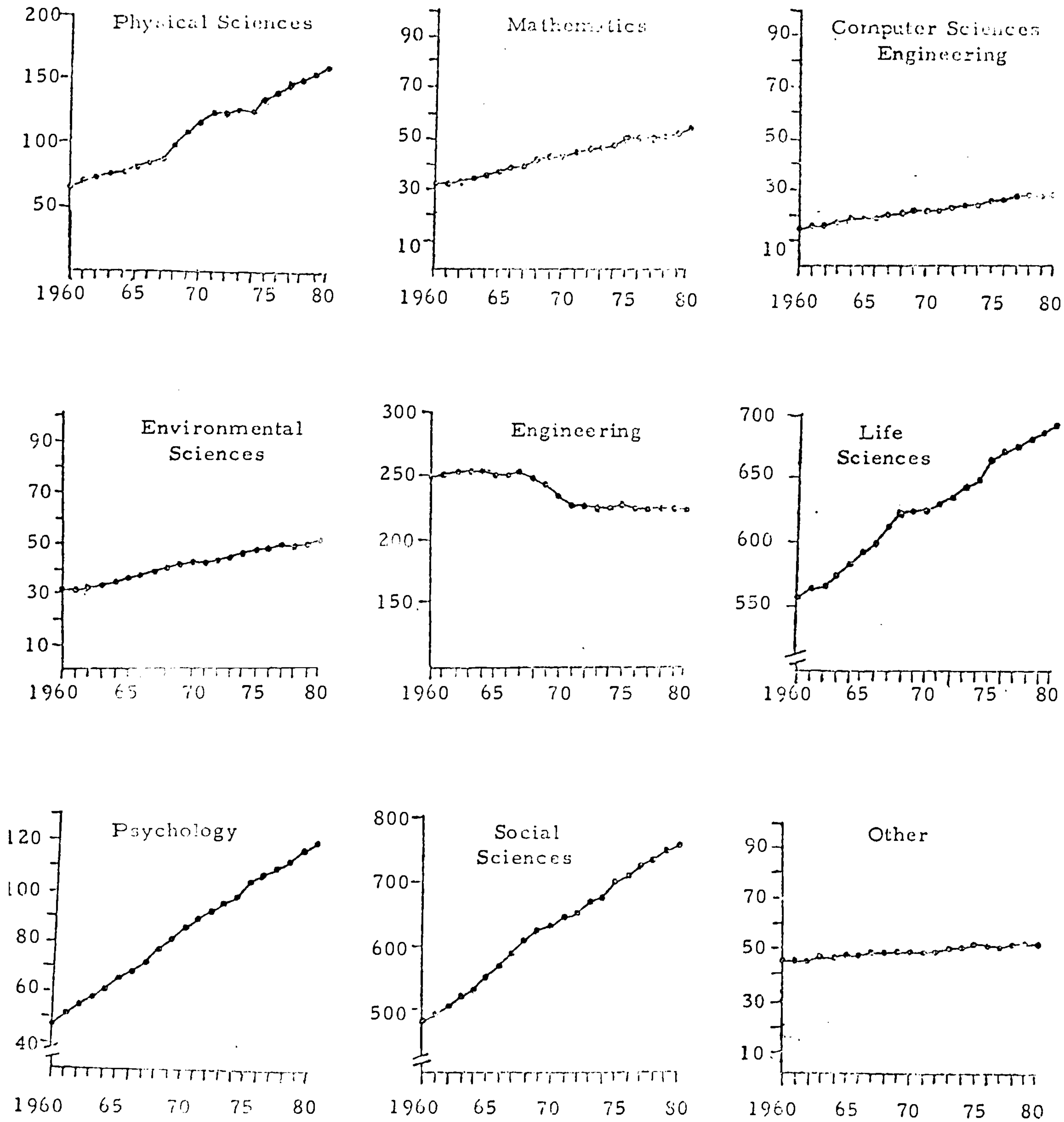
SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

The Indiana University study estimated the growth in number of scholarly journals to be 8.3 percent from 1969 to 1973. This comes to an average of 2 percent per year. Our estimate for the corresponding time period is 5.3 percent or 1.3 percent per year. It is noted that the percentage increase from 1965 to 1974 of the broadly defined serials is 19 percent and the corresponding increase for the scholarly journals is 17 percent.

Again based on our Journal Tracking Survey, the estimated number of journals and articles published in the nine fields of science is given in Table 3.12. The number of journals published in 1960, 1961 and 1975 through 1980 was found by time series analysis. The totals were adjusted to sum to the forecast number of journals shown in Table 3.12. Journal growth by field is depicted in Figure 3.10.

The figures show a dampening out in the number of journals in the U. S.. This appears to be due to both a similar phenomenon occurring in the number of scientists and engineers and also to the fact that more articles are being published per journal. To isolate these factors, we feel it is best to use the number of articles published as our primary statistical indicator of scientific and technical journal communication. Article rather than

Figure 3.10 NUMBER OF U. S. S&T SCHOLARLY JOURNALS BY FIELD OF SCIENCE: 1960-1980



SOURCE: Table 3.12.

Table 3.12 NUMBER OF JOURNALS, JOURNAL ARTICLES, AND ARTICLES PER JOURNAL, BY FIELD OF SCIENCE: 1960-1980

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	
Physical Sciences													
Journals	68	70	73	75	77	80	83	89	98	108	116	122	121
Articles	[illegible],996	10,500	10,950	11,439	11,938	12,698	13,649	14,872	15,981	16,397	17,235	18,673	19,463
Articles/Journal	147	150	150	153	155	159	164	167	163	152	149	153	161
Mathematics													
Journals	32	33	34	35	36	38	39	40	42	43	44	45	46
Articles	1,920	2,046	2,129	2,257	2,519	2,853	3,18[illegible]	3,484	3,744	3,985	4,155	4,244	4,205
Articles/Journal	60	62	63	64	70	75	82	87	89	93	94	94	91
Computer Sciences & Engineering													
Journals	15	16	16	17	18	18	[illegible]	20	21	22	22	22	23
Articles	450	512	539	621	718	760	76[illegible]	792	851	9[illegible]8	1,016	1,091	[illegible],109
Articles/Journal	30	32	34	36	40	42	40	40	40	42	46	50	48
Environmental Sciences													
Journals	31	32	33	34	35	36	37	39	40	41	42	42	43
Articles	961	1,024	1,093	1,177	1,416	1,775	2,456	3,421	4,155	4,340	4,032	3,781	3,554
Articles/Journal	31	32	33	35	40	49	66	88	104	106	96	90	83
Engineering													
Journals	250	250	251	251	251	250	250	251	249	243	234	227	227
Articles	14,500	15,000	15,390	15,904	17,011	18,163	19,154	19,910	20,342	20,203	20,350	21,260	21,761
Articles/Journal	58	60	61	63	68	73	77	79	82	83	87	94	96
Life Sciences													
Journals	577	586	580	587	592	599	606	617	627	632	634	636	639
Articles	65,774	67,160	66,531	65,719	64,567	66,730	69,143	69,393	68,853	69,208	71,502	74,014	72,866
Articles/Journal	114	115	115	112	109	111	114	112	110	110	113	116	114
Psychology													
Journals	47	51	55	58	62	66	69	73	78	82	86	90	93
Articles	3,102	3,366	3,647	3,758	3,877	4,077	4,254	4,354	4,431	4,623	4,841	4,894	4,976
Articles/Journal	66	66	66	65	62	62	62	60	57	56	56	54	54
Social Sciences													
Journals	498	514	519	533	546	560	573	592	613	627	638	649	657
Articles	14,187	14,740	14,644	15,532	15,701	14,655	13,826	14,544	16,057	16,559	16,212	15,726	15,387
Articles/Journal	28	29	28	29	29	26	24	25	26	26	25	24	23
Other Sciences													
Journals	46	46	46	47	47	48	48	49	49	49	49	49	49
Articles	3,036	3,036	3,022	2,990	3,134	3,194	3,538	3,946	4,444	4,938	5,395	5,755	6,083
Articles/Journal	66	66	66	64	67	66	74	80	91	101	110	117	124
TOTAL All Sciences													
Journals	1,492	1,520	1,553	1,591	1,628	1,667	1,702	1,752	1,797	1,823	1,837	1,856	1,887
Articles	105,932	107,920	10[illegible],350	111,861	115,29[illegible]	120,461	126,349	131,708	135,596	137,545	140,593	145,458	147,262
Articles/Journal	71	71	71	70	[illegible]	72	74	75	75	75	76	78	78

(Continued)

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Table 3.12 (cont.) NUMBER OF JOURNALS, JOURNAL ARTICLES, AND ARTICLES PER JOURNAL, BY FIELD OF SCIENCE: 1960-1980

Item	1973	1974	1975	1976	1977	1978	1979	1980	Percent Change			
									1960-65	1965-70	1970-75	1975-80
Physical Sciences												
Journals	124	125	133	138	144	148	152	157	18	45	15	18
Articles	19,407	18,835	20,380	21,009	21,740	22,350	23,090	23,830	27	36	18	17
Articles/Journal	157	151	155	157	156	160	163	165	8	-6	4	6
Mathematics												
Journals	47	48	51	51	51	52	53	55	18	16	16	8
Articles	4,107	4,063	3,751	3,804	3,539	3,572	3,586	3,670	49	46	-10	-7
Articles/Journal	87	85	74	75	69	69	68	67	25	25	-21	-9
Computer Sciences & Engineering												
Journals	24	24	26	26	27	28	28	28	20	22	18	8
Articles	1,090	1,075	1,129	1,152	1,176	1,197	1,220	1,243	69	34	11	1
Articles/Journal	45	45	43	44	44	43	44	44	40	9	-7	2
Environmental Sciences												
Journals	44	45	47	47	48	48	49	50	16	17	12	6
Articles	3,359	3,276	4,551	4,780	4,997	5,205	5,476	5,626	85	120	32	24
Articles/Journal	76	73	97	102	104	108	111	113	58	96	1	16
Engineering												
Journals	226	225	228	223	222	222	217	221	0	7	-3	-1
Articles	22,128	22,435	23,004	23,876	24,[illegible]	25,695	26,[illegible]	27,439	25	12	11	19
Articles/Journal	99	100	101	107	111	116	119	124	26	19	16	23
Life Sciences												
Journals	646	650	669	661	665	674	682	688	4	6	6	1
Articles	74,062	72,857	73,657	75,168	76,290	77,196	78,351	79,126	1	7	3	3
Articles/Journal	115	112	110	114	112	111	112	112	-3	2	-3	2
Psychology												
Journals	96	99	105	107	110	113	117	121	40	30	22	[illegible]
Articles	5,242	5,551	5,711	5,854	5,943	6,153	6,283	6,443	31	19	18	13
Articles/Journal	55	56	54	55	54	54	54	53	-6	11	-4	-2
Social Sciences												
Journals	670	679	702	709	724	738	752	765	12	14	10	8
Articles	15,514	15,821	16,141	16,051	15,873	16,119	16,191	16,454		11	-1	-2
Articles/Journal	23	23	23	23	21	22	21	21	7	-4	-8	-9
Other Sciences												
Journals	50	50	52	51	50	51	51	51	4	2	6	-2
Articles	6,454	6,659	6,836	7,178	7,509	7,825	8,162	8,467	5	69	27	24
Articles/Journal	129	133	131	141	150	153	160	166	0	66	19	27
TOTAL All Sciences												
Journals	1,919	1,945	2,011	2,013	2,041	2,074	2,106	2,136	12	10	10	6
Articles	150,311	150,572	155,345	158,863	161,795	165,312	168,939	172,348	14	17	10	11
Articles/Journal	78	77	78	79	79	80	80	81	1	5	3	4

[illegible]: Journal Tracking Survey, Market Facts Inc., Center for Quantitative Sciences.

journal production would seem to be most closely linked to the number of scientists and engineers, and our approach has the additional advantage of remaini valid under such innovations in publishing as separates and s, optic journals.

We have observed that the estimated average number of ar cles published annually in scholarly journals has increased somewhat over the period from 1960 to 1974. The average number of articles per journal in 1962 was 71; this number increased to 77 in 1974, which represents an increase of eight percent. These increases are probably due to an attempt on the part of journals and publishers to reduce publishing costs. In the Indiana University study, this approach to reducing costs was given by publishers as one of several approa hes employed by to economize.

Some additional evidence of the g wth of number of articles per journal can b. found in the literature. The NAS study of 1970 (59), based on a sample of fifty journals, reported a median growth rate of about seven percent a year ov r about a ten year period, although wide variations from journal to journal we observed (from zero growth to about 14 percent growth). In 1974 Narin and Carpente (78) presented data on the growth rate, in number of art cles published, for a sample of 492 large o heavily cited journals in seven major scientific disciplines. These data indi ate a growth in number of articles published, of 33. percent in a seven year period for the physics and geophysics journals and a te of g owth in the same period of 31 percent r the chemistry and metallurgy journals. This represents an average annual growth rate of betwe 4.0 and 4.2 percent for these groups of journals. The Narin and Carpenter data do not indicate continued growth in all fie during the period studied. In e gineeri and in mathematics, for example, the number of papers published incr ased up to 1971 but declined in 1972. Articles written by U. S. authors, in all fields covered, declined in the period 1971 - 1972. Althoug annual aberrations c this kind are bound to occur, in the long run a regular growth is likely to be observed in any sample of journals in any field of science.

1?1

A report published by the National Science Foundation in 1964 (98), based on a sample of 262 scientific journals, reported a 52 percent increase in a decade in the number of articles published per journal, an average annual growth of about 4.3 percent over the period. Our estimate for the following ten year period (1964 - 1974) is 30.6 percent increase or about 2.7 percent per year. Again, in the NSF study, there is wide variation from field to field. The sample of five engineering journals, for example, grew 154 percent in the period.

The estimated total number of scholarly scientific and technical articles published in the United States from 1960 to 1980 is repeated in Table 3.13. Also given in this table are the number of scientists and engineers, their average constant dollar salaries and the research and development constant dollar funding levels. It is hypothesized that these are related to the number of articles published.

An average number of articles written per scientist or engineer is found by dividing the number of articles written by the number of scientists and engineers for the previous year. This was done since most of the articles were actually written about one year prior to their being published. Thus, the average actually reflects the previous year's productivity in terms of scholarly manuscripts being written by individual scientists and engineers.

The average number of scholarly articles written per scientist or engineer shows a fairly steady decline from 1960 (0.0964) to 1974 (0.0783). Another way to look at this decline in productivity is that there were on the average, 10.9 scientists or engineers per scholarly article written in 1960 compared with 12.8 scientists or engineers per scholarly article written in 1974. The productivity of scientists and engineers varies substantially by field as will be shown a little later in this section.

Following this analysis, we determined if the decline in productivity could be related to R&D funding. The constant dollar funding levels are given in Table 3.13. These levels rise to a peak in 1968 and then sporadically decline slightly over the next six years. There was little correlation between

Table 3.13 ESTIMATED NUMBER OF ARTICLES PUBLISHED, NUMBER OF SCIENTISTS/ENGINEERS, AVERAGE NUMBER OF ARTICLES PUBLISHED, AND RESEARCH AND DEVELOPMENT FUNDING LEVELS: 1960-1980

Year	Total Number of Scientists/ Engineers[1] (000)	Total Number of Scholarly Articles Published (000)	Average Number of Articles per Scientist/Eng.*	R&D Funding (Constant $)[2] (Millions)	R&D Funds Per R&D Scientist/ Engineer (000)	Average Salary (Constant $)[3] (000)	Funding/ Salary Index
1959 . . .	1099	-	-	-	-	-	-
1960 . . .	1159	105.9	.0964	15,427	38.0	10.7	3.55
1961 . . .	1210	107.[illegible]	.0931	[illegible],125	37.4	10.9	3.43
1962 . . .	1272	109.9	.[illegible]08	17,149	[illegible].0	11.1	3.32
1963 . . .	1346	111.9	.0880	18,755	37.6	11.3	3.33
1964 . . .	1396	115.3	.0857	20,411	[illegible]	11.5	3.39
1965 . . .	1442	120.5	.0863	21,310	[illegible]	12.1	3.26
1966 . . .	1501	126.3	.0876	22,594	40.6	12.5	3.25
1967 . . .	1578	131.7	.0877	23,205	39.2	12.8	3.06
1968 . . .	[illegible]	135.6	.0859	23,718	39.7	12.9	3.08
1969 . . .	[illegible]	137.7	.0835	23,561	[illegible]	[illegible]3.1	2.98
1970 . . .	1797	140.6	.0815	22,646	37.[illegible]	13.1	2.86
1971 . . .	[illegible]834	142.7	.079[illegible]	22,249	36.[illegible]	[illegible]3.2	2.78
1972 . . .	1871	147.2	.0803	22,657	[illegible]	[illegible]	2.80
1973 . . .	1923	150.0	.0802	[illegible]	37.6	13.6	2.76
1974 . . .	1973	150.6	.0783	[illegible]	35.4	13.3	2.69
[illegible]							
1975 . . .	2026	[illegible]5.3	.0787	[illegible],725	34.5	13.2	2.61
1976 . . .	2081	158.[illegible]	.0784	21,61[illegible]	33.[illegible]	13.3	2.52
1977 . . .	21[illegible]	161.[illegible]	.0[illegible]	21,576	33.5	13.3	2.50
1978 . . .	21[illegible]	16[illegible].[illegible]	.0773	21,[illegible]0	33.2	13.3	2.50
1979 . . .	[illegible]	168.8	.0769	21,[illegible]	33.3	13.2	2.52
[illegible] . . .	231[illegible]	1[illegible]2.3	.0764	22,[illegible]	33.[illegible]	13.1	2.56
[illegible]							
[illegible]	2[illegible]	14	-11	3[illegible]	4	13	-8
1965-[illegible]	[illegible]	[illegible]	-6	6	-5	8	-12
1970-75	1[illegible]	[illegible]	-3	-4	-8	1	-9
1975-80	14	11	-3	2	-3	-1	-2

* Average [illegible] found by dividing the [illegible] of articles [illegible] by the [illegible] of scientists and engineers [illegible]

[1] Taken from [illegible]

[2] Taken from Ta[illegible]

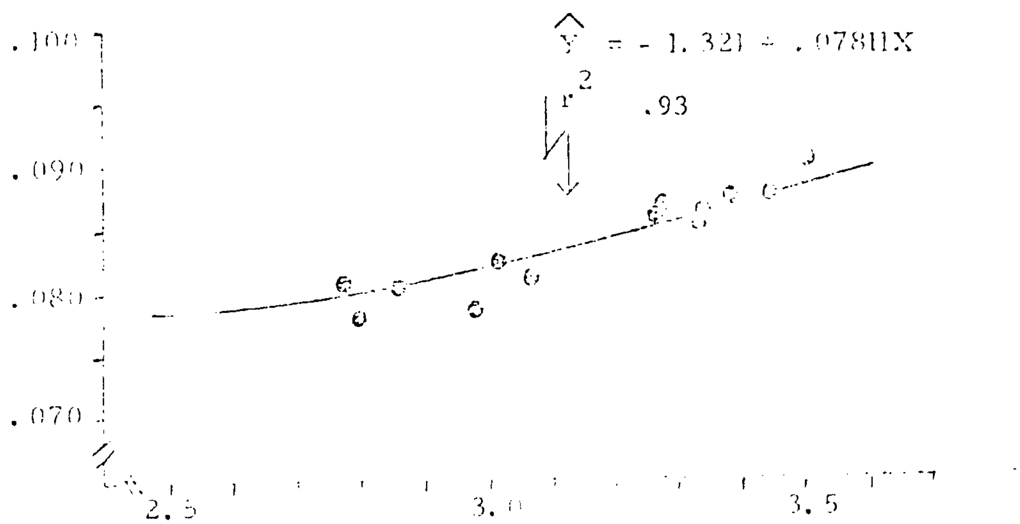
[3] Taken from Table [illegible]

SOURCE: [illegible]

the total constant dollar funding level and article productivity. It was thought, perhaps, that article productivity could be related better to funding per R&D scientist or engineer and that figure is also given in Table 3.13. The funding per scientist or engineer fluctuates from about $40.6 thousand in 1966 to about $34.5 thousand in 1975, and is positively correlated with average scholarly article productivity.

Another important consideration is that the average salary per scientist/engineer increased at a greater rate than the Gross National Product. We felt that this factor accounts for some of the increase in funding levels and should be included in our calculations. Therefore, as an index, average funding level was divided by average salary. The relationship of the average scholarly article productivity and the funding/salary index is shown in Figure 3.11. This relationship suggests that greater funding per scientist does, indeed, have a slightly favorable effect on scientific productivity as measured by number of scholarly articles written.

Figure 3.11 U. S. S&T SCHOLARLY JOURNAL ARTICLES PER SCIENTIST AND ENGINEER AS A FUNCTION OF FUNDING/SALARY INDEX (LAGGED TWO YEARS)



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

Even though the number of scholarly articles written is a function of both the number of scientists and engineers and R&D funding levels, we prefer to use the former as a basis for forecasting the number of scholarly articles to be published in the future, since this covariate provides a precise estimate. The funding level covariate is, itself, difficult to forecast, so that it is not a good variable to use for forecasting. On the other hand, we have good forecasts of the number of scientists and engineers through 1980. The relationship between total articles published and the number of scientists and engineers is shown in Figure 3.12. This can be expressed as:

$$\hat{Y} = 39.8 + 58.6X$$

where:

$\hat{Y}$ is the estimated number of scientific and technical scholarly articles (in thousands)

X is the number of scientists and engineers lagged one year (in millions).

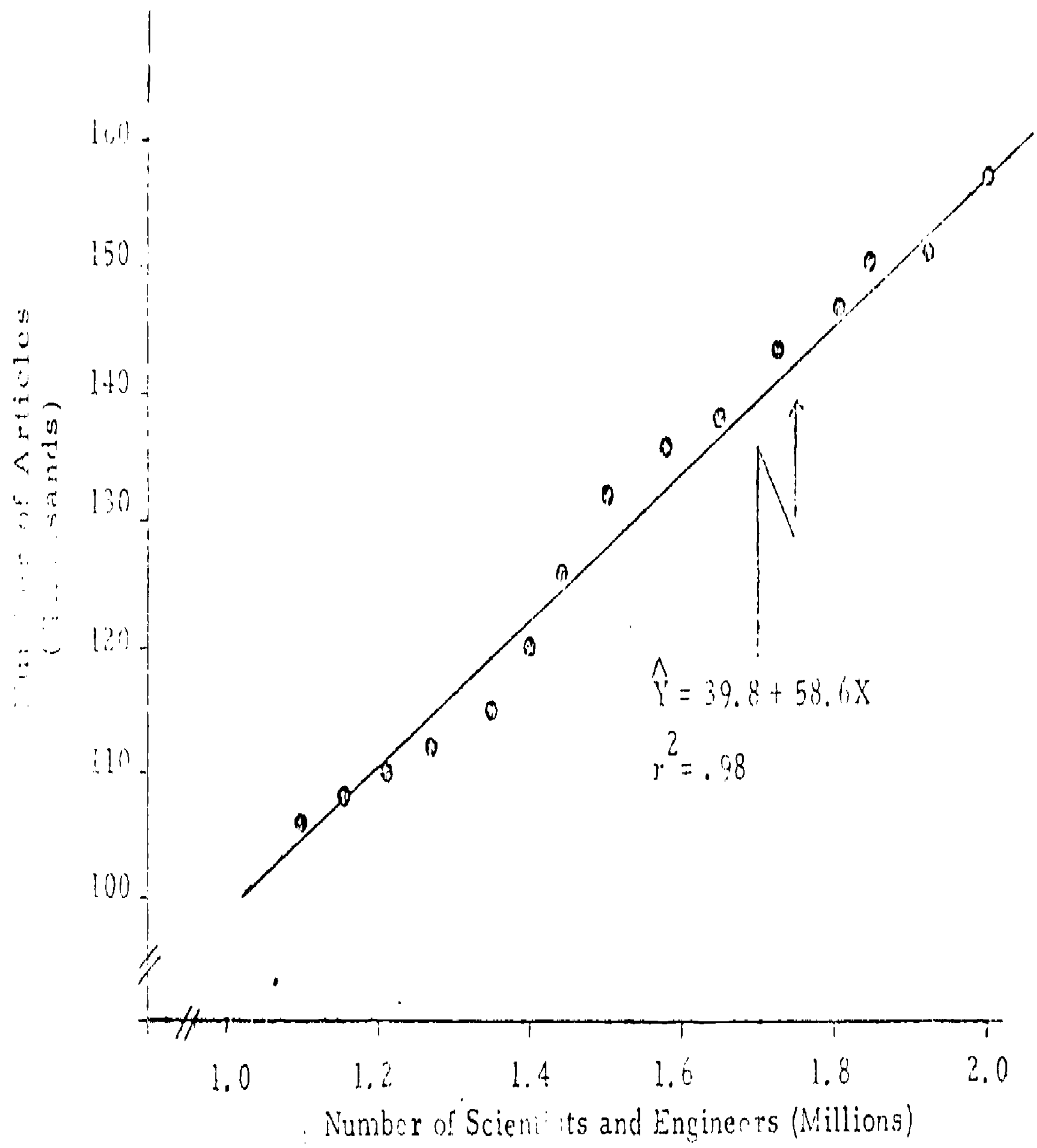
It is noted that this relationship is somewhat spurious in the sense that it implies that if there were no scientists or engineers there would be 39,800 articles written. Despite this deficiency of the model, we feel that the relationship from 1960 to 1974 is so well defined by the model that it serves as an excellent means to forecast over a short range of time to 1980.

Projections of articles in individual fields were in general made in the same manner as those for total articles using the number of scientists or engineers in the specific field. For Computer Sciences and Other Sciences, numbers of scientists were not available so projections were based solely on time. For Mathematics, it was found that the number of Ph.D's. was a better predictor of articles. Results obtained were quite good for all fields, with the correlation coefficients ranging [illegible] .89 for the Environmental Sciences to 0.99 for the Physical Sciences. The number of articles in each field, projected to 1980, is pictured in Figure 3.13.

[illegible] Time Required to Publish Scholarly Journal Articles

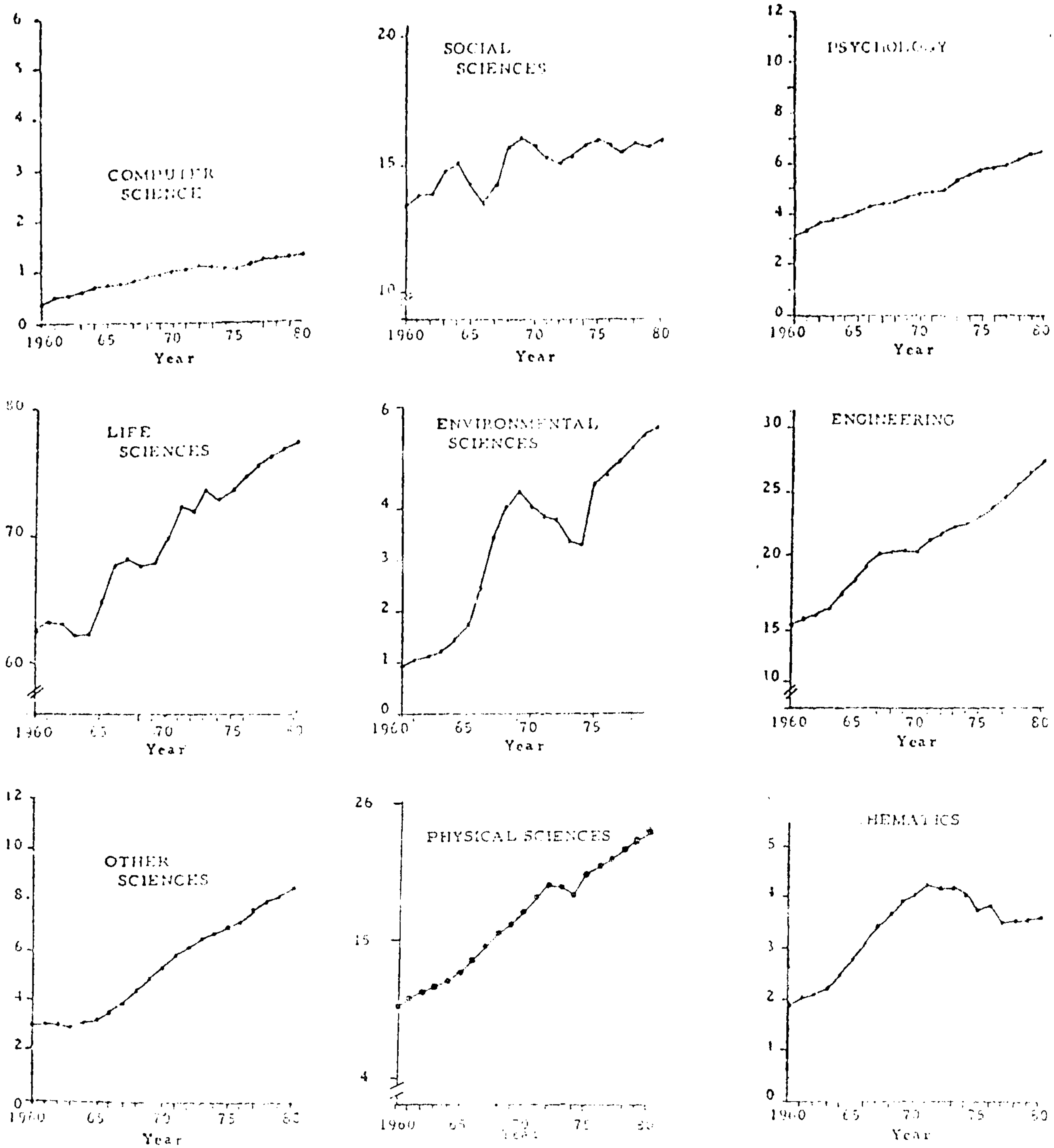
Delay in any publishing operation is normal. Revisions, typesetting, graphics preparation, and publishing backlogs all contribute to a delay between the time an article is written and the time it appears in print. This

Figure 3.12 NUMBER OF U. S. SCHOLARLY SCIENTIFIC AND TECHNICAL JOURNAL ARTICLES AS A FUNCTION OF SCIENTISTS AND ENGINEERS



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

Figure 3.13 NUMBER OF U. S. S&T SCHOLARLY JOURNAL ARTICLES BY FIELD OF SCIENCE: 1960-1980



SOURCE: Table 3.12

is a special concern in scientific and technical publishing due to the rapid obsolescence of information.

Data were collected in the Journal Tracking Survey to measure trends in publishing lags. The date a sampled article was first received by the journal was recorded whenever this date was given by the journal. The difference between date of receipt and date of publication was converted into months, and an average publishing lag was calculated for each field of science and each year of publication. It is recognized that these publishing lags do not give any indication of time consumed by rejection and resubmission of articles; because of this, they should be treated only as lower bounds for estimating actual publishing lags.

The average publishing lag, when all years and fields of science are considered, is 9.3 months. When an average lag for each year is calculated, combining all fields, little change over time is observed (see bottom row of Table 3.14). When individual fields are examined for trends, however, differences among fields appear. Generally, Physical Sciences journals have the shortest reported publishing lag while Mathematics and Statistics journals have the longest.

Publishing lags for individual fields are displayed in Figure 3.14, with an average publishing lag for all fields shown for comparison. It is apparent that there was no significant decrease overall in publishing lags between 1962 and 1974, although Engineering, Psychology and Life Sciences show a slight decrease to 1970 and then a levelling off or increase. The fields with the most consistent increases in publishing lags are Physical Sciences, Environmental Sciences, Computer Sciences, and Other Sciences. The fields experienced the greatest percentage increases in number of articles published between 1962 and 1974 (see Table 3.12). This suggests that article increases may have been outstripping journal capacity in those fields.

3.2.4 Distribution and Price of the Scholarly Journal Literature

Distribution of journals is measured by both the number of subscriptions to the journals and by the number of reprints sent out by various means. This section discusses overall distribution of scholarly scientific and technical journals in the United States, while subsequent sections deal with distribution of scholarly journals to foreign subscribers, institutional subscribers and individual subscribers, and distribution of reprints.

Table 3.14 PUBLISHING LAG, BY FIELD OF SCIENCE (IN MONTHS)*

Field of Science	YEAR ARTICLES PUBLISHED												
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	
1. Physical Sciences	6.2 (5.2)	4.3	2.5 (3.9)	4.9	7.3 (6.1)	6.1	4.9 (6.0)	7.0	9.2 (8.2)	8.3	7.5 (7.8)	7.[illegible]	[illegible] (7.5)
2. Mathematics & Statistics	14.0 (13.9)	13.8	13.7 (13.8)	13.9	14.2 (14.2)	14.4	14.7 (14.3)	13.7	12.7 (13.5)	14.1	15.6 (14.9)	15.2	14.[illegible] ([illegible])
3. Computer Sciences	6.8 (6.8)	6.9	7.1 (7.1)	7.4	7.8 (7.9)	8.6	9.5 (9.9)	11.7	13.9 (13.1)	13.7	13.6 (14.3)	15.[illegible]	[illegible] (16.7)
4. Environmental Sciences	6.9 (6.[illegible])	6.8	6.7 (6.9)	7.3	8.0 (7.9)	8.4	8.8 (8.6)	8.7	8.6 (8.8)	9.0	9.4 (9.1)	[illegible]	8.4 (8.6)
5. Engineering	8.1 (8.1)	8.2	8.4 (8.4)	8.6	8.8 (8.6)	8.5	8.3 (8.3)	8.0	7.7 (8.0)	8.4	9.2 (8.8)	8.9	8.6 (8.7)
6. Life Sciences	11.8 (11.4)	11.0	10.3 (10.8)	11.1	12.0 (11.4)	11.0	10.1 (10.1)	9.1	8.2 (8.6)	8.6	9.0 (9.1)	9.7	10.5 (10.1)
7. Psychology	10.4 (9.6)	8.9	7.5 (8.2)	8.2	8.9 (8.5)	8.5	8.2 (7.9)	6.9	5.7 (6.4)	6.5	7.3 (7.1)	7.6	7.9 (7.7)
8. Social Sciences	[illegible].5 (8.7)	7.9	6.4 (6.8)	6.1	5.9 ([illegible])	6.0	6.2 (6.6)	7.6	9.[illegible] (8.7)	9.4	9.7 (9.1)	8.3	7.0 (7.6)
9. Other Sciences	6.[illegible] (7.3)	8.0	9.[illegible] (8.9)	9.2	9.1 (9.4)	10.0	10.9 (10.5)	10.6	10.[illegible] (10.[illegible])	11.2	12.0 (12.1)	13.1	14.2 (13.6)
ALL FIELDS	10.3 (9.9)	9.6	8.9 (9.4)	9.6	10.3 (9.8)	9.6	9.0 (9.1)	8.6	8.3 (8.5)	8.7	9.1 (9.0)	9.2	9.4 ([illegible])

*Odd-numbered years [illegible] of [illegible] years' [illegible]; three year moving averages are in parentheses.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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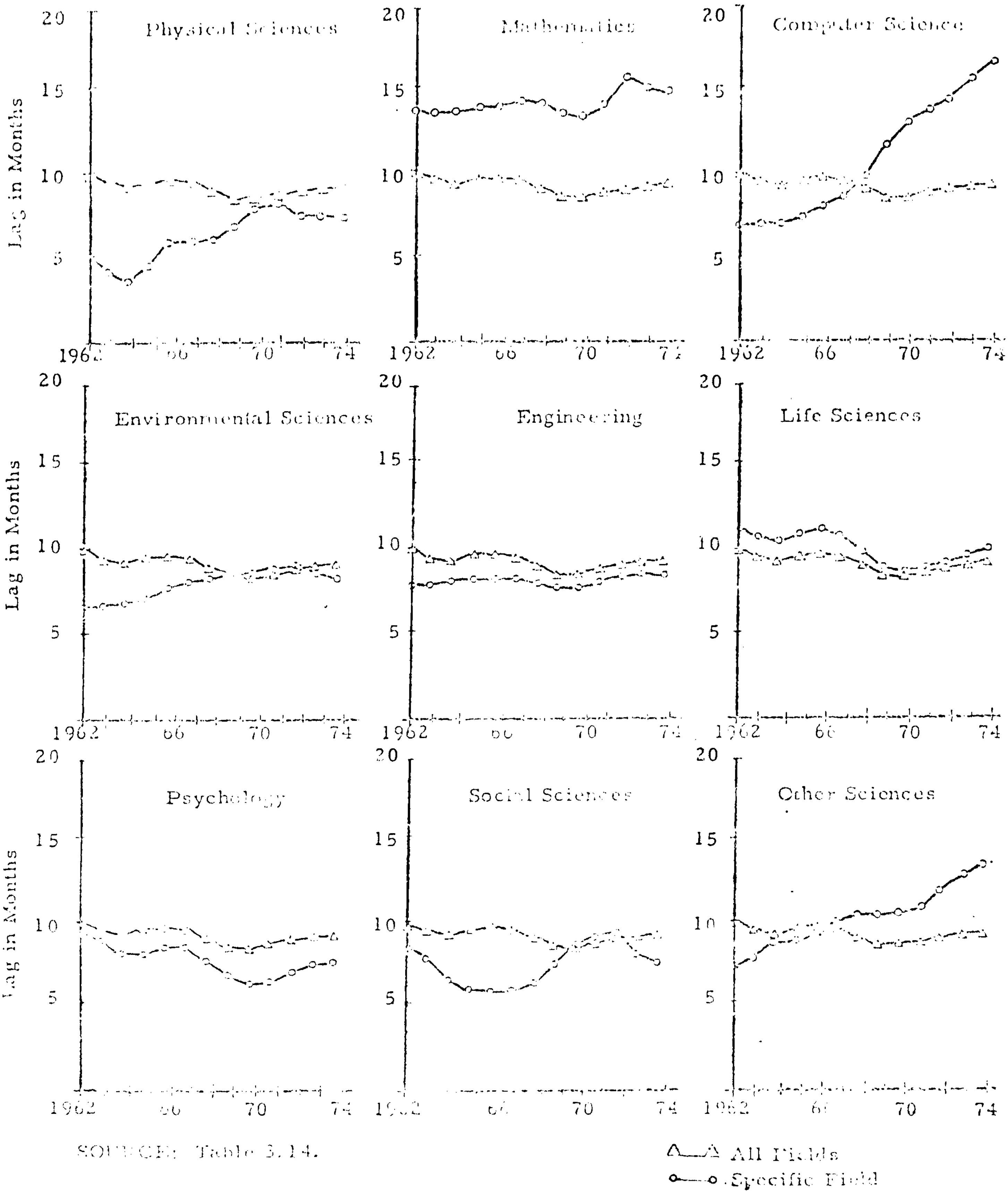
Figure 3.14 PUBLISHING LAG IN MONTHS BY FIELDS OF SCIENCE: 1962-1974



SOURCE: Table 3.14.

Our subscription data are based on a non-random sample of journals for which we could obtain some indication of trends between 1962 and 1974. Sources included the Indiana University study (48) and published reports by such groups as the American Chemical Society. Since few journals could be traced over the entire period of interest, our calculations were made indirectly. We first selected 1972 as our base and established an average number of subscriptions for large and small journals in that year. Growth ratios were then calculated for two year periods using all available data and applied to the 1972 figures. Results for the intermediate years were obtained by linear interpolation. The rates of change used are shown in Table 3.15, and the subscription numbers calculated in Table 3.16.

Table 3.15 OBSERVED RATES OF INCREASE IN NUMBER OF SUBSCRIPTIONS FOR LARGE AND SMALL JOURNALS: 1961-1974

(Percent Change)

Years of Change	Large Journals	Small Journals	All Journals
1961/62 - 1963/64 . . .	5.20	10.68	7.39
1963/64 - 1965/66 . . .	7.79	8.95	8.21
1965/66 - 1967/68 . . .	10.48	8.99	9.96
1967/68 - 1969/70 . . .	6.71	4.31	5.98
1969/70 - 1971/72 . . .	2.37	1.51	1.98
1971/72 - 1973/74 . . .	1.52	1.89	1.66

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

In 1972 the average number of subscriptions was about 32,000 for large journals, 3,900 for small journals and 7,700 for all journals combined. Applying our observed rates of change as described above yielded estimates of 5,591 subscriptions per journal in 1962 and 7,850 in 1974. This represents a 1962 to 1974 increase of 40 percent, equivalent to an average annual increase of 2.[illegible] percent.

Table 3.16 ESTIMATED AVERAGE NUMBER OF SUBSCRIPTIONS FOR LARGE AND SMALL JOURNALS AND TOTAL SUBSCRIPTIONS: 1960-1980

Year	Average Number of Subscriptions			Total Subscriptions (000)
	Large Journals	Small Journals	Both	
1960 . . .	21,686	2,299	4,755	7,141
1961 . . .	21,750	2,570	5,152	7,831
1962 . . .	23,450	2,772	5,591	8,683
1963 . . .	24,059	2,920	5,797	9,223
1964 . . .	24,669	3,068	6,004	9,775
1965 . . .	25,630	3,206	6,251	10,420
1966 . . .	26,591	3,343	6,497	11,058
1967 . . .	27,985	3,494	6,821	11,950
1968 . . .	29,378	3,644	7,145	12,768
1969 . . .	30,363	3,722	7,358	13,414
1970 . . .	31,349	3,801	7,572	13,910
1971 . . .	31,720	3,829	7,647	14,193
1972 . . .	32,092	3,858	7,722	14,571
1973 . . .	32,336	3,894	7,786	14,941
1974 . . .	32,580	3,931	7,850	15,268
PROJECTIONS				
1975 . . .	-	-	8,152	16,160
1976 . . .	-	-	8,301	16,710
1977 . . .	-	-	8,466	17,280
1978 . . .	-	-	8,607	17,850
1979 . . .	-	-	8,751	18,450
1980 . . .	-	-	8,897	19,040
PERCENT CHANGE				
1960-65 . .	18	39	31	46
1965-70 . .	22	19	21	33
1970-75 . .	-	-	8	16
1975-80 . .	-	-	9	18

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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Multiplying the estimated number of subscriptions per journal by the number of journals in each year results in estimates of the total number of journal subscriptions. These figures are also shown in Table 3.16. Projections of total subscriptions were based on the relationship between number of subscriptions and number of scientists and engineers, and indicate a continued growth in the number of subscriptions to a 1980 figure of about 19,000. Projections of the average number of subscriptions per journal were calculated from our projections of total subscriptions and number of journals.

3.2.5 Distribution and Price to Foreign Subscribers

We had only 18 observations of journals in which foreign subscribers were indicated. Thus, we chose to use the Indiana University subscription data, covering 148 journals, even though their data is probably biased due to a low response rate (12 percent). The proportion of foreign subscriptions to the total for various types of publishers, as identified by the Indiana study, is shown in Table 3.17. The weighted average for all journals ranges from 21.5 percent foreign subscribers in 1969 to 23.0 percent in 1973.

From our limited subscription data back to 1962, we established the proportion of foreign subscribers to the total to be about one-half that of the Indiana University study using this relationship, we estimated the proportions back to 1960. These results, along with the actual number of foreign subscribers and the foreign subscription price, are shown in Table 3.18.

Projections of the number of foreign subscribers are the difference between projections made of all subscribers and those of domestic subscribers. The results show a slight decrease in the proportion of foreign subscribers over the 1975 - 1980 period, and a levelling off of the actual number of subscribers. Average foreign subscription prices have increased substantially in current dollar terms over the entire period of interest, and this trend is projected to continue. The average price, of course, reflects a wide variety of prices for different journals in different fields, as suggested by Table 3.19, "Estimated Price to Foreign Subscriber by Field of Science."

Table 3.17 PROPORTION OF FOREIGN SUBSCRIBERS BY TYPE OF PUBLISHER: 1969, 1971, 1973

Type of Publisher	Number of Journals	1969 (%)	1971 (%)	1973 (%)
Commercial	645	41.2	42.9	44.1
Society	1,073	12.2	13.4	14.4
University Press	127	16.0	22.8	25.7
Other Not-for-Profit . . .	614	19.2	18.4	15.7
Weighted Total	2,459	21.8	22.9	23.0

SOURCE: Fry, Bernard M. and Herbert S. White, "Economics and Interaction of the Publisher-Library Relationship in the Production and Use of Scholarly and Research Journals" (NSF GN-41308), Indiana University, November 1975.

Table 3.18 ESTIMATED PROPORTION OF SUBSCRIPTIONS DUE TO FOREIGN SUBSCRIBERS AND NUMBER OF FOREIGN SUBSCRIPTIONS: 1960-1980

Year	Total Number of Subscribers (000)	Proportion of Foreign Subscribers (%)	Total Number of Foreign Subscribers (000)	Price to Foreign Subscribers ($)
1960 . . .	7,141	19.1	1,364	6.01
1961 . . .	7,831	19.4	1,519	6.57
1962 . . .	8,683	19.7	1,710	8.48
1963 . . .	9,223	20.0	1,845	8.38
1964 . . .	9,775	20.3	1,984	8.39
1965 . . .	10,420	20.6	2,146	8.60
1966 . . .	11,058	20.9	2,311	9.33
1967 . . .	11,950	21.2	2,533	10.39
1968 . . .	12,768	21.5	2,745	11.66
1969 . . .	13,414	21.8	2,924	12.82
1970 . . .	13,910	22.4	3,116	14.22
1971 . . .	14,193	22.9	3,250	15.98
1972 . . .	14,571	22.9	3,337	18.23
1973 . . .	14,941	23.0	3,436	20.63
1974 . . .	15,268	23.3	3,557	21.90
		PROJECTIONS		
1975 . . .	16,160	23.4	3,780	20.74
1976 . . .	16,710	23.6	3,940	21.82
1977 . . .	17,280	23.7	4,100	22.90
1978 . . .	17,850	23.9	4,260	23.98
1979 . . .	18,450	24.0	4,420	25.06
1980 . . .	19,040	24.1	4,590	26.14
		PERCENT CHANGE		
1960-65 . .	46	8	57	43
1965-70 . .	33	9	43	45
1970-75 . .	16	4	21	46
1975-80 . .	18	[illegible]	21	26

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Table 3.19 ESTIMATED PRICE TO FOREIGN SUBSCRIBERS BY FIELD OF SCIENCE: 1962-1974

Field of Science	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Physical Sciences . . .	11.53	12.21	12.68	12.25	15.01	21.85	29.52	33.94	37.36	43.04	47.64	48.90	47.87
Mathematics & Statistics	11.75	11.44	11.26	11.52	12.20	12.85	13.69	14.76	15.87	16.80	17.72	18.81	19.44
Computer Sciences . . .	11.11	11.22	11.95	13.18	14.49	15.30	15.27	14.84	14.80	15.56	18.35	22.37	25.00
Environmental Sciences	3.46	3.62	4.10	4.72	5.96	7.70	10.63	14.28	17.50	19.56	20.33	20.96	21.21
Engineering	7.45	7.86	8.67	9.48	9.92	9.98	10.06	10.54	11.30	11.95	13.87	17.18	19.53
Life Sciences	10.45	10.03	9.80	10.19	11.46	12.98	14.56	15.95	17.31	18.82	21.45	25.06	27.35
Psychology	7.92	8.33	8.80	8.92	9.06	9.56	10.09	10.27	10.99	12.60	15.87	19.93	22.36
Social Sciences	7.94	7.78	7.51	7.28	7.25	7.38	7.85	8.50	9.86	11.76	13.61	14.88	15.22
Other Sciences	7.26	7.16	7.01	6.90	7.97	10.18	12.51	12.82	14.85	16.62	18.59	20.03	20.48
Total	8.47	8.38	8.39	8.59	9.32	10.38	11.65	12.81	14.21	15.97	18.23	20.63	21.90

SOURCE: Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

3.2.6 Distribution and Price to Institutional Subscribers

As will be seen later, libraries and other institutions serve as a major source of journal articles to scientists and engineers. Thus the number of subscriptions held by these organizations is an important indicator of scientific and technical communication. In order to arrive at these estimates, the number of foreign subscribers was subtracted from the number of total subscribers to arrive at U. S. subscriptions, and this category was further subdivided into individual and institutional subscriptions.

The proportion of institutional subscriptions and individual subscriptions to the total domestic figure came primarily from the Indiana University study, since that was our best source of data. The median proportion of institutional subscribers used is given in Table 3.20. The weighted average of the proportion of institutional subscribers did not vary significantly from 1969 to 1973. Thus, in the absence of better data, we assumed that the proportion would remain a constant 39 percent over the 1960 to 1974 period. This figure was then multiplied times total domestic subscriptions in order to estimate total institutional circulation. Results of these calculations are given in Table 3.21, along with institutional subscription prices.

In order to project domestic, institutional and individual subscriptions we attempted regression analysis with several independent variables, including subscription price, time, and the number of scientists and engineers. Our results led us to the prediction of domestic and institutional subscriptions as a function of scientists and engineers. The number of individual subscriptions was then calculated as the difference between these two figures.

The equations used for the projection of domestic and institutional subscriptions were:

$$\hat{Y} = -2.21 + .0072X$$

where:

$\hat{Y}$ is the number of domestic subscriptions (in thousands)

X is the number of scientists and engineers (in thousands)

Table 3.20 ESTIMATED MEDIAN PERCENTAGE OF INSTITUTIONAL SUBSCRIBERS BY TYPE OF PUBLISHER: 1969, 1971, 1973

Type of Publisher	Number of Journals	1969 (%)	1971 (%)	1973 (%)
Commercial	645	56.1	56.5	56.9
Society	1,073	22.6	24.1	25.5
University Press	127	50.4	50.4	53.5
Other Not-for-Profit . .	614	50.6	42.0	42.5
Weighted Total	2,459	39.8	38.4	39.4

SOURCE: Fry, Bernard M. and Herbert S. White, "Economics and Interactions of the Publisher-Library Relationship in the Production and Use of Scholarly and Research Journals" (NSF GN-41308), Indiana University, November, 1975.

$$\hat{Y} = -.99 + .0029X$$

where:

$\hat{Y}$ is the number of institutional subscriptions (in thousands)

X is the number of scientists and engineers (in thousands)

Table 3.21 ESTIMATED TOTAL NUMBER OF DOMESTIC SUBSCRIBERS, INSTITUTIONAL SUBSCRIBERS AND INSTITUTIONAL SUBSCRIPTION RATES: 1960-1980

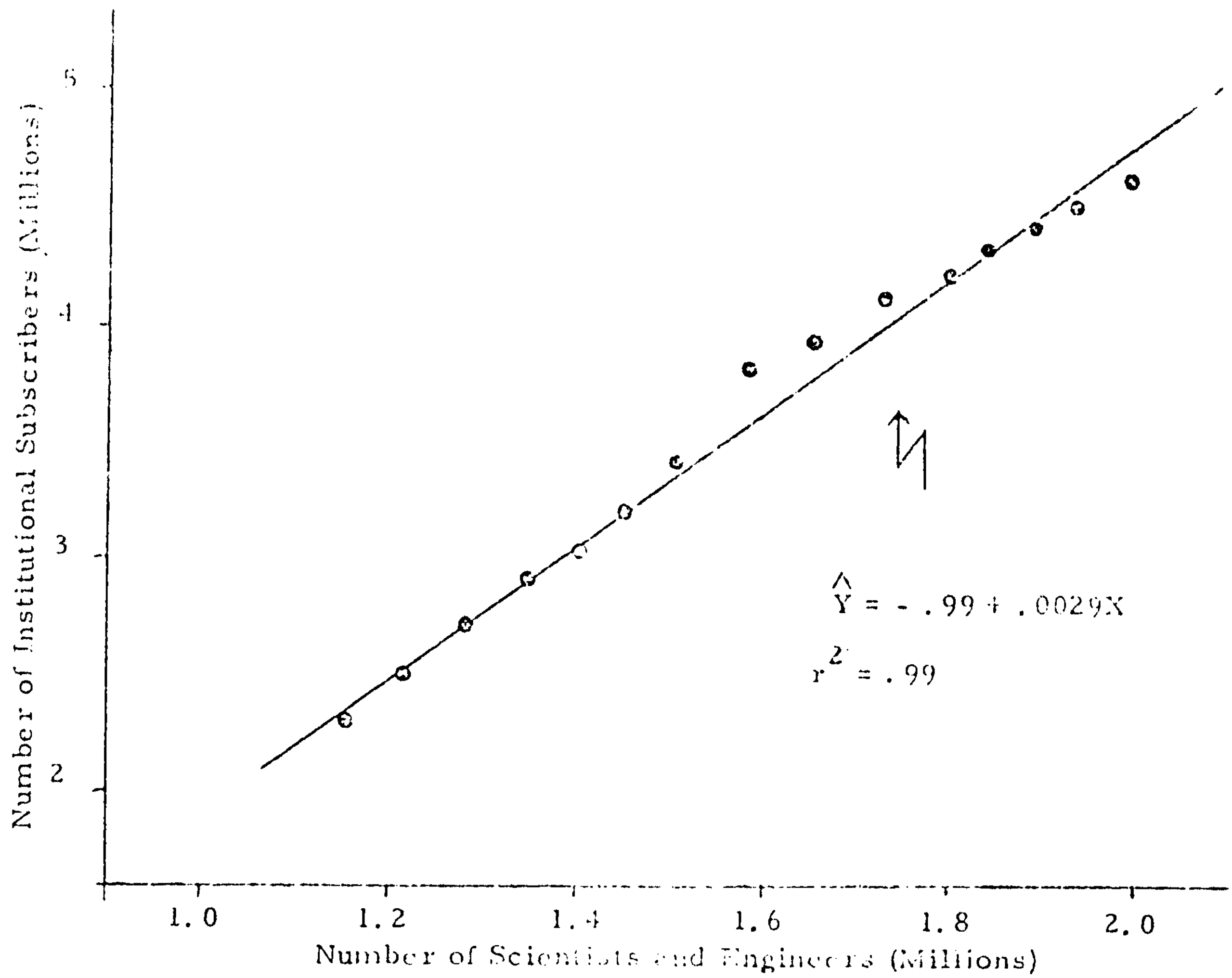
Year	Total Number of Domestic Subscribers[1] (000)	Total Number of Institutional Subscribers[2] (000)	Institutional Subscription Price (Current $)	Institutional Subscription Price (Constant $)*
1960 . . .	5,777	2,253	7.86	8.97
1961 . . .	6,312	2,461	9.30	10.45
1962 . . .	6,973	2,719	12.73	14.15
1963 . . .	7,378	2,877	13.25	14.54
1964 . . .	7,791	3,038	13.77	14.87
1965 . . .	8,274	3,227	14.42	15.29
1966 . . .	8,747	3,411	15.07	15.55
1967 . . .	9,417	3,673	16.48	16.48
1968 . . .	10,023	3,909	17.89	17.20
1969 . . .	10,490	4,091	19.84	18.20
1970 . . .	10,794	4,210	21.78	18.94
1971 . . .	10,943	4,268	23.30	19.38
1972 . . .	11,234	4,381	24.82	19.97
1973 . . .	11,505	4,487	27.20	20.73
1974 . . .	11,711	4,567	29.57	20.44
PROJECTIONS				
1975 . . .	12,380	[illegible]	29.18	18.46
1976 . . .	12,770	5,045	30.60	18.14
1977 . . .	13,180	5,210	32.02	17.78
1978 . . .	13,590	5,376	33.44	17.37
1979 . . .	14,030	5,550	34.86	17.02
1980 . . .	14,450	5,721	36.28	16.65
PERCENT CHANGE				
1960-65 .	43	43	83	70
1965-70 .	30	30	51	24
1970-75 .	15	16	34	-3
1975-80 .	17	17	24	-10

* GNP implicit price deflator [illegible] used to obtain 1967 constant dollars.

SOURCE: [1] Market Facts, Inc., Center for Quantitative Sciences.
[2] Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

These relationships are plotted in Figure 3.15 and 3.16, and 1975 - 1980 projections are given in Table 3.21. Institutional subscriptions over the entire 1960 - 1980 period are plotted in Figure 3.17.

Figure 3.15 NUMBER OF INSTITUTIONAL JOURNAL SUBSCRIBERS AS A FUNCTION OF NUMBER OF SCIENTISTS AND ENGINEERS



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

Subscription price information was collected from journal issues during the course of our Journal Survey. Institutional subscription price, i.e., the price a library must pay, was one of the subdivisions recorded. Not all journals gave this information. This was especially true of older issues from the early and middle 1960's. Therefore, when an actual institutional subscription price was not mentioned, the recommended individual rate was used. The

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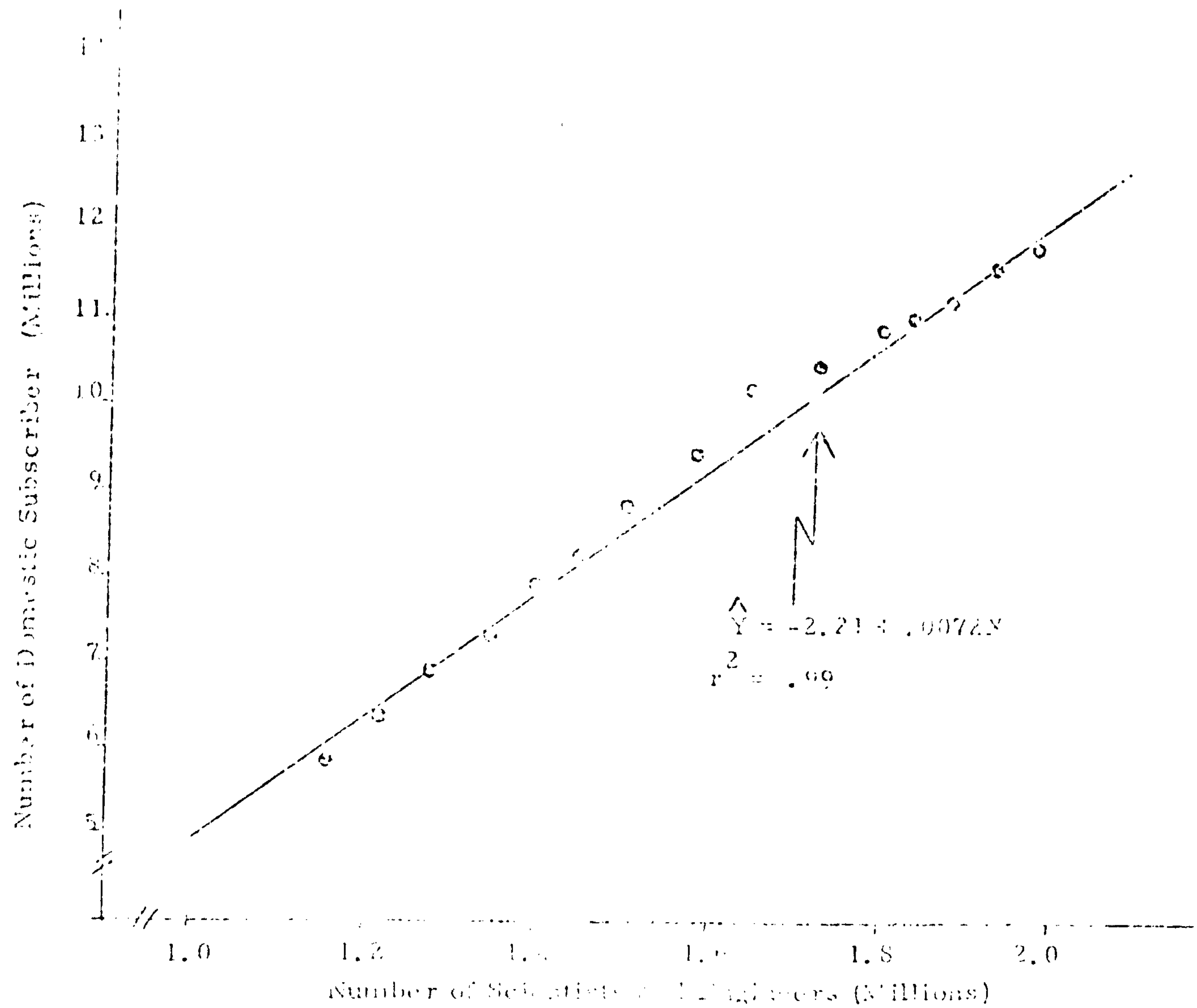
[illegible]



SOURCE: [illegible] Sciences

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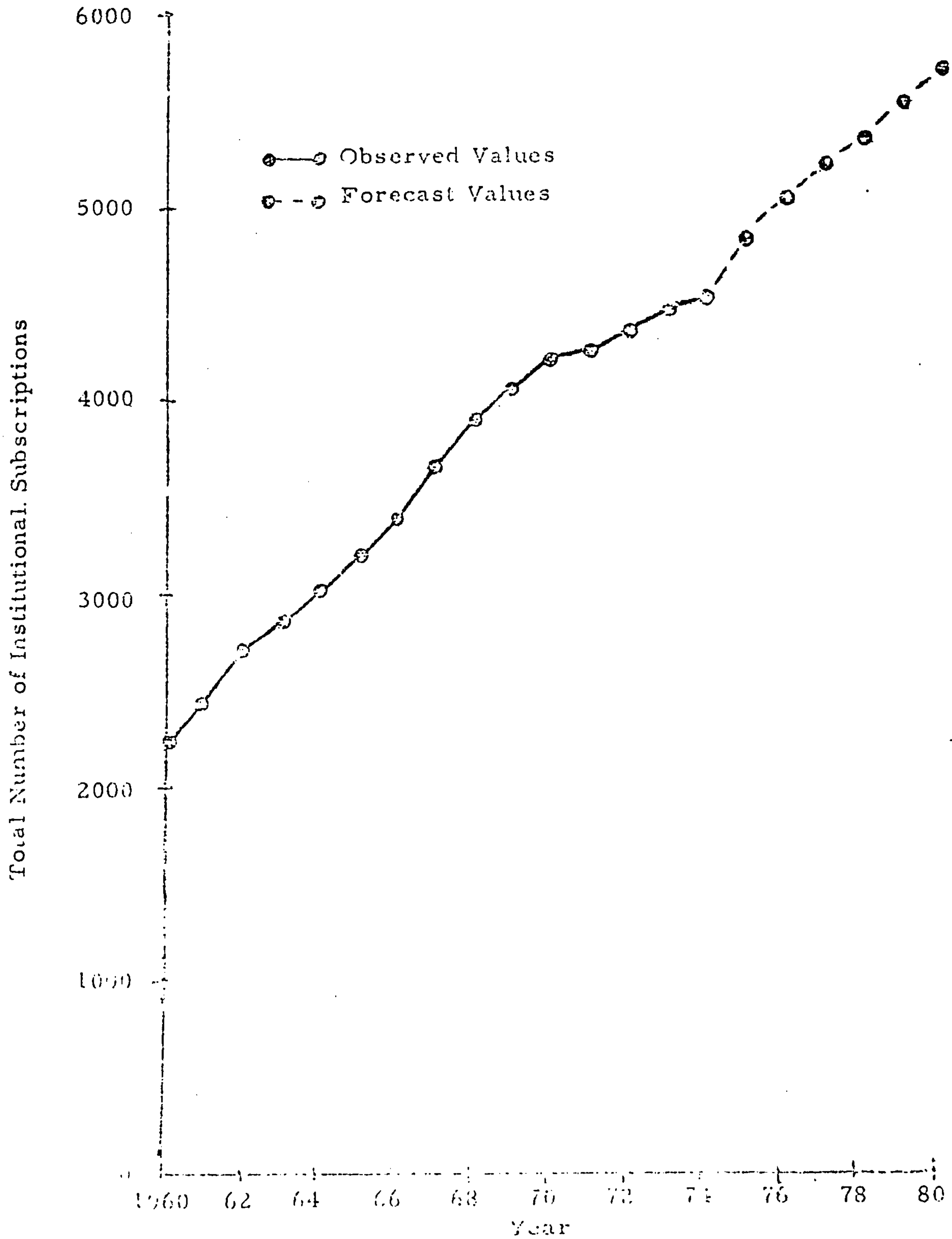
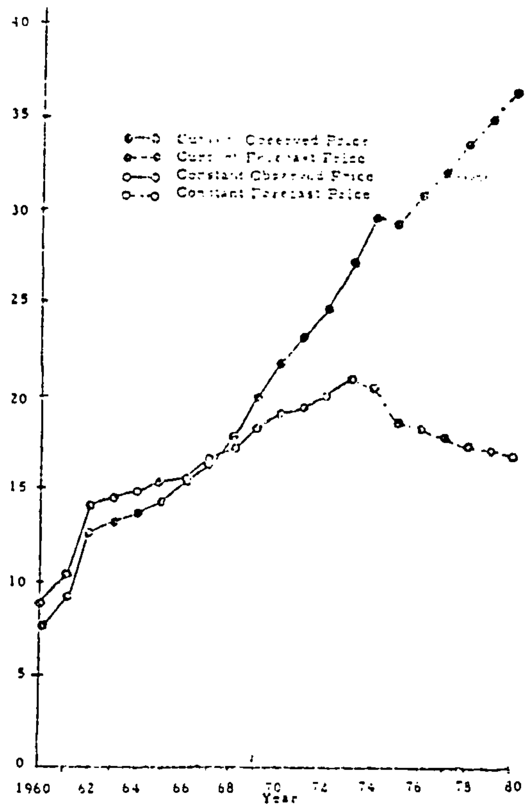
Figure 3.17 NUMBER OF INSTITUTIONAL SUBSCRIPTIONS: 1960–1980



SOURCE: Table 3.21

institutional prices obtained were given in Table 3.21 in current and constant dollars and are also plotted in Figure 3.18. The current dollar institutional price increase from 1960 to 1974 was 275 percent. As discussed in the next section, the corresponding current dollar price increase for individual subscribers was a comparable 281 percent.

Figure 3.18 AVERAGE INSTITUTIONAL PRICE FOR ALL FIELDS: 1960-1980



SOURCE: Table 3.21

The Indiana University study results for institutional subscriptive prices are somewhat different from our data. Their figures are given in Table 3.22. The Indiana price estimates are considerably lower than ours, for example $17.77 in 1973 as compared with our $27.19. At the same time, their rate of increase is somewhat greater -- 44 percent between 1969 and 1973 compared with our 37 percent. Another source, the Purdue University library, reports average prices of $32.24 and $40.57 for the scholarly journals they purchased in 1971 and 1973 respectively.

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Table 3.22 ESTIMATED AVERAGE LIBRARY SUBSCRIPTION PRICES, BY TYPE OF PUBLISHER: 1969, 1971, 1973

Type of Publisher	Total Number of Journals	1969 ($)	1971 ($)	1973 ($)
Commercial[1]	645	18.62	21.68	27.93
Society[1]	1073	11.78	13.00	16.26
University Press[1]	127	10.24	11.31	14.73
Other Not-for-Profit[1]	614	7.21	7.91	[illegible].35
Weighted Average[1]	2459	12.35	13.92	17.77
Tracking Survey Estimates[2]	-	19.83	23.30	27.19

SOURCE: [1]Fry, Bernard M. and Herbert S. White, "Economics and Interaction of the Publisher-Library Relationship in the Production and Use of Scholarly and Research Journals" (NSF GN-41308), Indiana University, November 1975.

[2]Journal Tracking Survey, Market Facts Inc., Center for Quantitative Sciences.

One reason for the low subscription prices found in the Indiana study may be their inclusion of humanities journals, generally lower-priced than those in the sciences. By field estimates from the Indiana study and the Journal Tracking Survey are shown in Table 3.23 and Table 3.24 respectively, and the Tracking survey data is also plotted in Figure 3.18.

Excluding results for humanities journals, the Indiana average subscription price data is somewhat higher, for example, $19.69 in 1973 compared with $17.77 in the same year for their total sample. Prices are greatest for pure science journals, and considerably less for both the applied science and technology and the social science journals. This trend is also evident in the

Table 3.23 ESTIMATED AVERAGE LIBRARY SUBSCRIPTION PRICES BY FIELD OF SCIENCE: 1969, 1971, 1973

Field of Science	Number of Journals	1969 ($)	1971 ($)	1973 ($)
Pure Science[1]	473	20.94	23.85	31.48
Applied Science & Technology[1]	717	13.37	15.25	19.66
Social Sciences[1] . . .	970	8.56	9.51	12.63
Weighted Total	2160	12.87	14.55	19.09
Tracking Survey Estimates[2]	-	19.83	23.3[illegible]	27.19

SOURCE: [1]Fry, Bernard M. and Herbert S. White, "Economics and Interaction of the Publisher-Library Relationship in the Production and Use of Scholarly and Research Journals" (NSF GN-41303), Indiana University, November, 1975.

[2]Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

Tracking Sur data, which shows the largest subscription prices for the Physical Sciences and Mathematics journals and the smallest for the Social Science journals. Both subscription prices and percentage increaese in them over the years vary substantially among fields.

3.2.7 Distribution and Price to Individual Subscribers

Table 3.25 gives the estimated total journal circulation to individual subscribers, along with the average number of individual subscriptions per scientist/engineer. Total circulation is plotted in Figure 3.20. Projections of the number of individual subscribers were calculated by subtracting institutional projections from those for total domestic subscribers.

It is noted that the average number of individual subscriptions ranges from about 3.0 to 3.7 over the period of time from 1960 to 1974. This seems high; however, in a study conducted by Westat (14) in 1973 among life scientists, it was estimated that the average number of subscriptions taken by respondents to their survey was just over six subscriptions per scientist. The average output in terms of number of articles per scientist in 1974 was 0.08 over all

Table 3.24 INSTITUTIONAL SUBSCRIPTION PRICES, BY FIELD OF SCIENCE: 1962-1974

(Current and Constant 1967 Dollars)*

Field of Science	1962		1964		1966		1968		1970		1972		1974	
	Current	Constant	Current	Constant	Current	Constant	Current	Constant	Current	Constant	Current	Constant	Current	Constant
Physical Sciences . . .	18.62	20.69	20.21	21.83	21.87	22.57	27.16	26.11	34.65	30.13	53.62	43.15	63.17	43.67
Mathematics	17.80	19.79	19.90	21.50	25.38	26.19	26.91	25.87	32.28	28.07	39.34	31.66	45.52	31.47
Computer Sciences . . .	10.67	11.86	14.53	15.70	12.36	11.88	14.15	13.60	19.72	17.15	24.75	19.92	27.03	18.66
Environmental Sciences	12.65	14.06	14.37	15.52	16.33	16.85	19.22	18.48	25.28	21.98	30.46	24.51	37.61	26.00
Engineering	11.13	12.37	12.02	12.98	16.24	16.76	18.88	18.15	21.36	18.57	24.67	19.85	32.40	22.40
Life Sciences	13.08	14.54	14.16	15.30	15.25	15.74	19.65	18.89	26.20	22.78	29.62	23.84	34.66	23.96
Psychology	10.01	11.13	11.64	12.57	13.38	13.81	14.70	14.13	17.93	15.59	18.48	14.87	24.32	16.81
Social Sciences	13.36	14.85	13.75	14.86	13.75	14.19	14.96	14.38	15.99	13.90	16.30	13.11	17.53	12.12
Other Sciences	7.30	8.11	7.93	8.57	9.31	9.61	10.85	10.43	13.96	12.14	16.23	13.06	19.56	13.52
All Fields	12.73	14.15	13.77	14.87	15.07	15.55	17.89	17.20	21.78	18.94	24.82	19.97	29.57	20.44

* Using GNP implicit price deflator (1975-1980 NPA) to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Table 3.25 ESTIMATED TOTAL DOMESTIC DISTRIBUTION, INDIVIDUAL SUBSCRIPTIONS, AVERAGE NUMBER OF SUBSCRIPTIONS PER SCIENTIST AND ENGINEER, AND RESEARCH AND DEVELOPMENT FUNDING IN CONSTANT DOLLARS: 1960--1980

Year	Total Domestic Subscriptions (000)	Total Individual Subscriptions (000)	Average No. of Individual Subscriptions	R&D Funding [Constant $]* (Billions)
1960 . . .	5,777	3,524	3.04	15.4
1961 . . .	6,312	3,851	3.18	16.1
1962 . . .	6,973	4,254	3.34	17.1
1963 . . .	7,378	4,501	3.34	18.8
1964 . . .	7,791	4,753	3.40	20.4
1965 . . .	8,274	5,047	3.50	21.3
1966 . . .	8,747	5,336	3.55	22.6
1967 . . .	9,417	5,744	3.64	23.2
1968 . . .	10,023	6,114	3.71	23.7
1969 . . .	10,490	6,399	3.71	23.6
1970 . . .	10,794	6,584	3.66	22.6
1971 . . .	10,943	6,675	3.64	22.2
1972 . . .	11,234	6,853	3.66	22.8
1973 . . .	11,505	7,018	3.65	23.2
1974 . . .	11,711	7,144	3.62	22.2
PROJECTIONS				
1975 . . .	12,380	7,495	3.70	21.7
1976 . . .	12,770	7,725	3.71	21.6
1977 . . .	13,160	7,970	3.73	21.6
1978 . . .	13,590	8,214	3.74	21.6
1979 . . .	14,030	8,460	3.76	21.8
1980 . . .	14,450	8,729	3.77	22.2
PERCENT CHANGE				
1960-65 . . .	43	43	10	38
1965-70 . . .	30	30	4	6
1970-75 . . .	15	14	1	-4
1975-80 . . .	18	16	2	2

* GNP implicit price deflator (1975-[illegible]) used to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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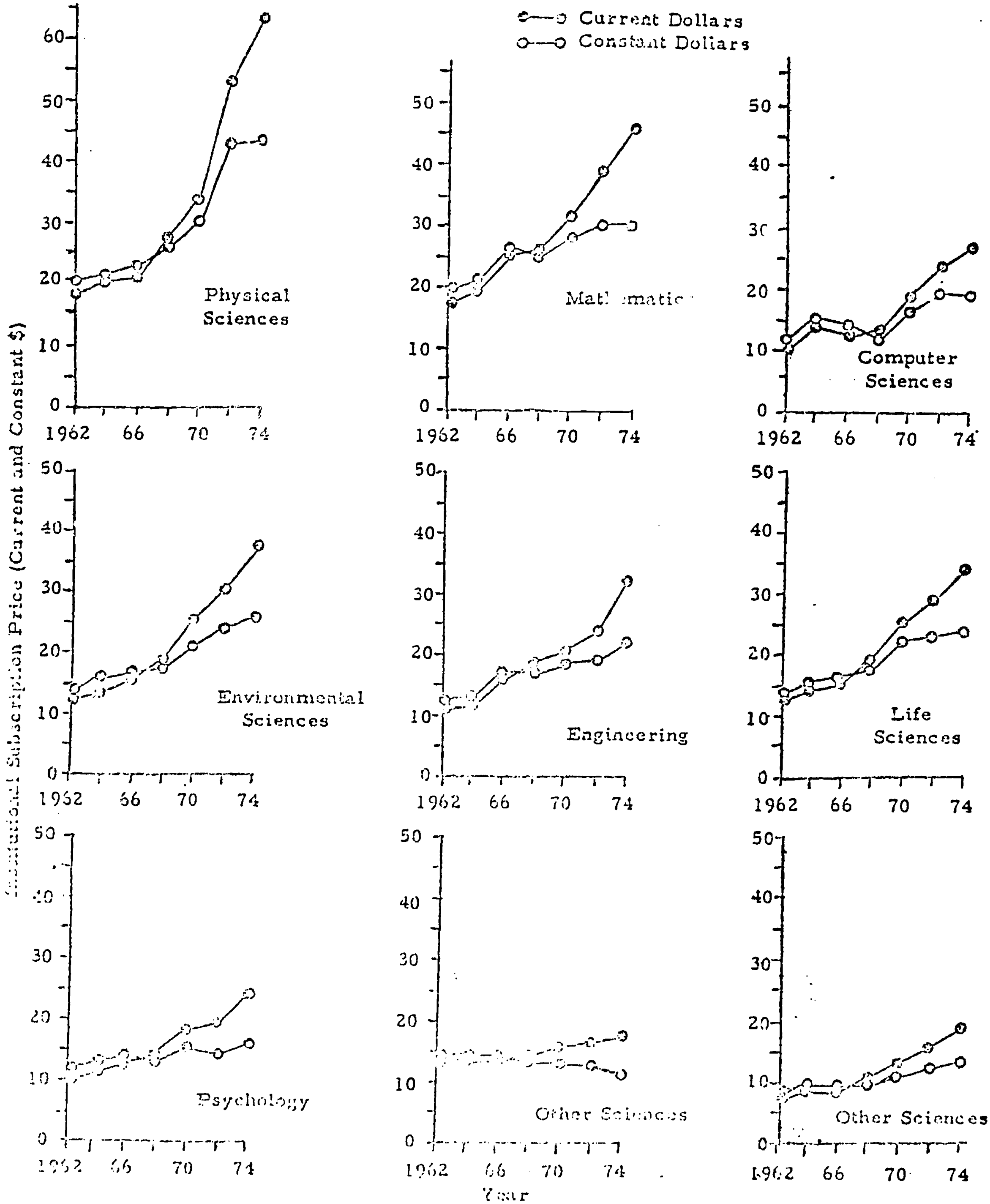
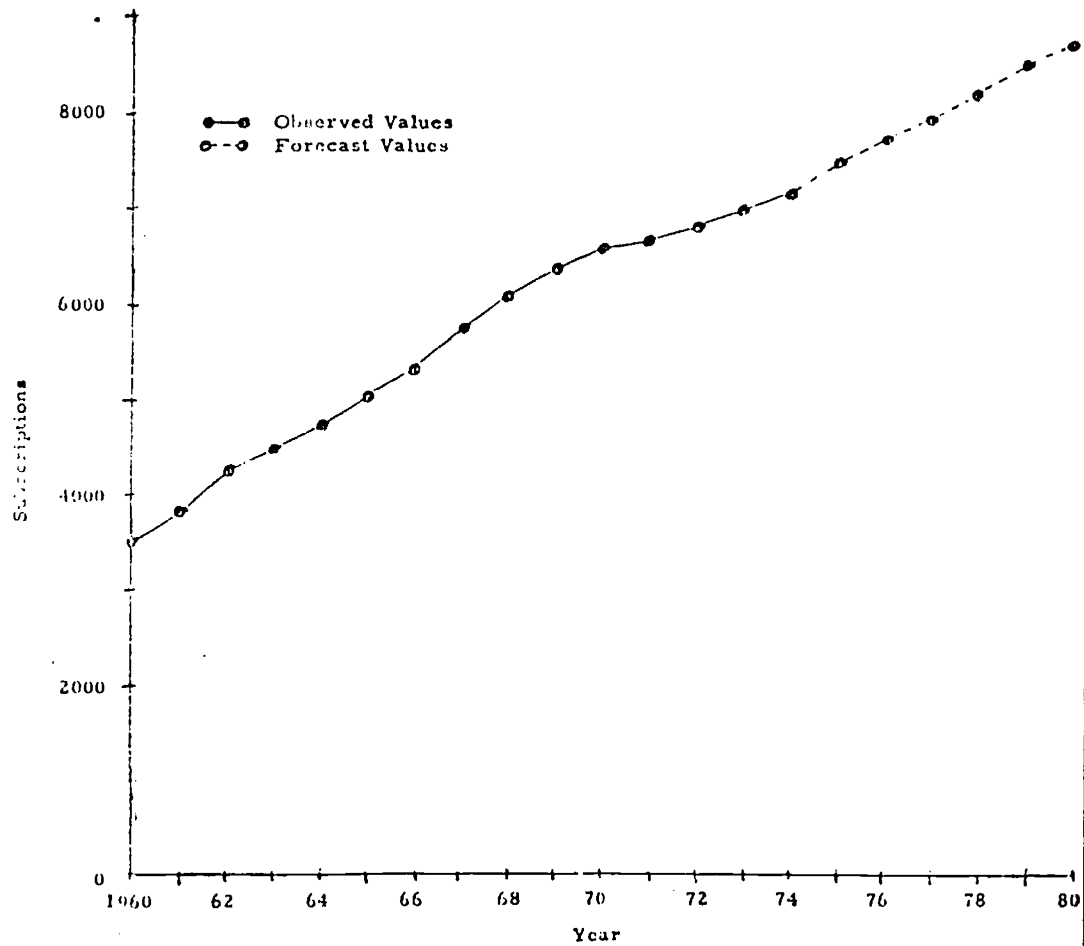
Figure 3.19 INSTITUTIONAL SUBSCRIPTION PRICES BY FIELD OF SCIENCE: 1962-1974



SOURCE: Table 3.24.

Figure 3.20 NUMBER OF INDIVIDUAL JOURNAL SUBSCRIPTIONS: 1960-1980



SOURCE: Table 3.25

Table 3.26 ESTIMATED AVERAGE SUBSCRIPTION PRICES TO INDIVIDUALS IN CURRENT AND CONSTANT DOLLARS* AND AVERAGE NUMBER OF SUBSCRIPTIONS HELD: 1960-1980

Year	Average Individual Subscription Price ($)	Average Individual Subscription Price (Constant $)	Average No. of Individual Subscriptions	Average Price Per Article (Constant $)	Average Price Per Kiloword Page (Constant $)
1960 . . .	5.27	6.00	3.04	0.0845	0.0156
1961 . . .	6.21	6.98	3.18	0.0983	0.0182
1962 . . .	8.71	9.68	3.34	0.1363	0.0252
1963 . . .	9.19	10.08	3.34	0.1440	0.0262
1964 . . .	9.67	10.45	3.40	0.1472	0.0274
1965 . . .	9.68	10.27	3.50	0.1426	0.0263
1966 . . .	9.70	10.01	3.55	0.1353	0.0252
1967 . . .	10.47	10.47	3.64	0.1396	0.0259
1968 . . .	11.25	10.82	3.71	0.1443	0.0265
1969 . . .	12.67	11.62	3.71	0.1549	0.0281
1970 . . .	14.10	12.26	3.66	0.1613	0.0291
1971 . . .	15.45	12.85	3.64	0.1647	0.0302
1972 . . .	16.80	13.52	3.66	0.1733	0.0324
1973 . . .	18.44	14.05	3.65	0.1801	0.0335
1974 . . .	20.08	13.88	3.62	0.1803	0.0330
PROJECTIONS					
1975 . . .	19.37	12.25	3.70	0.1571	0.0291
1976 . . .	20.31	12.04	3.71	0.1524	0.0282
1977 . . .	21.25	11.80	3.73	0.1494	0.0282
1978 . . .	22.19	11.53	3.74	0.1441	0.0267
1979 . . .	23.13	11.29	3.76	0.1411	0.0261
1980 . . .	24.07	11.04	3.77	0.1363	0.0252
PERCENT CHANGE					
1960-65 .	84	71	15	69	69
1965-70 .	46	19	5	13	11
1970-75 .	37	0	1	-3	58
1975-80 .	24	-10	2	-13	-13

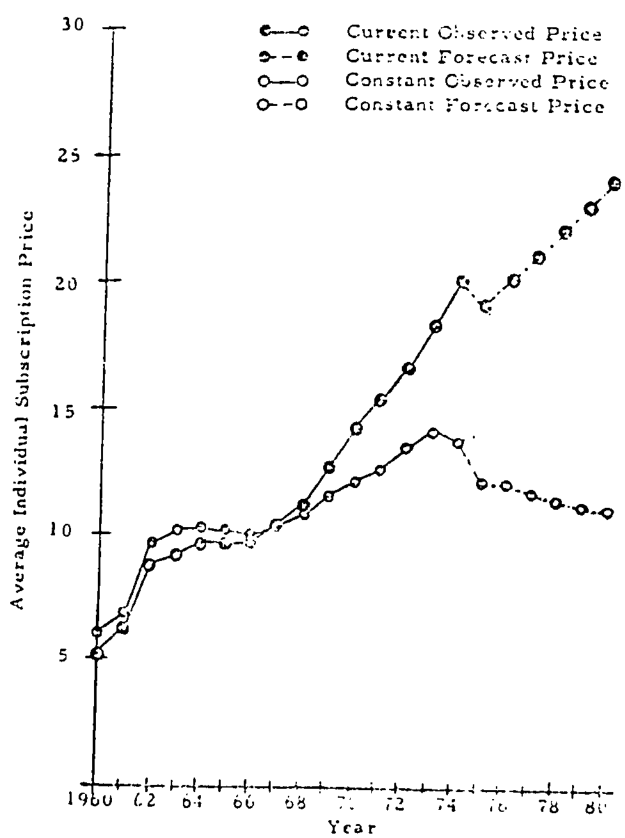
*Using GNP Implicit price deflator (1975-1980 [illegible]) [illegible] Constant Dollars.

SOURCE: Market Facts, Inc., [illegible]

sciences and 0.39 for life sciences. Thus, one would expect the average number of subscriptions for life sciences to be somewhat higher than for the remaining fields of science. The trend of the average number of individual subscriptions is slightly up over time. An important economic question is whether this trend is related to changes in subscription price.

The average individual subscription price per journal was estimated from the Journal Tracking Survey data by observing the quoted price for each journal in the sample. These figures are given in Table 3.26 and presented graphically in Figure 3.21. Results indicate a 1960 - 1974 range of prices of $5.27 to $20.03 in current dollars, or $6.00 to $13.88 in constant dollars.

Figure 3.21 AVERAGE INDIVIDUAL SUBSCRIPTION PRICE FOR ALL FIELDS OF SCIENCE:



SOURCE: Table 3.26

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Average individual subscription price versus the average number of individual subscriptions is plotted in Figure 3.22. The expected economic relationship, where demand decreases with increasing prices, does not appear to hold. Looking at individual subscription figures it is clear that what is happening is that some journals are losing subscribers when their prices increase and other journals are picking up those subscribers despite increased prices. Thus, there apparently are quality attributes of journals that must be affecting the subscription behavior.

Figure 3.22 NUMBER OF INDIVIDUAL SUBSCRIPTIONS SOLD AS A FUNCTION OF AVERAGE INDIVIDUAL SUBSCRIPTION PRICE IN CONSTANT DOLLARS

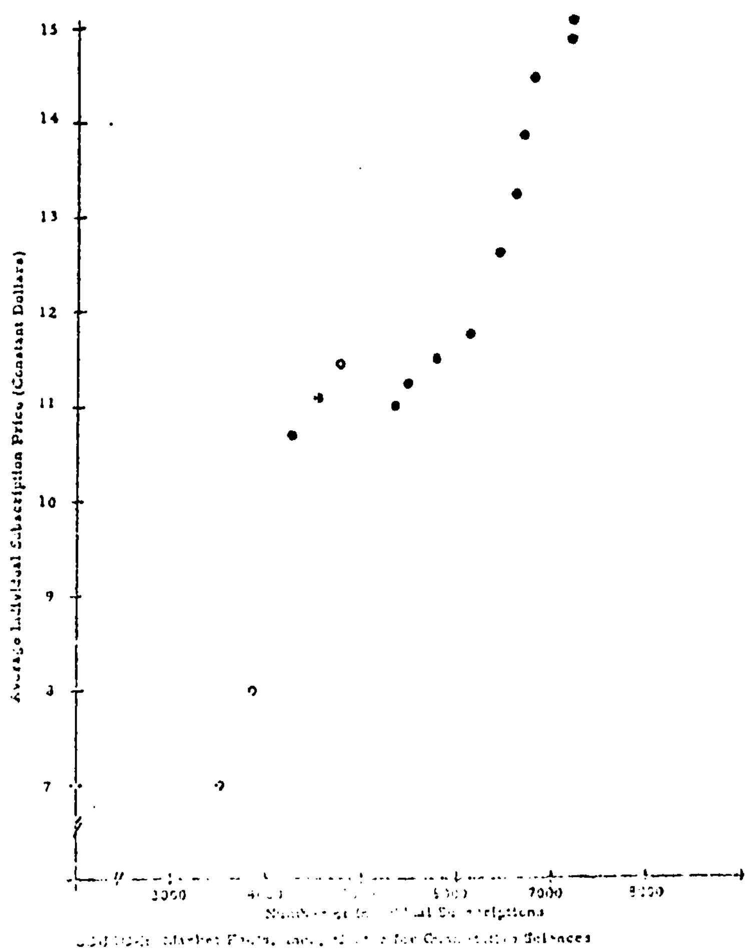

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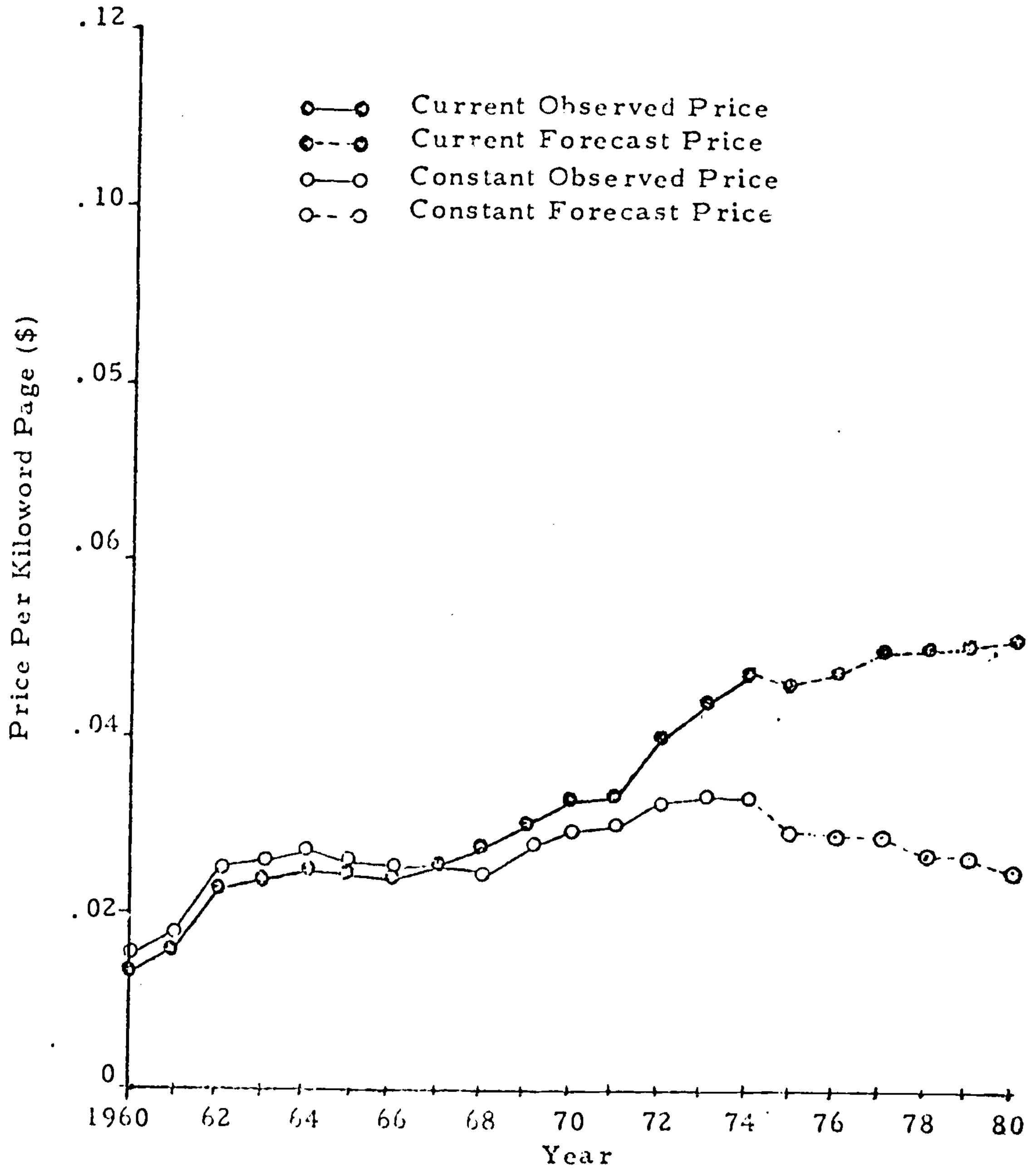
Table 3.26 also shows the average price per article, determined by dividing the average constant dollar subscription price by average number of articles per journal found in Table 3.12. The price per article has been increasing steadily since the mid-1960's, although it is projected to decline somewhat in the period to 1980. It is noted that the price per article received of less than $0.20 is still remarkably inexpensive. The average number of articles received per scientist and engineer annually is in the range of about 400 to 475 articles. Depending on how many of these articles are read and used, the journal means of distributing articles would seem to be rather efficient.

Another measure of journal costs is the price per kiloword page. This is also shown in Table 3.26, and plotted in Figure 3.23. The average price (in constant dollars) per kiloword page has gone from about 2.5 cents through the mid-1960's to a high of 3.3 cents in 1974. The SATCOM report (35) indicates that the price per kiloword page per subscriber in 1968 is in the same range as that observed in our survey. In that report, it was indicated that the price per kiloword page varied by publishing entity, field of science and size of circulation. Journals published by societies tend to have lower prices than private publishers. Our average prices over time are in the three cent per kiloword page range. The SATCOM results indicated that U. S. society publications had price ranges of one to four cents for mathematics, less than one to six cents for chemistry, less than one to seven cents for physics and one to 52 cents for electrical engineering. U. S. private publishers had price ranges from four to ten cents for mathematics, four to 14 cents for chemistry and physics, and less than two cents for electrical engineering. The Indiana University study (48) shows average price per page as being in the two to three cent range.

The breakdown of individual subscription prices by field of science is shown in Table 3.27 and Figure 3.24. These were identified in the Journal Tracking Survey. In constant dollars, the most expensive individual subscription prices in 1974 were for Physical Sciences ($29.12), Mathematics ($20.77) and Life Sciences ($20.03) journals. These are also the fields which have exhibited the sharpest increases since 1962. Practically all fields (except Physical Sciences) show a levelling off, or even decrease in constant dollar price since 1972.

The individual average prices of periodicals obtained from The Bowker Annual are presented in Table 3.28. This table displays the average price of

Figure 3.23 PRICE PER KILOWORD: 1960-1980



SOURCE: SATCOM

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Table 3.27 INDIVIDUAL SUBSCRIPTION PRICE BY FIELD OF SCIENCE: 1962-1974

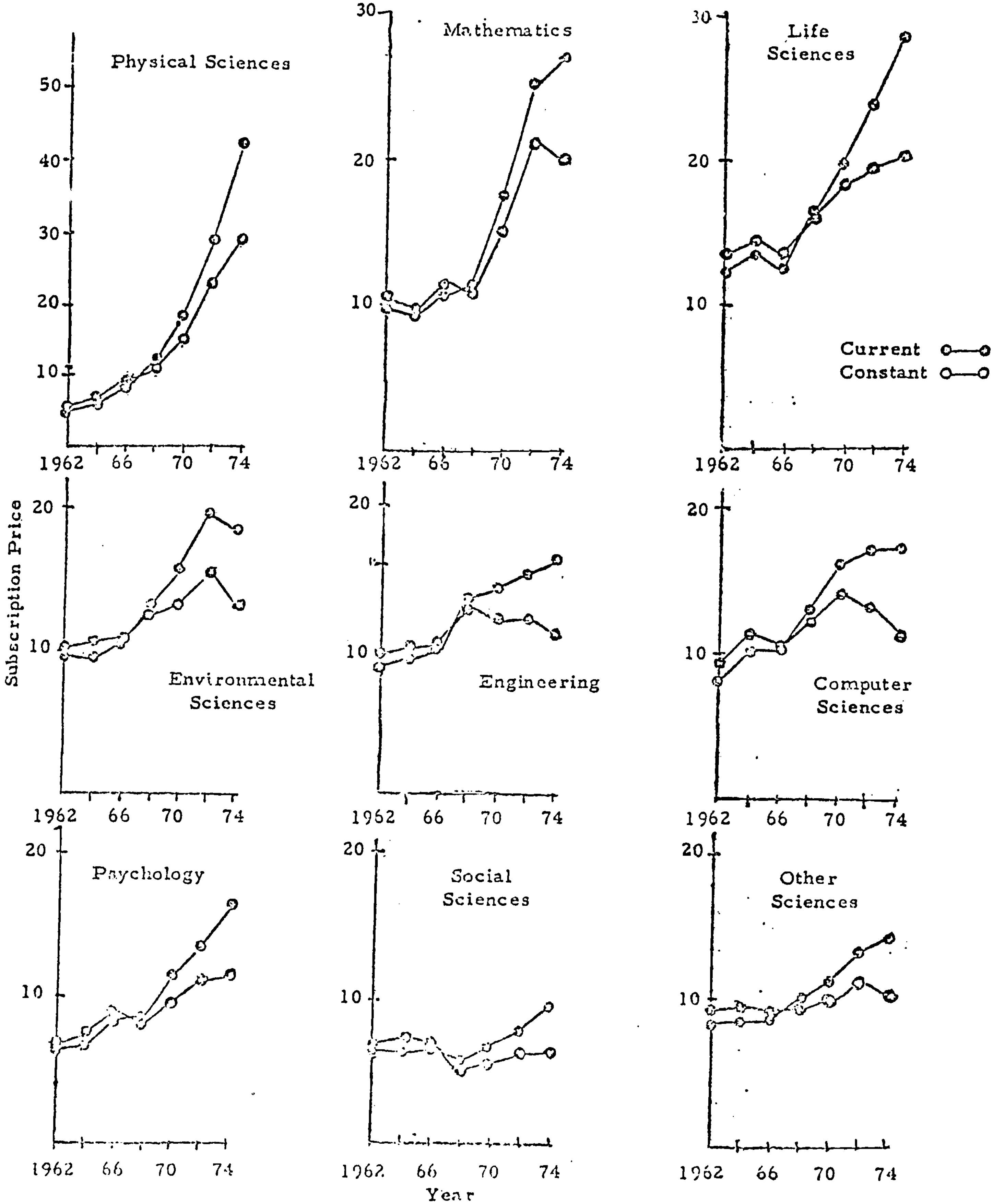
(Current and Constant 1967 Dollars)*

Field of Science	1962 Current	1962 Constant	1964 Current	1964 Constant	1966 Current	1966 Constant	1968 Current	1968 Constant	1970 Current	1970 Constant	1972 Current	1972 Constant	1974 Current	1974 Constant
Physical Sciences . . .	5.72	(6.36)	6.15	(6.64)	8.20	(8.46)	12.43	(11.95)	18.02	(15.67)	29.06	(23.39)	42.12	(29.13)
Mathematics	9.84	(10.94)	9.20	(9.94)	11.95	(12.33)	12.58	(12.10)	18.77	(16.32)	26.44	(21.28)	30.06	(20.77)
Computer Sciences . . .	8.19	(9.08)	10.50	(11.32)	10.60	(10.93)	13.09	(12.58)	16.16	(14.06)	17.01	(13.68)	17.36	(11.99)
Environmental Sciences	9.33	(10.37)	9.93	(10.73)	10.45	(10.78)	13.40	(12.88)	15.40	(13.39)	19.50	(15.69)	18.93	(13.09)
Engineering	9.00	(10.00)	9.89	(10.68)	10.09	(10.41)	13.82	(13.29)	14.55	(12.65)	15.64	(12.59)	16.46	(11.38)
Life Sciences	12.04	(13.38)	13.01	(14.29)	12.72	(13.13)	16.74	(16.10)	20.92	(18.19)	24.05	(19.35)	28.97	(20.93)
Psychology	6.06	(6.74)	6.96	(7.52)	8.39	(8.66)	8.65	(8.32)	11.24	(9.77)	13.88	(11.17)	16.52	(11.42)
Social Sciences	6.10	(6.78)	6.56	(7.09)	6.56	(6.77)	5.38	(5.17)	6.73	(5.85)	7.83	(6.30)	9.32	(6.44)
Other Sciences	8.28	(9.20)	8.63	(9.32)	8.81	(9.09)	10.01	(9.62)	11.51	(10.01)	13.70	(11.03)	14.73	(10.19)
Average All Fields	8.71	(9.68)	9.67	(10.45)	9.70	(10.01)	11.25	(10.82)	14.10	(12.26)	16.80	(13.52)	20.06	[illegible]

*Using GNP implicit price deflator (1975-1980 NPA) to obtain 1967 Constant Dollars.

SOURCE: Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

Figure 3.24: AVERAGE INDIVIDUAL SUBSCRIPTION PRICE BY FIELD OF SCIENCE: 1962-1974



SOURCE: Table 3.27.

Table 3.28 AVERAGE PRICE FOR PERIODICALS BY FIELD OF SCIENCE: 1960-1980

(Dollars)

Year	Agriculture	Business & Economics	Chemistry & Physics	Engineering	Home Economics	Library Science	Math., Botany, Geology & Gen. Science	Medicine	Psychology	Sociology & Anthropology	Zoology
1960 . . .	2.84	5.34	11.30	5.86	4.43	3.71	7.27	10.29	9.37	4.52	8.90
1961 . . .	3.03	5.45	12.25	6.14	4.49	3.83	7.70	11.19	10.65	4.59	8.95
1962 . . .	3.34	5.68	13.95	6.48	4.51	4.20	8.28	11.49	11.34	4.89	9.05
1963 . . .	3.49	6.06	16.07	6.69	4.67	4.43	9.58	12.22	11.45	4.91	5.31
1964 . . .	3.71	6.26	16.50	7.32	5.12	5.01	10.70	13.25	11.62	5.07	9.83
1965 . . .	3.83	6.39	18.42	7.70	5.37	5.15	10.96	14.02	11.85	5.26	10.31
1966 . . .	4.11	6.63	19.73	8.19	5.67	5.51	12.29	15.53	12.67	5.48	10.96
1967 . . .	4.34	7.09	22.35	9.04	6.05	5.64	13.75	17.97	13.82	5.86	12.53
1968 . . .	4.74	7.45	24.26	10.07	6.48	6.26	15.42	15.42	14.33	6.09	13.49
1969 . . .	4.97	8.07	26.60	10.98	6.84	6.85	16.71	20.77	15.40	6.[illegible]	14.15
1970 . . .	5.17	9.03	33.45	12.07	7.56	7.88	18.11	23.44	17.12	7.31	16.86
1971 . . .	5.74	9.72	38.31	13.28	7.94	8.65	20.06	27.00	18.70	7.92	19.29
1972 . . .	6.35	9.95	45.46	16.04	10.25	9.40	22.63	29.59	20.98	9.12	22.39
1973 . . .	7.21	12.25	56.61	23.37	12.21	10.48	25.99	33.60	23.17	11.28	24.07
1974 . . .	8.12	13.90	65.47	24.38	12.31	12.53	30.27	36.31	25.79	13.03	24.78
PROJECTIONS*											
1975 . . .	7.93	12.41	65.37	23.37	12.18	11.77	31.65	39.55	24.34	10.83	27.20
1976 . . .	8.51	13.23	74.40	26.07	13.22	12.78	35.08	43.71	26.00	11.61	29.84
1977 . . .	9.14	14.09	84.43	29.09	14.34	13.89	38.89	48.31	27.80	12.47	32.72
1978 . . .	9.73	15.03	95.01	32.46	15.57	15.07	43.11	53.38	29.72	13.37	35.89
1979 . . .	10.54	16.02	108.72	38.22	16.90	16.36	47.79	58.99	31.74	14.32	39.37
1980 . . .	11.30	17.07	123.37	40.42	18.34	17.57	52.96	65.19	33.92	15.38	43.15
PERCENT CHANGE											
1960-65 .	35	20	63	31	21	[illegible]	51	36	26	16	16
1965-70 .	35	41	82	57	41	53	65	67	44	39	64
1970-75 .	54	37	96	94	61	49	75	69	42	48	61
1975-80 .	42	38	88	73	51	49	67	65	39	42	59

*Except as noted, Market Facts, Inc., Center for Quantitative Sciences.

SOURCE: The Bowker Annual of Library and Book Trade Information, R. R. Bowker Company, 1962-1975 (Data 1960-1974).

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all U. S. science and technology periodicals and also a breakdown of the periodicals by field of science. The data is plotted in Figure 3.25. When comparing these averages with the averages obtained in the Journal Tracking Survey, it is seen that the rate of increase is less for the Survey sample price than for the overall (Bowker) price of scientific and technical periodicals. This difference is presumably due to the more exhaustive coverage of the Bowker figures, as compared with our sample which was limited to scholarly periodicals.

3.2.8 Distribution of Articles by Reprints

A reprint (or offprint) is a copy of an article obtained by an author from a publisher at the time his or her article is published. Some journal publishers also sell article reprints to supplement their income. Authors may obtain reprints of their own articles from publishers for a price, for free, or in return for paying a page charge. Authors then distribute these reprints in response to requests from interested colleagues, or they may simply supply them to their colleagues as an adjunct to an informal exchange of information. Reprints may also be distributed by an author's employer as a form of marketing, or a professor may distribute reprints obtained from a publisher to students instead of using photocopies. Reprints may be a significant method of scientific communication, not only because of the actual numbers involved but because of the degree of author control and informal communication which may accompany an exchange of information in this form.

Respondents to the Author Survey were asked (a) how many reprints they obtained from the publisher of their own article, and (b) how many requests for reprints they had received. Consideration of these two numbers allows us to make some estimates of the actual extent that reprints are used.

The top line of Figure 3.26 shows our estimate of the total number of reprints obtained by authors of their own articles from publishers for the period 1968 - 1980. This estimate is based on actual and projected numbers of U. S. published scientific and technical articles, multiplied times an average number of reprints obtained per article. The trend line 1968 - 1975 is based on three-year moving averages of author survey data, and the projection for 1975 - 1980 is based on a constant 142 prints obtained per article. We do not feel that the observed data indicates a significant decrease or increase in

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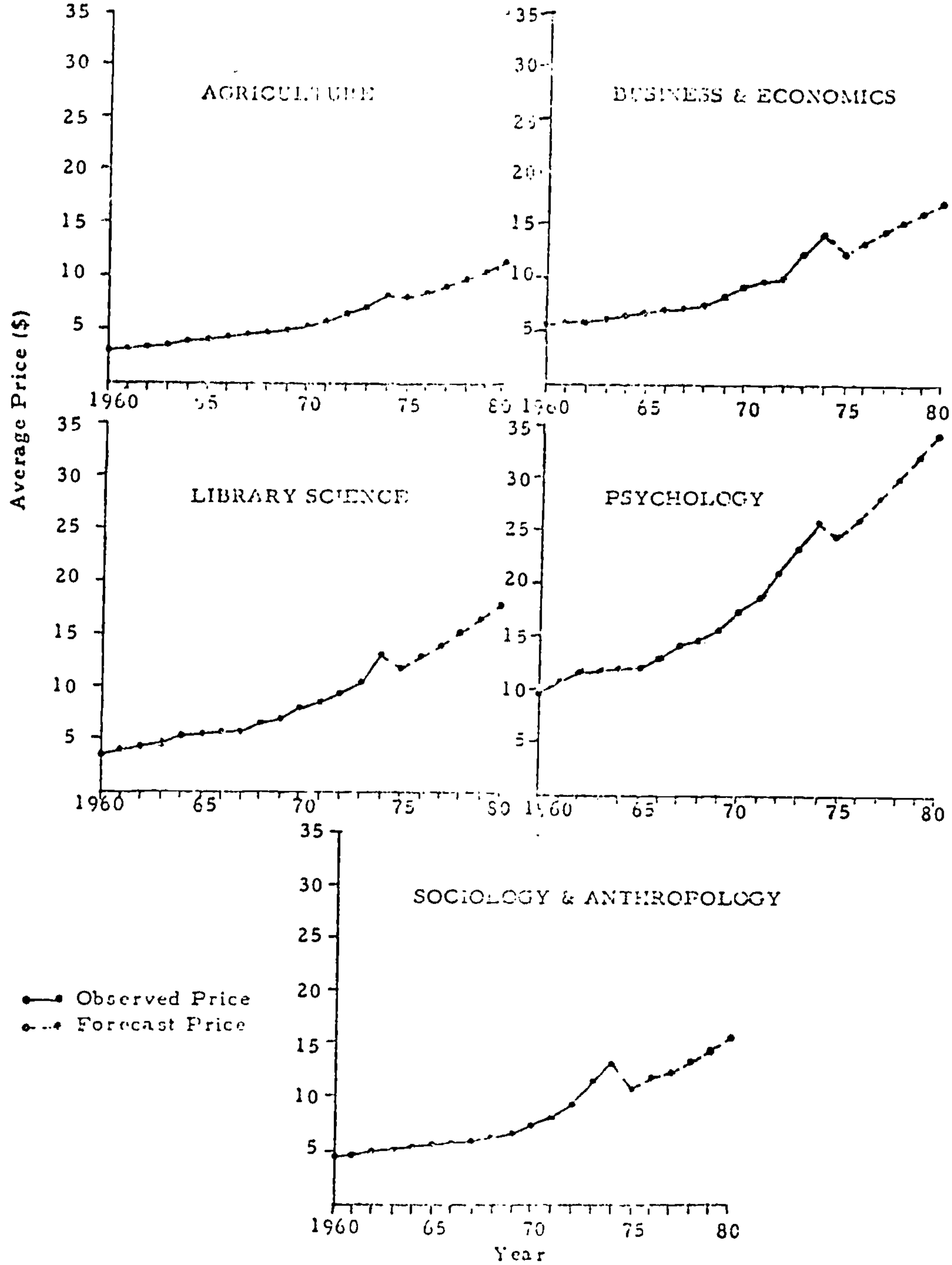
Figure 3.25 AVERAGE PRICE OF PERIODICALS BY FIELDS OF SCIENCE: 1960-1980



SOURCE: Table 3.28.

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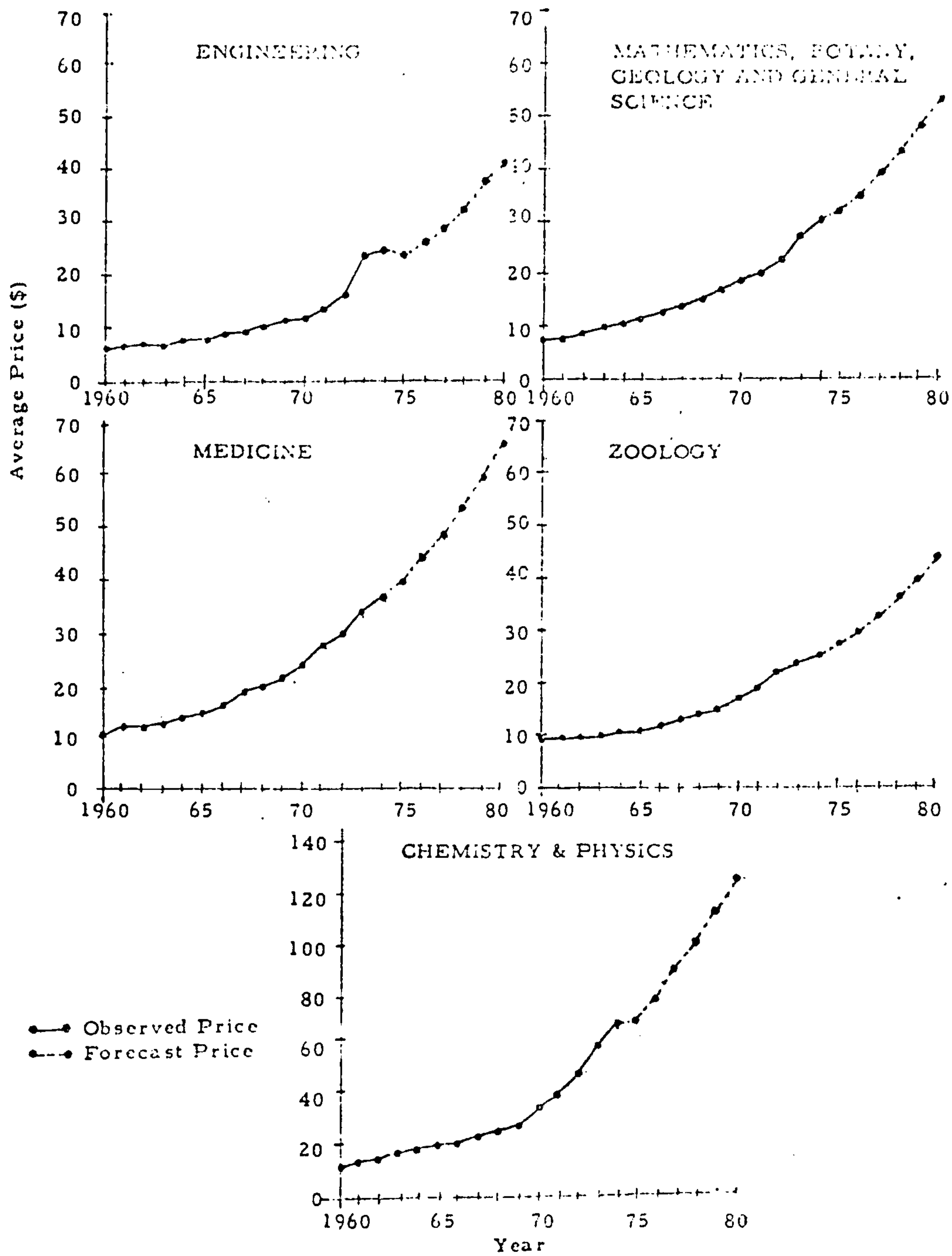

SOURCE: Table 3.28.

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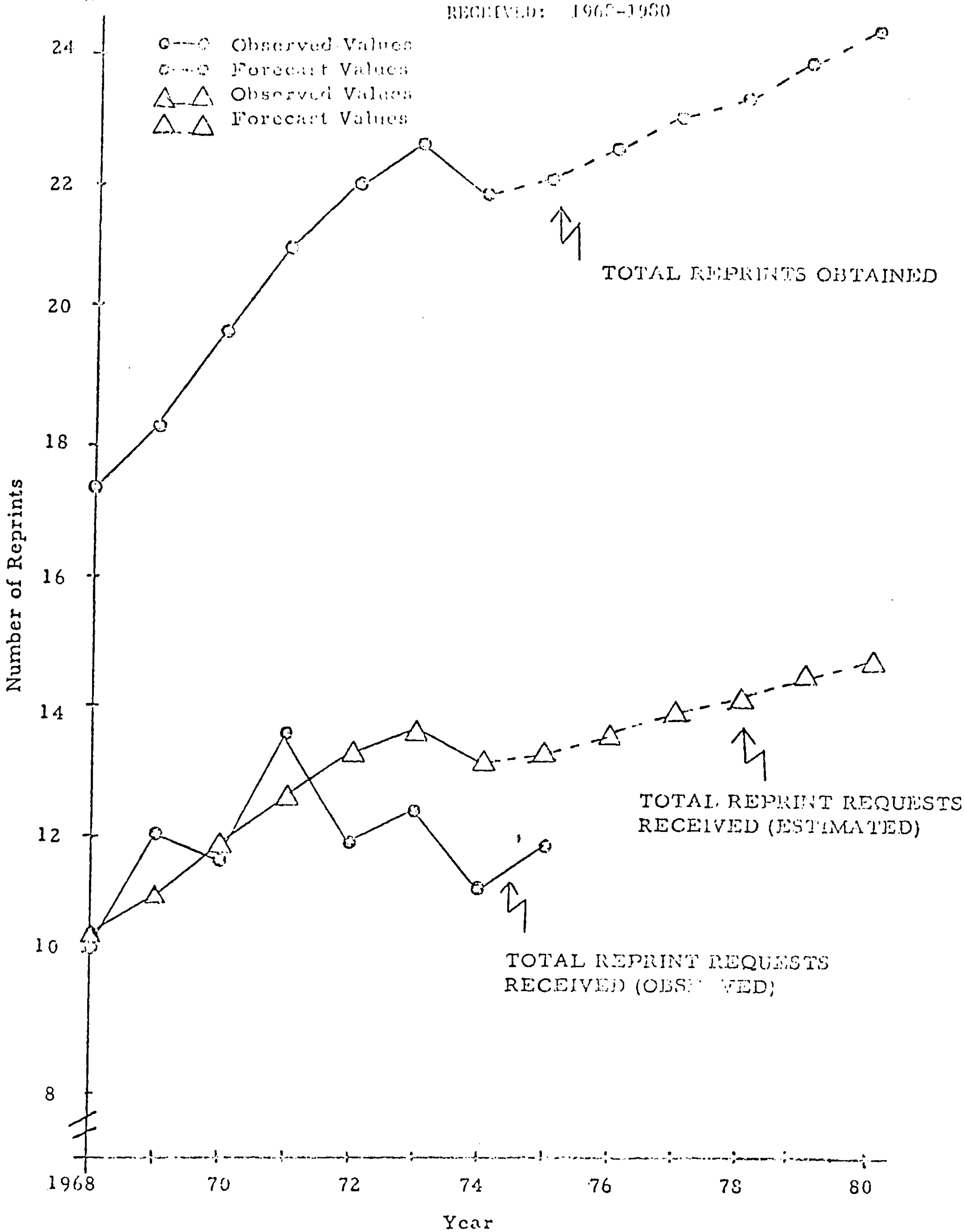
Figure 3.26 NUMBER OF REPRINTS OBTAINED BY AUTHORS AND NUMBER OF REQUESTS RECEIVED: 1968-1980



SOURCE: Table 3.29 and 3.30.

reprints obtained per article between 1968 and 1975, and we use the arithmetic average as a conservative multiplier. Numeric data is displayed in Table 3.29.

Respondents were also asked how many requests for reprints they had received. Depending upon the size of the potential audience for an article, this number may indicate the degree of interest in an author's work shown by those individuals who are willing to communicate directly with the author. If we assume that all (or nearly all) reprint requests are filled, we have a further indicator of the actual distribution of scientific and technical information via the article format.

Table 3.30 displays reprint requests received per article. Note that these averages are between 51 and 65 percent of the number of reprints obtained per article. We suggest three explanations for this. First, not all of an author's reprint supply might be exhausted, even after six or seven years have passed. Second, especially for articles published during the latter years covered by the survey, reprint requests might still be received making these numbers gross under estimates of the actual number of requests to be received over time. Third, not all reprints are distributed on request; some are distributed without having been requested, perhaps to students or co-workers. If we assume that, on the average, 60 percent of the reprints which an author obtains are eventually requested for distribution, the right-hand column of Table 3.30 is obtained as graphed in Figure 3.26.

The second part of the Author Survey, dealing with how authors obtain access to articles which they cite, did not reveal a corresponding increase in the number of articles obtained via reprint channels which were subsequently cited between 1968 and 1975. One should remember that this time frame represents two separate operations: the <u>requesting</u> of reprints and the <u>citing</u> of articles obtained as reprints. Because many articles obtained as reprints may never be cited by the requesting author, these two numbers are not comparable.

We must conclude, however, that reprint distribution, as slow and cumbersome as it is, remains a strong method of article distribution. This coupled with increasing interlibrary loan demands, leads us to believe that a market exists for the distribution of separate articles, assuming that such an operation can be sufficiently centralized, marketed, and operated so as to

Table 3.29 ESTIMATED NUMBER OF REPRINTS OF THEIR OWN ARTICLES OBTAINED BY AUTHORS: 1968-1980

Year	Reprints Obtained Per Article	Total Articles Published Per Year (000)	Total Reprints Obtained Per Year (000)
1968 . . .	128	136	17,408
1969 . . .	133	138	18,354
1970 . . .	140	141	19,740
1971 . . .	147	143	21,021
1972 . . .	150	147	22,050
1973 . . .	151	150	22,650
1974 . . .	145	151	21,895
1975 . . .	142	155	22,010
PROJECTIONS			
1976 . . .	142	159	22,578
1977 . . .	142	162	23,004
1978 . . .	142	165	23,430
1979 . . .	142	169	23,998
1980 . . .	142	172	24,424

SOURCE: Author Survey, Market Facts, Inc., Center for Quantitative Sciences.

Table 3.30 ESTIMATED NUMBER OF REPRINT REQUESTS RECEIVED BY AUTHORS OF SCIENTIFIC AND TECHNICAL ARTICLES: 1968-1980

Year	Requests Received Per Article (Observed)	Total Requests Received (Observed, 000)	Total Requests Received (Estimated, 000)
1968 . . .	76	10,336	10,445
1969 . . .	87	12,006	11,012
1970 . . .	82	11,562	11,844
1971 . . .	95	13,585	12,613
1972 . . .	81	11,907	13,230
1973 . . .	83	12,450	13,590
1974 . . .	74	11,174	13,137
1975 . . .	77	11,935	13,206
PROJECTIONS			
1976 . . .	-	-	13,547
1977 . . .	-	-	13,802
1978 . . .	-	-	14,058
1979 . . .	-	-	14,399
1980 . . .	-	-	14,654

SOURCE: Author Survey, Market Facts, Inc., Center for Quantitative Sciences.

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be economically viable. The major caveat we have in this respect, however, is that such an operation (e.g., a clearinghouse) would not promote the element of informal scientific communication which accompanies reprint exchange, a point made by several of our consultants.

3.3 Growth of the Scientific and Technical Report Literature

A number of government organizations announce and distribute scientific and technical report literature produced under Federal government sponsorship. Principal among these are the National Technical Information Service (NTIS) and the United States Government Printing Office (GPO). NTIS, part of the Department of Commerce, is the central point in the United States for public sale of R&D reports generated by Federal agencies, their contractors, or grantees. The GPO prints and disseminates a wide variety of government materials, including scientific and technical reports. A discussion of data obtained from these two organizations for the period 1965 on follows.

3.3.1 The National Technical Information Service

The National Technical Information Service processes primarily government reports and a small number of journal articles and a small percentage of journal articles. Figures on total items processed and reports processed are shown in Table 3.31.

Table 3.31 also shows Federal obligations for research and development. These demonstrate the lack of correlation between growth of NTIS and research and development funding.* It is felt that much of the growth in report literature covered by NTIS is attributable to their aggr[illegible]ive approach to gaining coverage of scientific and technical reports from a broad range of Federal agencies.

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*In the same vein, we attempted to correlate research project data from the Smithsoni[illegible] Science Information Exchange (SSIE) with the number of reports process[illegible] NTIS. This analysis required identifying a sample of new research [illegible]ojects announced by SSIE and tracking their titles, contract numbers, or principal investigator names through announcement by NTIS. The process proved to be unsuccessful due to our inability to correctly identify the reports in NTIS. This study is described in detail in Appendix VIII.

Table 3.31 NUMBER OF ITEMS PROCESSED BY NTIS: 1965-1980

Year	Total No. of Items Processed[3]	Reports Processed[4]	Federal R&D[1] Funds (Millions Constant $)[2]
1965 . . .	18,504	14,063	15,501
1966 . . .	27,881	21,747	15,810
1967 . . .	29,500	23,600	16,529
1968 . . .	29,500	24,190	15,307
1969 . . .	38,400	32,256	14,347
1970 . . .	43,650	37,539	13,338
1971 . . .	48,670	42,830	12,947
1972 . . .	54,980	49,482	13,288
1973 . . .	55,597	51,149	12,818
1974 . . .	60,600	56,358	12,265[e]
1975 . . .	65,700	61,100	12,532[e]
PROJECTIONS*			
1976 . . .	70,700	65,929	11,976
1977 . . .	75,800	70,638	11,775
1978 . . .	80,900	75,347	11,527
1979 . . .	85,900	80,056	11,423
1980 . . .	91,000	84,766	11,212

[1] Based on NSF estimates.

[2] Market Facts, Inc., Center for Quantitative Sciences.

[4] [illegible] plant.

[2] [illegible] price deflator ([illegible]) to obtain 1967 Constant Dollars.

[3] [illegible] Indexing Services, Member Service [illegible] 1977.

[5] [illegible] 1975.

Forecasts of NTIS growth are made by simple time series analysis. The forecasts from 1975 to 1980 are shown in Figure 3.27 based on the following equation:

$$\hat{Y} = 14.1 + 4.7X$$

where:

$\hat{Y}$ is the number of scientific and technical reports

X is the year (0 = 1965, 1 = 1966 . . .)

It is cautioned that much of the past growth in NTIS has been due to expanded coverage, and that this trend must continue if the forecasts are to hold.

The number of copies sold by NTIS and the associated revenues are given in Table 3.32. Past experience (68) has shown that a large proportion of the sales of a report occur in the first year after publication, and thus we determined the average number of copies sold per report by dividing total copies sold in one year by the number of reports processed the previous year. The relationship between that was shown in Figure 3.28 has a high correlation and is used as a basis for forecasting total copies. The relationship is given by:

$$\hat{Y} = -212.7 + 53.1X$$

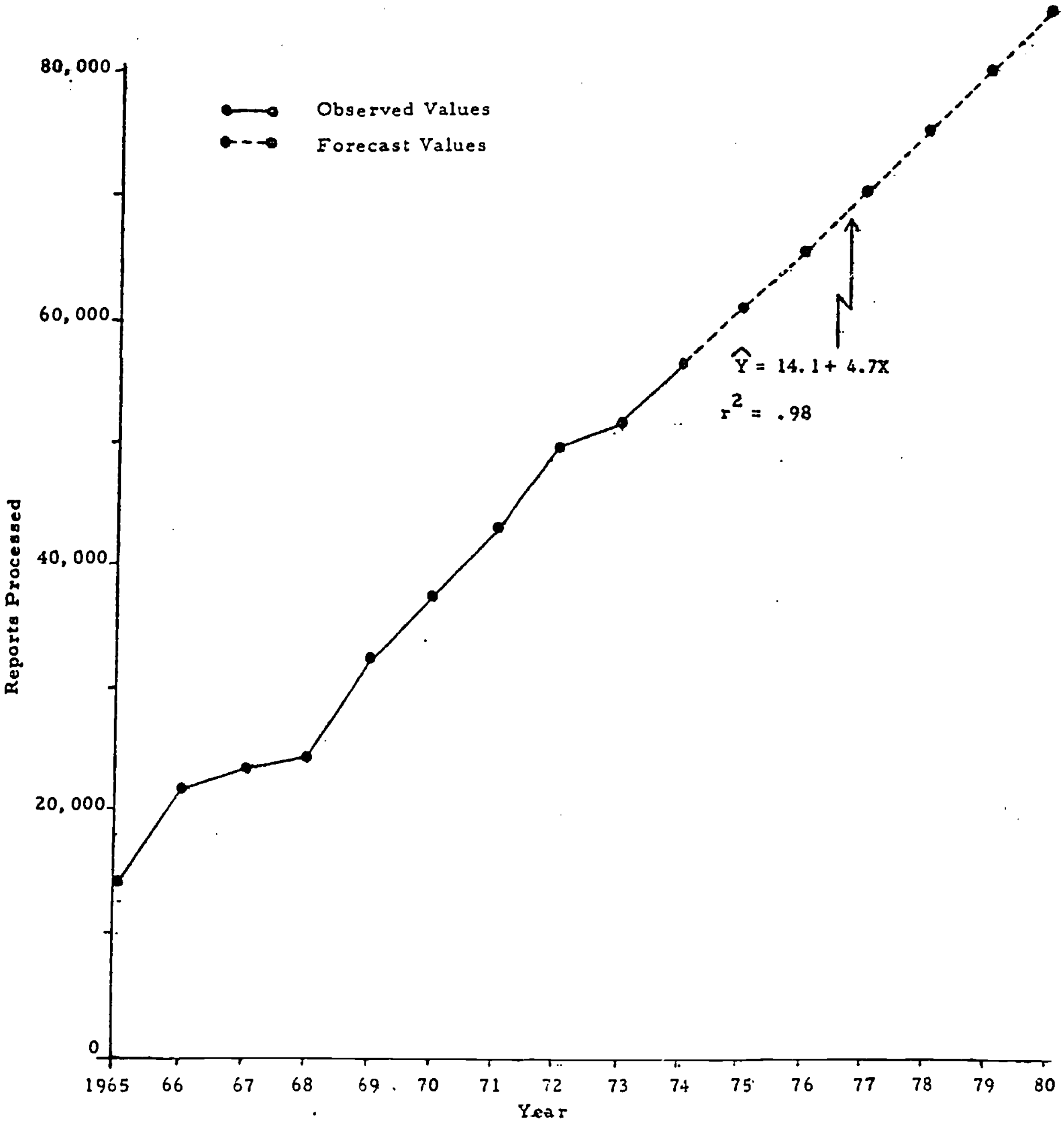
where:

$\hat{Y}$ is estimated number of copies sold in thousands

X is the number of reports processed in thousands (lagged one year).

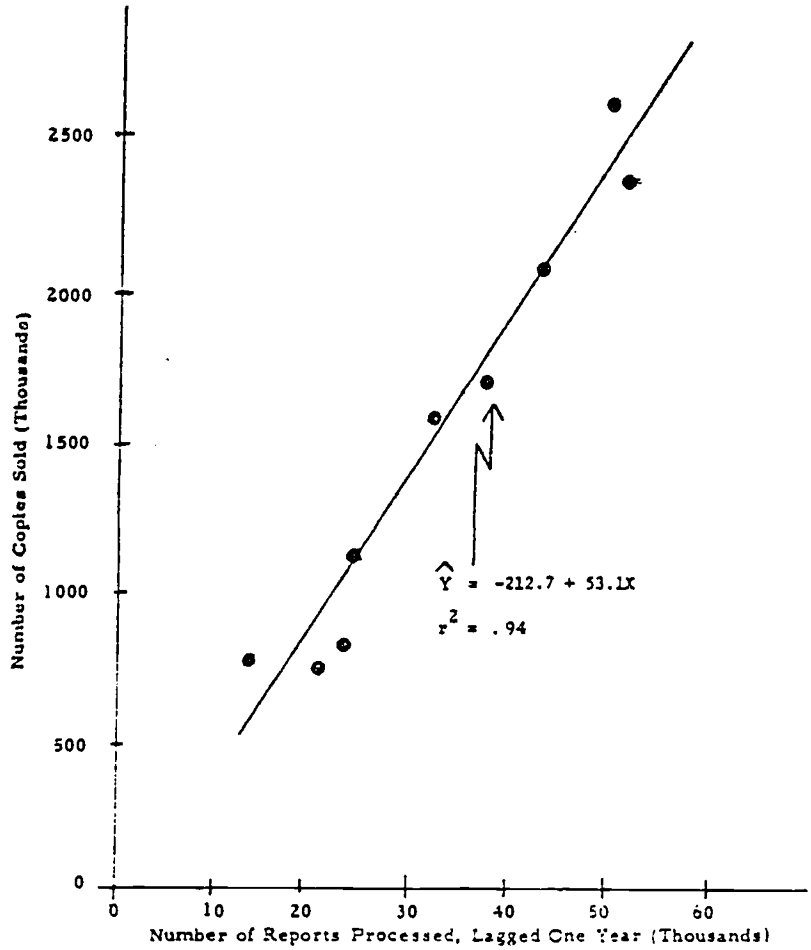
The forecast values of total and per copy sales for paper copy and microfiche are also given in Table 3.32. The latter two values are plotted in Figure 3.29 in order to illustrate the contrast between these two forms of distribution. From 1966 to 1974 microfiche sales have increased an impressive 465 percent while paper copy sales have increased only 51 percent. These trends are expected to continue, with microfiche sales increasing about 36 percent

Figure 3.27 NUMBER OF REPORTS PROCESSED BY NTIS: 1965–1980



SOURCE: Table 3.31

Figure 3.28 NUMBER OF COPIES OF NTIS REPORTS SOLD AS A FUNCTION OF REPORTS PROCESSED (LAGGED ONE YEAR)



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

from 1975 to 1980 and paper copy sales increasing about 31 percent during the same period. It is pointed out that NTIS has waged a strong sales effort over the recent years and that they have emphasized such programs as selective dissemination of microfiche. These efforts have contributed substantially to overall sales as well as to sales of microform. The dip in sales of microform from 1973 to 1974 was due to a new policy by the Defense Documentation Center to make their microfiche (some of which are available from NTIS) available on an automatic distribution basis.

The average price of paper copy and microfiche copies is also found in Table 3.32. These prices are calculated by dividing revenue by the number of copies sold for each form of distribution. The average prices are for all

Table 3.32 NUMBER OF COPIES OF SCIENTIFIC AND TECHNICAL REPORTS SOLD (PAPER COPY & MICROFORM) AND REVENUE AT NTIS: 1963-1980

Year	Paper Copy Sold[1] (000)	Copies Per Report[2]	Paper Copy Revenue[2] (000) [Current $]	Paper Copy Revenue[2] (000) [Constant $]*	Average Revenue[2] [Current $]	Average Revenue[2] [Constant $]*	Microfiche Sold[1] (000)	Microfiche Revenue[1] (000) [Current $]	Microfiche Revenue[2] (000) [Constant $]*	Average Revenue[2] [Current $]	Average Revenue [Constant $]*	Total Copies Sold[1] (000)	Percent Paper Copy[2]	Percent Microform Copy[2]
1963 . . .	-	-	616.2	698.0	-	-	-	80.6	-	-	-	-	-	-
1964 . . .	-	-	621.7	747.4	-	-	-	87.9	-	-	-	-	-	-
1965 . . .	-	-	662.4	702.6	-	-	-	84.0	-	-	-	-	-	-
1966 . . .	501	35.6	724.6	799.4	1.55	1.60	281	93.2	101.3	.35	.38	784	63.9	36.1
1967 . . .	466	21.4	1,110.1	1,110.1	2.38	2.38	295	144.7	144.9	.49	.49	761	61.2	38.6
1968 . . .	451	19.2	1,196.1	1,140.4	2.62	2.52	369	155.5	149.7	.45	.43	820	55.5	44.5
1969 . . .	[illegible]	25.1	1,936.[illegible]	[illegible]	3.27	3.00	514	213.0	200.8	[illegible]	[illegible]	1,12[illegible]	[illegible]	[illegible]
1970 . . .	715	22.2	2,255.1	1,959.9	3.15	2.74	869	311.8	290.2	.38	.33	1,584	45.1	54.9
1971 . . .	686	11.3	2,315.2	1,925.1	3.37	2.81	1,017	502.5	421.8	.50	.41	1,70[illegible]	[illegible]	[illegible]
1972 . . .	570	15.6	2,592.9	1,999.2	3.71	2.93	1,421	914.3	751.8	.66	.53	2,031	32.0	68.0
1973 . . .	637	14.1	[illegible]	2,597.5	4.81	3.73	1,941	1,090.0	810.6	.56	.43	2,618	26.4	73.6
1974 . . .	752	14.9	3,873.0	2,695.3	5.15	3.56	1,799	1,097.0	750.6	.69	.48	2,356	32.1	67.9
1975 . . .	[illegible]	11.3	3,501.7	2,119.1	5.07	3.21	2,317	1,600.0	885.6	.60	.34	[illegible]	[illegible]	[illegible]
PROJECTIONS[2]														
1976 . . .	768	12.6	4,1[illegible]2.6	2,467.[illegible]	5.42	3.21	2,260	1,610.0	906.1	.72	.41	[illegible]	26.0	75.0
1977 . . .	797	12.1	4,587.2	2,566.7	5.76	3.20	2,393	1,590.0	1,049.3	.76	.42	3,19[illegible]	26.2	75.3
1978 . . .	823	11.7	5,016.3	2,605.5	6.10	3.17	2,737	2,160.0	1,121.9	.79	.41	3,560	23.3	76.7
1979 . . .	850	11.3	5,478.1	2,574.1	6.44	3.14	2,950	2,460.0	1,200.8	.84	.41	3,7[illegible]	22.[illegible]	77.[illegible]
1980 . . .	876	10.9	5,963.2	2,726.7	6.78	3.11	3,165	2,770.0	1,270.2	.86	.40	4,0[illegible]	21.7	78.3
PERCENT CHANGE														
1970-75 .	+7	-47	50	9	61	15	168	319	205	58	15	89	-51	26
1975-80 .	31	-8	76	22	34	-3	36	99	43	47	5	35	-1	13

*Using GNP implicit price deflator (1975-1980 NPA) to obtain 1967 Constant Dollars.

SOURCE: [1]National Technical Information Service, Springfield, Virginia, 1975.

[2]Market Facts, Inc., Center for Quantitative Sciences.

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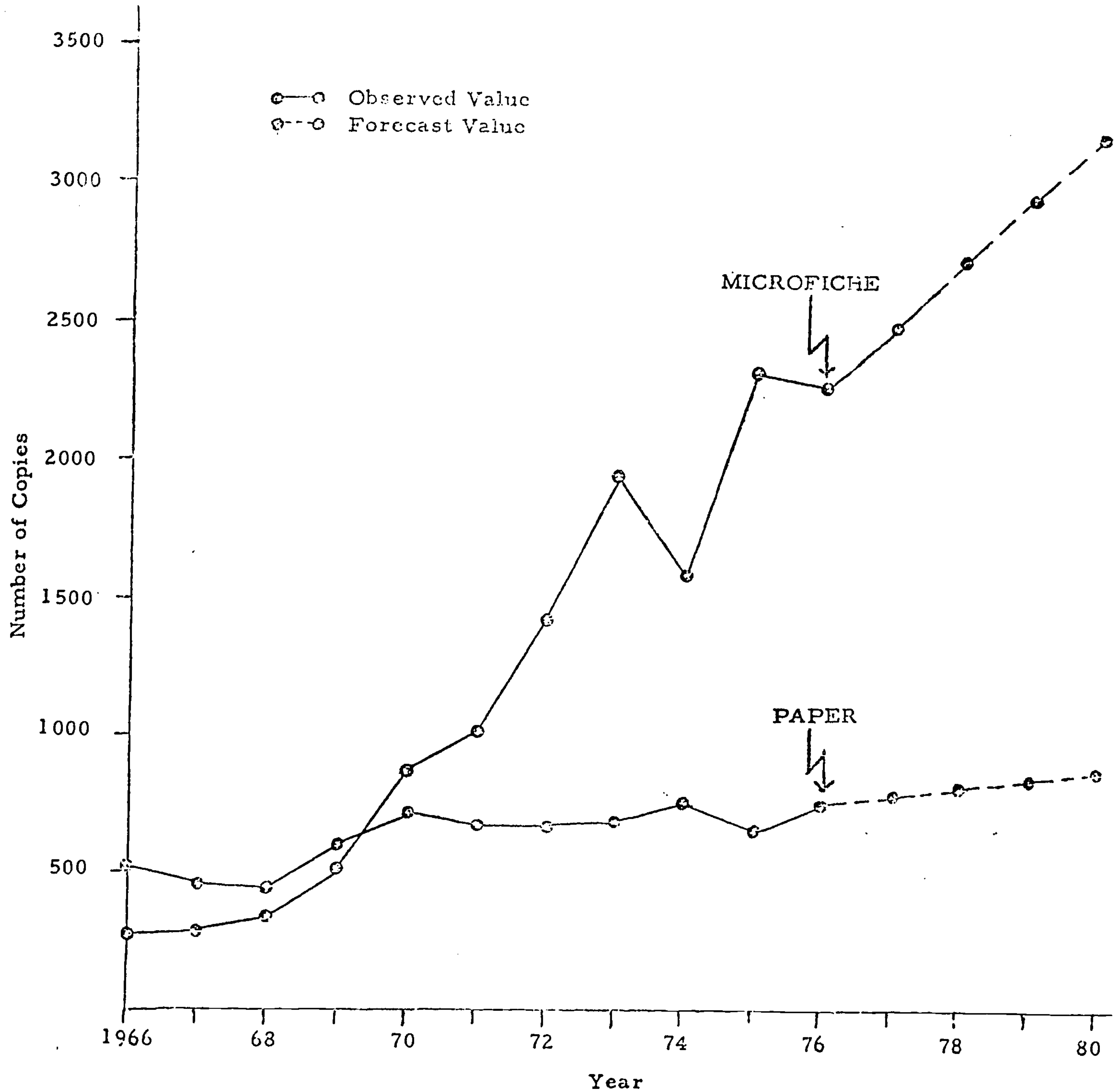
Figure 3.29 NUMBER OF PAPER AND MICROFICHE COPIES SOLD AT NTIS: 1966-1980



SOURCE: Table 3.32

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copies sold in a given year, and reflect both prices of documents announced that year and also previous pricing policies.* This brings the average price down. Average prices for paper copy and microform are given in Figure 3.30 with projections to 1980. Current dollar price increases for paper copy and microfiche are 232 percent and 97 percent, respectively, from 1966 to 1974. Constant dollar price increases were 123 percent and 31 percent respectively. Certainly, the large difference in price changes might partially contribute to the discrepancy observed in paper copy and microform sales over the years. Sensitivity of paper copy sales to prices is suggested by Figure 3.31., which shows average paper copy sales per report plotted against the average price of paper copies. Obviously, price is not the only factor that has dampened paper copy sales at NTIS, but it certainly must contribute.

3.3.2 The United States Government Printing Office

The United States Government Printing Office also reproduces and distributes government sponsored research reports. They process substantially fewer of these reports than NTIS but, on the average, their reports have wider distribution. In order to obtain data on the GPO, we drew a sample of approximately 40 scientific and technical reports** from the Monthly Catalog (75) for each year from 1965 to 1974. From this sample we noted such information as price, subject field, number of pages and number of copies distributed. This information is summarized in Table 3.33.

The first column in Table 3.33 gives the total number of reports announced by GPO and the second column gives our estimate of the number of those that are scientific and technical. Of the S&T reports, a number are available at NTIS, and the remainder are reproduced and distributed primarily by GPO. There has been a substantial growth in scientific and technical reports reproduced and distributed by GPO over the period 1965 to 1974, as illustrated in Figure 3.32. This growth is forecast to continue according to the following equation:

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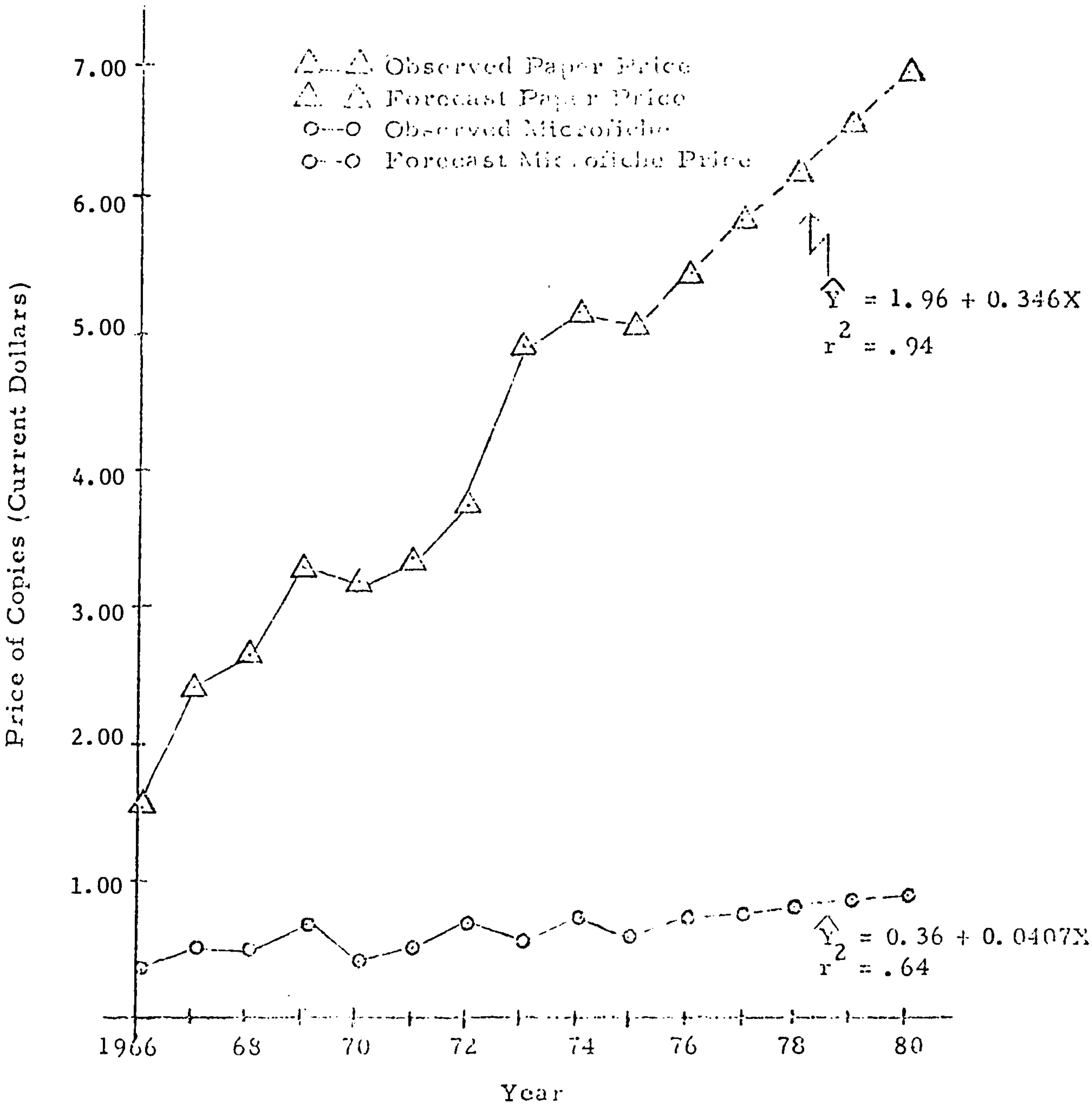
*In 1974, price increases began to be applied to all documents, old or new.

**Only reports that were judged to be written by scientists or engineers for their peers were included. Reports that were written for distribution to the general public were not included.

Figure 3.30 PRICE OF PAPER COPY AND MICROFICHE REPORTS AT NTIS: 1966-1980



SOURCE: Table 3.32

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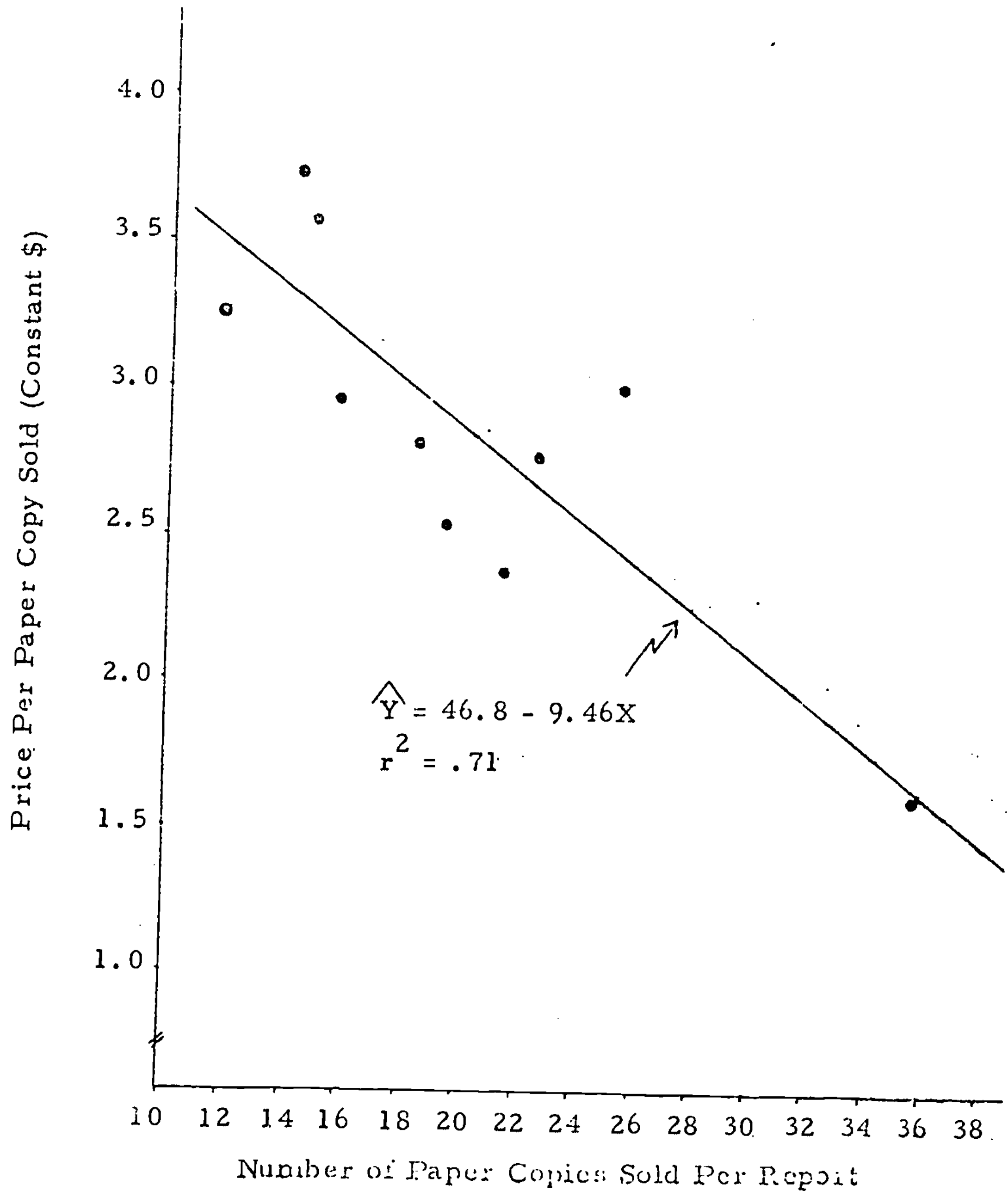
Figure 3.31 NUMBER OF PAPER COPIES PER NTIS REPORT SOLD AS A FUNCTION OF AVERAGE PRICE



SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Table 3.33 NUMBER OF COPIES OF SCIENTIFIC & TECHNICAL REPORTS SOLD AND REVENUE AT GPO: 1965-1980

Year	Total No. of Reports (000)	Est. No. of Scientific & Tech. Rpts. Announced	Est. No. of S&E Reports (Non-NTIS)	Est. Total Copies Sold (Millions)	Est. Ave. Copies Sold (3 Yr. Mov. Ave.)	Est. Ave. Price (Current $)	Ave. Price (Constant $)	Est. Revenue (Millions Current $)	Est. Revenue (Millions Constant $)	Ave. No. of Pages	Price Per Page (Cents)
1965 . . .	19.2	1,870	748	.90	1,209	1.38	1.46	1.24	1.32	113	1.2
1966 . . .	17.1	1,940	713	.98	1,371	1.41	1.46	1.38	1.42	125	1.1
1967 . . .	17.2	2,140	1,122	1.96	1,746	1.42	1.42	2.78	2.78	181	0.8
1968 . . .	17.1	2,290	935	1.54	1,643	1.59	1.53	2.45	2.36	246	0.6
1969 . . .	16.4	1,790	1,118	1.70	1,523	1.52	1.39	2.58	2.37	207	0.7
1970 . . .	17.3	1,740	1,005	1.64	1,627	1.30	1.13	2.13	1.85	137	0.9
1971 . . .	17.1	1,820	1,099	1.94	1,778	1.37	1.14	2.66	2.21	157	0.9
1972 . . .	14.2	2,250	1,646	3.14	1,909	1.57	1.26	4.93	3.97	179	0.9
1973 . . .	16.0	2,910	2,090	3.53	1,688	2.16	1.65	7.62	5.81	108	2.0
1974 . . .	10.6	2,770	1,961	3.21	1,639	2.40	1.66	7.70	5.32	130	1.8
					PROJECTIONS*						
1975 . . .	-	-	2,084	3.82	1,834	2.23	1.41	8.52	5.39	-	-
1976 . . .	-	-	2,275	4.24	1,874	2.38	1.41	10.14	6.01	-	-
1977 . . .	-	-	2,405	4.60	1,914	2.54	1.41	11.68	6.48	-	-
1978 . . .	-	-	2,441	4.77	1,954	2.71	1.41	12.93	6.72	-	-
1979 . . .	-	-	2,519	5.03	1,995	2.89	1.41	14.54	7.10	-	-
1980 . . .	-	-	2,587	5.26	2,035	3.07	1.41	16.15	7.41	-	-
					PERCENT CHANGE						
1965-70 .	-10	-7	34	80	35	-6	-23	72	38	-	-25
1970-75 .	-	-	107	133	13	72	25	300	191	-	-
1975-80 .	-	-	24	38	11	38	0	90	37	-	-

* GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

Market Facts, Inc., Center for Quantitative Sciences. (Study based on sample of items announced in Monthly Catalog of U.S. Government Publications, 1965-1974.)

$$\hat{Y} = 2212 - 103X_1 + 119X_2$$

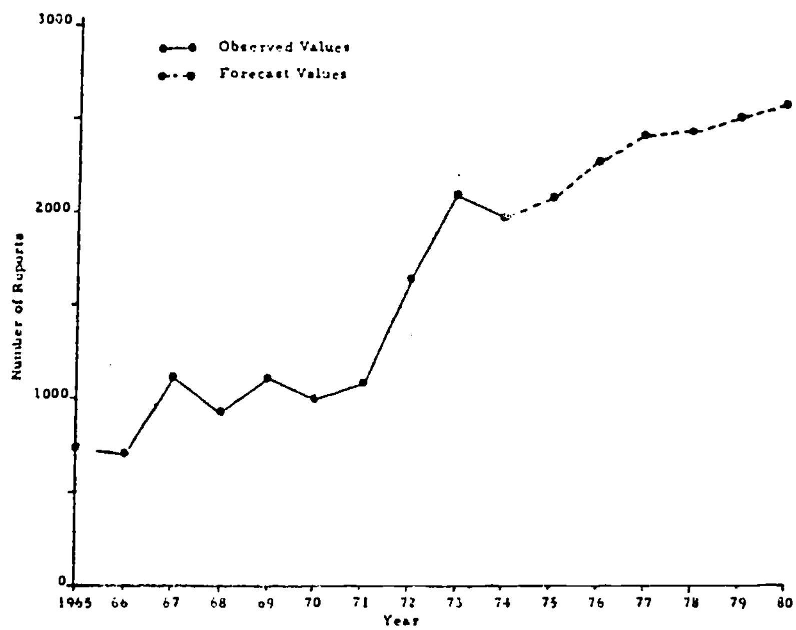
where:

$\hat{Y}$ is the estimated number of new reports

X_1 is Federal obligations for R&D, lagged 2 years

X_2 is the year (0 = 1965, 1 = 1966, . . .)

Figure 3.32 NUMBER OF SCIENTIFIC AND TECHNICAL REPORTS PUBLISHED BY GPO: 1965-1980



SOURCE: Table 3.33

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The growth from 1965 to 1974 was 161 percent, or an average of 11 percent per year. The forecast from 1975 to 1980 shows an additional growth of 24 percent. The average number of copies sold per report also increased from 1965 to 1974 by an estimated 36 percent, or about 3.4 percent per year. A growth rate of 38 percent is forecast for 1975 to 1980, based on values derived from the following linear equation (see Figure 3.33):

$$\hat{Y} = 1433 + 40.1X$$

where:

X is the estimated average number of copies sold

X is the year (0 = 1965, 1 = 1966, . . .)

The combination of an increased number of reports and increased sales of these reports yields a total growth rate of 253 percent for the number of copies of scientific and technical reports distributed from 1965 to 1974.

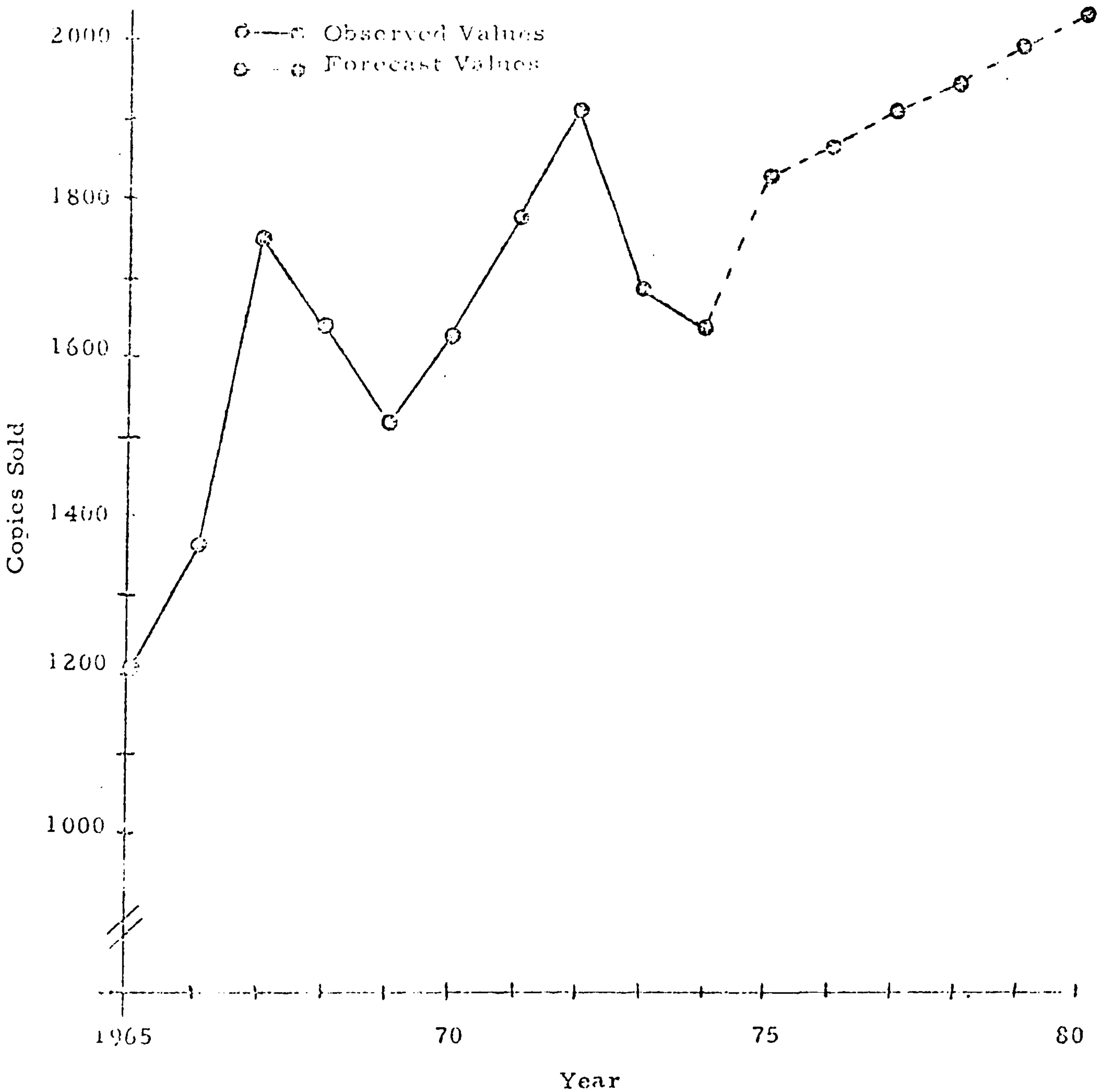
The estimated average price per copy remained relatively constant until 1973 when it increased substantially. This increase is reflected in both price per copy and price per page. If 1973 and 1974 prices represent a policy change, then our forecasts of price (based on an average constant dollar price of $1.41) may be low. If so, then our estimates of revenue may be low as well, depending on the impact of increased price on demand. There is limited evidence that the increase in price may have reduced the average number of copies sold but this evidence is not strong. The overall revenue to GPO from sales of scientific and technical reports appears to have increased greatly, over 500 percent between 1965 and 1974.

3.4 Growth of Other Communication Forms

3.4.1 Published Conference Proceedings

A form of communication that is particularly important in science and technology is the conference, and an important form of book publication is the proceedings of such conferences. Some figures on the growth of published conference proceedings in science and technology are given in Table 3.34.

Figure 3.33 NUMBER OF COPIES SOLD PER SCIENTIFIC AND TECHNICAL REPORT AT GPO: 1965-1980



SOURCE: Table 3.33

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Table 3.34 NUMBER OF PUBLISHED CONFERENCE PROCEEDINGS IN SCIENCE, MEDICINE, ENGINEERING AND TECHNOLOGY: 1965-1973

	1965	1966	1967	1968	1969	1970	1971	1972	1973
Volumes of Published Proceedings	1726	1762	1948	2121	2272	2367	2419	2287	1579

SOURCE: The Directory of Published Proceedings, Interdok Corporation, Harrison, New York, 1965-1973.

It is important to recognize that these figures are not accurate indicators of the number of conference proceedings published each year on a worldwide basis. Rather, they represent the number of proceedings published for conferences held each year as identified by the staff of the Directory of Published Proceedings (42) as of January, 1975. The publishers are continuing to identify additional proceedings for various years of this period so that figures for at least the later years (1971 to 1973) are undoubtedly incomplete. The figures do reveal a steady increase through 1971, which presumably reflects a growth in the number of conferences held internationally as well as in the number of published proceedings available.

These figures may in fact be somewhat low. The British Index of Conference Proceedings Received by NLL (62) is now growing at the rate of about 7,000 items a year (compared with the 2,000 items a year indicated in Table 3.34), but this publication is not restricted to science and technology.

3.4.2 The Patent Literature

The growth of the U. S. patent literature in the period 1960 to 1980 is indicated in Table 3.35. In 1974 the number of patent applications was 28 percent greater than in 1960. The number of patents issued in 1974 was approximately 60 percent greater than the number issued in 1960. Thus, the patent literature of the United States seems now to be growing at an average annual rate of approximately 3.4 percent. Figures 3.34 and 3.35 show our projections for applications filed and patents issued respectively, based on the following equations:

$$\hat{Y} = 81.9 + 2.2X$$

where:

$\hat{Y}$ is the estimated number of patent applications filed

X is the year (0 = 1960, 1 = 1961, . . .)

$$\hat{Y} = 47.1 + 2.6X$$

where:

$\hat{Y}$ is the estimated number of patents issued

X is the year (0 = 1960, 1 = 1961, . . .)

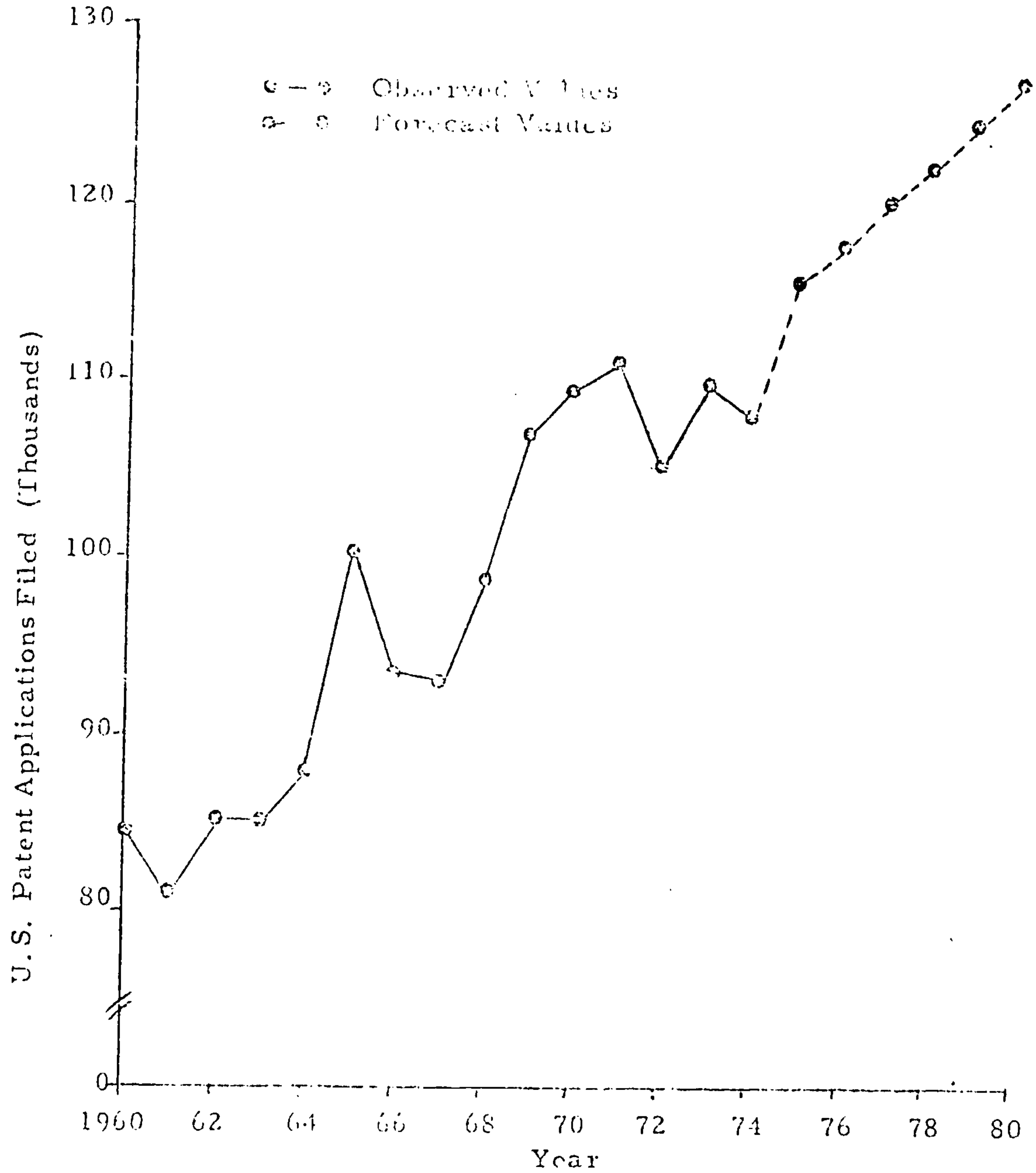
Although a very special case, the patent literature is particularly interesting because it provides the only instance in which accurate figures are available on the difference between composition and publication. In this special case there is no evidence of a widening gap between composition and publication. In the time period covered by Table 3.35 the ratio of patents issued to applications filed appears to have improved (i.e., increased) somewhat. This is undoubtedly due to efforts on the part of the U. S. Patent Office to speed up the examining process.

3.4.3 The Dissertation Literature

The growth of the dissertation literature is reflected in data presented in Table 3.36. The first columns show the number of doctoral degrees awarded in the U. S. from 1960 through 1980. In the 1960 to 1974 period, the total number of doctoral degrees more than tripled, while the number of doctoral degrees awarded in science and technology increased 150 percent. These growth rates dampened considerably during the last five years.

Also presented in the table are figures for the number of dissertations listed in Dissertation Abstracts International (44). These figures are compiled mainly from universities in the United States and Canada, with

Figure 3.34 NUMBER OF U. S. PATENT APPLICATIONS FILED: 1960-1980



SOURCE: Table 3.35

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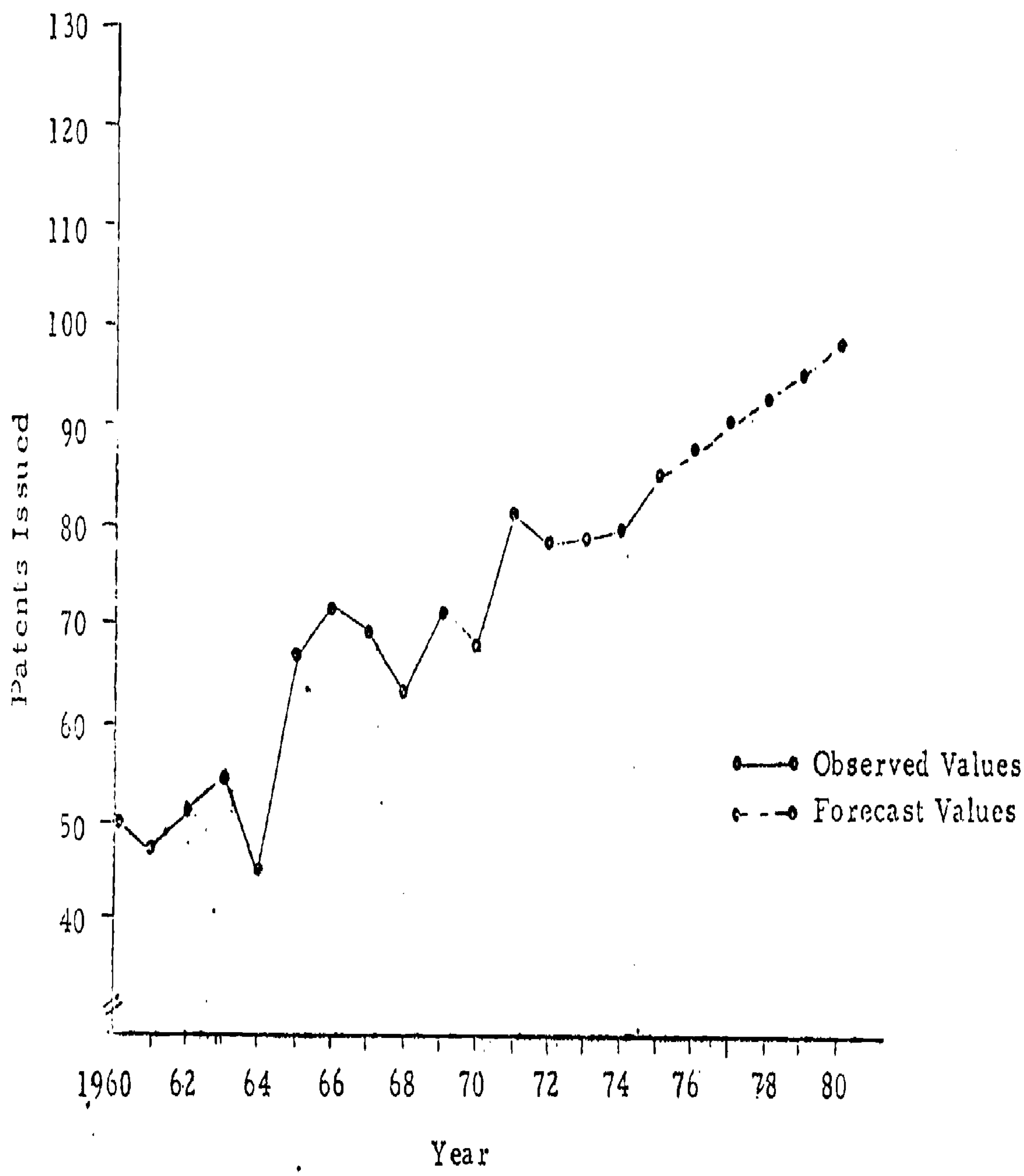
Figure 3.35 NUMBER OF U. S. PATENT APPLICATIONS ISSUED: 1960-1980



SOURCE: Table 3.35.

Table 3.35 NUMBER OF U.S. PATENT APPLICATIONS AND PATENTS ISSUED: 1960-1974

(Thousands)

Year	Applications Filed	Patents Issued
1960	84.5	50.0
1961	81.2	47.5
1962	85.3	51.3
1963	85.0	54.3
1964	87.8	44.4
1965	100.4	66.6
1966	93.5	71.9
1967	93.0	69.1
1968	98.7	62.7
1969	107.1	71.2
1970	109.4	68.0
1971	111.1	81.8
1972	105.3	78.2
1973	109.6	78.6
1974	108.0	79.9
PROJECTIONS*		
1975	115.6	85.5
1976	117.8	88.0
1977	120.0	90.6
1978	122.2	93.2
1979	124.5	95.7
1980	126.7	98.3
PERCENT CHANGE		
1960-65 . . .	19	33
1965-70 . . .	9	2
1970-75 . . .	6	26
1975-80 . . .	10	15

* Market Facts, Inc., Center for Quantitative Sciences

SOURCE: Bureau of the Census, DOC, *Statistical Abstract of the United States*, 1960 1974.

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Table 3.36 NUMBER OF DOCTORAL DEGREES AWARDED IN THE U.S. AND NUMBER OF DISSERTATIONS APPEARING IN DISSERTATION ABSTRACTS INTERNATIONAL: 1960–1980

Year	Number of Doctoral Degrees[1] All Fields	Number of Doctoral Degrees[1] Science & Technology	Number of Dissertations Published[2] All Fields	Number of Dissertations Published[2] Science & Technology
1960 . .	9,829	3,892	6,174	3,387
1961 . .	10,575	3,931	7,291	4,119
1962 . .	11,622	4,432	7,642	4,203
1963 . .	12,822	4,877	8,757	4,816
1964 . .	14,490	5,344	11,549	6,349
1965 . .	16,467	6,102	15,693	8,865
1966 . .	18,237	6,659	16,928	9,584
1967 . .	20,617	7 358	20,401	11,601
1968 . .	23,089	8,160	21,775	12,084
1969 . .	26,188	8,957	26,218	14,422
1970 . .	29,866	9,948	29,572	15,885
1971 . .	32,107	10,448	31,611	16,570
1972 .	33,330	10,010	31,575	16,184
1973 . .	34,100	10,120	30,678	15,594
1974 . .	33,700	9,490	31,961	15,606
PROJECTIONS*				
1975 . .	34,900	9,380	33,155	16,080
1976 . .	36,900	9,920	35,055	16,826
1977 . .	39,300	10,040	37,240	17,689
1978 . .	40,100	10,140	38,095	17,905
1979 . .	40,200	10,170	38,190	17,758
1980 . .	41,200	10,430	39,140	18,004
PERCENT CHANGE				
1960–65	68	60	154	162
1965–70	81	63	88	79
1970–75	17	-6	12	1
1975–80	18	11	18	12

*Dissertations Projections: Market Facts, Inc., Center for Quantitative Sciences.

SOURCE: [1]National Center for Educational Statistics, DHEW, Projections of Educational Statistics to 1980-81, 1971 edition, and Projections of Educational Statistics to [illegible]-84, 1974 edition.

[2]Dissertation Abstracts International, Xerox-University Microfilm, Ann Arbor, Michigan, 1960-1975.

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negligible reporting from foreign universities. They must be viewed with some caution for a number of reasons. First, they are not complete, even for the United States, because some major universities do not report their dissertations to the publisher at all while others report only for certain departments. Secondly, the base for the statistics of Table 3.36 is not constant because the number of universities reporting is increasing (from about 160 in 1965 to about 310 in 1974). Fonally, when a university begins to report to DAI they may include earlier dissertations en bloc. Also, as one can see in the Table, the number of science and technology degrees conferred. This is partly due to the fact that DAI includes Canadian, plus a few foreign, dissertations and partly to the en bloc reporting mentioned above. It is also possible that DAI may make a more liberal interpretation of what constitutes science and technology.

The growth of DAI cannot, then, be used as a completely accurate indicator of the growth of the dissertation literature. The data of Table 3.36 can, however, be regarded as a reasonable indicator of the growth of the dissertation literature that is most available and best controlled. For the sciences, this literature has grown at an average annual rate of 11.5 percent a year, considerably greater than the growth rate indicated by science and technology degrees.

3.4.4 The Translation Literature

The translation literature can be regarded as, in a sense, secondary because it represents not primary publication but the appearance of primary publications in alternative forms (in this case alternative languages). The growth of the translation literature is important, however, because it is one indicator of the extent to which formal international communication occurs (i.e., the degree to which published information is exported and exploited abroad). Clearly, it is not the only indicator of activity because much technical literature is imported/exported and used in its original language form.

Growth rates for the translation literature are difficult to pin down. Table 3.37 gives data from two sources for the book literature. The UNESCO data for science and technology indicate quite a small rate of growth, worldwide, for the period 1965 - 1971. These figures are not very reliable partly because of the short time span. They indicate an average annual increase of only a little under two percent. By comparison, the translation of scientific and technical

Table 3.37 NUMBER OF BOOK TRANSLATIONS AND SIZE OF THE COLLECTION OF THE NATIONAL TRANSLATION CENTER, JOHN CRERAR LIBRARY: 1960-1974

Year	Nat'l. Translation Center Collection[1] (000)	Book Translations				
		Worldwide[2]	Worldwide (S&T)[2]	From English[2]	From English (S&T)[2]	Into English[3]
1960 . . .	78.0	-	-	-	-	1,035
1961 . . .	84.0	-	-	-	-	-
1962 . . .	89.0	-	-	-	-	-
1963 . . .	96.0	-	-	-	-	-
1964 . . .	102.0	-	-	-	-	1,876
1965 . . .	107.6	36,072	5,561	13,330	1,866	1,749
1966 . . .	119.4	39,620	5,647	14,228	2,021	1,667
1967 . . .	128.1	39,438	5,387	15,279	2,173	1,225
1968 . . .	134.9	36,817	5,389	13,698	2,125	1,253
1969 . . .	142.0	38,152	5,938	14,344	2,533	1,084
1970 . . .	156.8	40,039	5,934	16,471	2,664	1,232
1971 . . .	175.0	42,985	6,157	17,164	2,725	1,126
1972 . . .	193.8	-	-	-	-	1,093
1973 . . .	205.6	-	-	-	-	1,428
1974 . . .	216.2	-	-	-	-	1,611
PERCENT CHANGE						
1960-65 .	38	-	-	-	-	69
1965-70 .	46	11	7	24	43	-30
1970-74 .	38	-	-	-	-	31

SOURCE: 1 National Translation Center, John Crerar Library, Chicago, Illinois (1960-1964 average estimates).

2 United Nations Education, Scientific, and Cultural Organization, Statistical Yearbook, 1966-1972.

3 The Bowker Annual of Library and Book Trade Information, R. R. Bowker Company, 1965-1975.

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books from English to other languages appears to be increasing at a much faster pace. If the UNESCO figures can be regarded as reasonably reliable, these translations from English increased about 46 percent from 1965 to 1971.

Another set of figures appearing in Table 3.37 represents the growth of the National Translations Center. For several reasons, these figures are not an accurate indicator of the extent of translation of foreign science and technology into English. First, the collections of the Center are not complete and the growth rate is at least partly dependent on the level at which the Center is funded. Second, the Center is not devoted exclusively to science and technology, although the great bulk of the collection does fall in this area. Thirdly, the figures of Table 3.37 do not necessarily accurately reflect the amount translated year by year since, in any particular year, the Center may add to its collections material translated in previous years (e.g., by acquisition of a special collection). Nevertheless, at a minimum, we can say that the data in Table 3.37 represents the growth of the body of foreign technical literature, translated into English that is most accessible and best controlled. We can, then, draw the conclusion that the foreign technical literature most accessible in translation in the United States has been growing at an average annual rate of about 7.6 percent per year over the period 1960 - 1974.

Another figure that, on the surface, should be interesting is the number of items translated annually through the Joint Publications Research Service (JPRS). The JPRS series represents U. S. translations from periodical and nonperiodical publications, mostly from China, the Soviet Union and other nations of the Communist bloc. These statistics are widely variant from year to year and present no evidence of any pattern of growth.

3.4.5 Other Indicators of Publication Growth

There is one other indicator of publication growth that is of some interest: the number of items copyrighted annually in the United States. These data are presented in Table 3.38 for the period 1960 - 1975. In this fifteen year period the number of items for which a copyright was registered by the Library of Congress increased about 65 percent. If only books, pamphlets and leaflets are considered, the growth rate from 1960 registrations to 1975 registrations was 86 percent or about 4.2 percent a year, which is

Table 3.38 COPYRIGHT REGISTRATIONS IN THE UNITED STATES: 1960-1975

(Thousands)

Year	Books, Pamphlets, Leaflets	Periodical Issues	Total
1960	60.0	64.2	243.9
1961	62.4	66.2	247.0
1962	66.5	67.5	254.8
1963	68.4	69.7	264.8
1964	71.7	74.5	279.0
1965	76.1	78.3	293.6
1966	77.3	77.9	286.9
1967	80.9	81.6	294.4
1968	85.1	81.8	303.4
1969	83.6	80.7	301.3
1970	88.4	83.9	316.5
1971	96.1	84.5	329.7
1972	103.2	84.7	344.6
1973	104.5	88.5	353.6
1974	104.8	92.2	372.8
1975	111.9	95.06	401.2
PERCENT CHANGE			
1960-65 . .	27	22	20
1965-70 . .	16	7	8
1970-75 . .	26	13	27

SOURCE: Bureau of the Census, DOC, Statistical Abstract of the United States, 1960-1975.

very close to the figures given earlier for the rate of increase in book publications. It is important to recognize that the totals given in the table are not restricted to science and technology, and in fact, include maps, sound recordings and other types of material. The periodical registrations grew 44 percent, an average of 2.4 percent per year.

3.5 The Cost of Composition and Recording of Information

There is little information in the literature concerning the processes involved in composition and recording of information. Therefore, we relied heavily on a study performed in 1973 by Westat, Inc. (14), for the National Science Foundation that provides some information concerning these functions for the journal literature. This study provides some evidence concerning the activities involved in preparing journal articles, the labor required in these activities, and hence, the costs involved. The composition and recording functions are extremely important to the journal system since quality of articles is largely established in these functions. Furthermore, as shown below, the costs involved in these processes are large and likely to exceed the costs involved in reproduction and initial distribution of articles.

DeSolla Price (123) has characterized authors of journal articles in an interesting fashion. He claims that about one-half of the total output of papers is generated by a small elite of highly productive authors. For example, he states, about one-half of the articles is produced by only one percent of the scientists. The Westat study of life sciences indicates that ninety percent of the authors held doctorate degrees and about one-third of the respondents had not published in the past two years. Both studies suggest that authors tend to be the more experienced scientists.

The composition and recording functions involve those activities performed by authors and their support staff, reviewers and editors. The study referenced about provided estimates of the time spent by 269 authors in the life sciences. We assume that this amount of time is reasonably consistent among authors from other fields of science and over time. The principal author activities are given in Table 3.39 along with the time devoted to preparation of initial manuscripts and to subsequent revisions.

Table 3.39 ESTIMATED TIME REQUIRED TO PREPARE INITIAL JOURNAL ARTICLE MANUSCRIPTS AND SUBSEQUENT REVISIONS

(Hours)

Activity	Initial Manuscript	1st Revision	2nd Revision	3rd Revision	4th Revision	5th Revision
Literature Search	30.5	4.8	3.5	3.0	2.7	2.5
Preparation of Bibliography	7.1	1.8	1.7	1.7	1.7	1.7
Typing Manuscript	7.9	4.8	4.0	3.6	3.5	3.4
Writing of Manuscript	53.5	9.6	5.8	3.6	2.8	2.0
Formal Internal Edit	6.9	2.1	2.2	2.2	2.2	2.2
Informal Internal Edit	6.6	3.1	1.9	1.5	1.2	1.0
Proofreading Typed Manuscript	2.5	1.8	1.7	1.7	1.7	1.7
Proofreading/Alteration of Galleys	2.5	2.0	2.4	2.4	2.4	2.4
Total Author Time	81.6	17.4	12.5	9.9	8.8	7.8
Total Support Time	36.0	12.6	10.7	9.9	9.5	9.2

SOURCE: *Survey of Authors, Reviewers and Subscribers to Journals in the Life Sciences* (NSF-C769), Westat, Inc., July 1974.

In the study above, it was estimated that about 20 percent of the articles required no revision and an average of 1.3 revisions were made by the remaining articles. In the author survey conducted by us across all fields of science, 32 percent of the articles required no revisions and the remainder underwent an average of 1.2 revisions. The estimated proportion of articles requiring from no revisions up to five revisions and the cumulative labor time requirements are given in Table 3.40. An estimate of total hours spent by authors and support staff can be obtained by summing the product of the proportion of manuscripts times the labor time required for each step. The total author time is estimated to be 96.6 hours per article and support time is estimated to be 47.5 hours. This labor effort is converted to cost at the end of this section.

Table 3.40 ESTIMATED PROPORTION OF ARTICLES REQUIRING UP TO FIVE REVISIONS AND CUMULATIVE LABOR TIME

Activity	Initial Manuscript	1st Revision	2nd Revision	3rd Revision	4th Revision	5th Revision
Proportion of Mss.	0.32	0.50	0.12	0.03	0.02	0.01
Author Time (hours)	81.6	99.0	111.5	121.4	130.2	138.0
Support Time (hours)	36.0	48.6	59.3	69.2	78.7	87.9

SOURCE: Survey of Authors, Reviewers and Subscribers to Journals in the Life Sciences (NSF-C769), Westat, Inc., July 1974.

In the Westat study in the life sciences, 53 percent of the respondents indicated that they had served as a reviewer of manuscripts at some time for scientific journals. Of these reviewers, 91 percent had Ph.D. degrees, most were employed at universities, and about three-fourths of them had over ten years experience. The average time spent by reviewers in this activity was 6.2 hours per manuscript reviewed. This figure will also be converted to costs and included in the figures for composition and recording.

Now, in order to establish for the costs of composition and recordings, we treated the previous results for authors and reviewers as though they applied to journal articles in all fields. Thus, we multiplied our time estimates by average salaries (with 50 percent overhead applied) for scientists/engineers and support personnel. Results are given in Table 3.41. It is noted that the total estimated cost of composition and recording for scholarly scientific and technical journals was $285 million in 1975. If the same costs hold for all scientific and technical journals, this total is approximately $1.400 billion in 1975. These numbers are expected to reach $428 million and $2.512 billion respectively by 1980. As will be shown later, the relative costs of composition and recording are appreciable in view of the entire cost of journal publication.

The average costs per article incurred in composition and recording appear to have more than doubled from 1960 and 1980. The constant dollar costs have also gone up by 22 percent in the 1960 to 1975 period and are expected to increase about 28 percent to 1980. The growth of total costs is even more remarkable since it reflects growth in the literature as well as increased salaries. Total costs are estimated to have tripled from 1960 to 1975 for scholarly journals and gone up by a factor of eight for all journal articles, and should increase by 372 percent from 1960 to 1980. It is possible that these costs may have as much, if not more, impact on the quality and extent of journal publishing as the rising costs of reproduction and distribution that we are more familiar with.

We have no comparable data for estimating composition and recording costs associated with preparing books, scientific and technical reports, dissertations and patents. However, if one makes some very gross assumptions concerning these functions, we can obtain some rough estimates of these costs as a function of the number of items prepared and the salaries of scientists and engineers and their support staffs over the years. Our estimates for each type of material are presented in Table 3.42.

Based on these gross estimates, we calculated the order of magnitude of composition and recording costs for the scientific and technical literature from 1960 to 1980. Our results are given in Table 3.43. From 1960 to 1974,

Table 3.41 COST OF COMPOSITION & RECORDING OF SCIENTIFIC & TECHNICAL JOURNAL ARTICLES: 1960-1980

Year	No. of S&T Scholarly Articles (000)	No. of S&T Articles (000)	Estimated Cost per Article (Current $)	Estimated Cost per Article (Constant $)*	Total Scholarly S&T Articles (Millions)	Total S&T Articles (Millions)
1960	106	211	8.55	9.73	91	204
1961	108	215	8.81	9.90	95	263
1962	110	219	9.06	10.07	100	269
1963	112	223	9.35	10.26	105	316
1964	115	231	9.60	10.37	110	319
1965	120	240	10.11	10.93	121	357
1966	126	252	10.82	11.17	136	452
1967	132	263	11.41	11.41	151	559
1968	136	270	11.95	11.50	163	636
1969	138	275	12.70	11.65	175	707
1970	141	282	13.46	11.70	190	794
1971	145	292	14.19	11.80	206	890
1972	147	297	14.84	11.94	218	989
1973	150	303	15.98	12.18	240	1,143
1974	151	304	17.15	11.86	259	1,264
PROJECTIONS						
1975	155	314	18.40	11.64	285	1,400
1976	159	322	19.72	11.69	314	1,655
1977	162	328	[illegible].05	11.69	341	1,855
1978	165	337	[illegible].20	11.58	368	2,061
1979	169	344	23.55	11.54	400	2,285
1980	172	353	24.90	11.42	428	2,512
PERCENT CHANGE						
1960-65 . . .	13	14	18	12	33	75
1965-70 . . .	16	18	33	7	57	122
1970-75 . . .	10	11	38	-3	50	76
1975-80 . . .	11	12	35	5	50	79

*Using GNP implicit price deflator (1975-1980 NPA) to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Table 3.42: ESTIMATES OF TIME SPENT ON COMPOSITION AND RECORDING BY SCIENTISTS AND SUPPORT STAFF

Literature Form	Estimated Time Spent (Hours)	
	Scientists	Support Staff
Journal Article	102.8	47.5
Book	480.0	240.0
Technical Report	120.0	80.0
Dissertation	320.0	120.0
Patent	160.0	80.0

SOURCE: Market Facts, Inc., Center for Quantitative Sciences

total composition and recording costs increased 447 percent, reflecting increases of 520 percent for journal articles, 736 percent for books, 558 percent for technical reports (1965 - 1974), 820 percent for dissertations, and 156 percent for patents. Again, the reasons these costs have gone up so much and will continue to do so is that they reflect both increases in number of items produced and a significant increase in salaries.

3.6 The Cost of Reproduction and Distribution of Information

Again, good data are not available on the cost of reproduction and distribution of scientific and technical literature. Until such information is made available by publishers, we must use the limited evidence there is. The best information is for journal articles, and we will discuss this at length below.

3.6.1 Cost of Reproduction and Distribution of Scientific and Technical Journals

In order to identify the costs associated with the publication of scientific and technical journals, an economic cost model was utilized. This model was previously developed for use in a feasibility study of editorial

Table 3.43 ESTIMATED TOTAL COST OF COMPOSITION AND RECORDING OF SCIENTIFIC & TECHNICAL JOURNAL ARTICLES, BOOKS, REPORTS, DISSERTATIONS AND PATENTS: 1960-1980

(Millions of Dollars)

Year	Estimated Cost					
	S&T Journal Articles	S&T Books	S&T Reports	S&T Dissertations	U.S. Patents	Total S&T Literature
1960 . . .	204	14	-	5	[illegible]	337
1961 . . .	263	21	-	6	132	[illegible]
1962 . . .	269	26	-	7	122	[illegible]
1963 . . .	316	33	-	8	[illegible]	[illegible]
1964 . . .	319	40	-	11	[illegible]	509
1965 . . .	357	43	19	16	162	577
1966 . . .	452	50	31	18	200	[illegible]
1967 . . .	559	49	36	23	167	[illegible]
1968 . . .	635	56	38	25	[illegible]	[illegible]
1969 . . .	707	53	53	32	235	1,063
1970 . . .	784	74	65	27	232	1,202
1971 . . .	890	85	78	40	[illegible]	[illegible]
1972 . . .	993	92	95	41	247	[illegible]
1973 . . .	1,143	102	107	43	275	1,670
1974 . . .	1,264	127	135	46	[illegible]	[illegible]
PROJECTIONS						
1975 . . .	1,470	124	145	54	355	[illegible]
1976 . . .	1,655	138	168	57	366	2,374
1977 . . .	[illegible]	157	192	64	[illegible]	[illegible]
1978 . . .	2,061	165	216	68	429	[illegible]
1979 . . .	2,285	182	243	72	464	[illegible]
1980 . . .	2,512	199	271	76	497	[illegible]
PERCENT CHANGE						
1960-65 . .	75	207	-	220	42	77
1965-70 . .	122	72	242	131	43	101
1970-75 . .	76	69	123	30	44	52
1975-80 . .	79	60	67	49	40	95

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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processing centers (14), and was modified by us to allow the determination of cost trends over time.

The model is based on the identification, in great detail, of the various components of the journal publication process. Functions considered in going from an outline preparation of a manuscript through distribution of a published article include authorship, editing, technical review, printing and distribution, and business management. These functions can be further broken down into a number of subfunctions.

Each of the activities involved in journal publication has a cost associated with it, made up of components such as labor, equipment and supply costs. For example, one activity involved in the journal publication process would be the typesetting of a manuscript for galley proofs. The cost of this operation would be based on such factors as the size of the manuscript, the method of typesetting, wage and equipment costs, and a number of overhead figures. Combining these appropriately, the total cost for typesetting can be determined. Similarly, following the flow of manuscripts through the publication process, costs for each activity can be developed and combined into total costs.

Parameters used in the original cost model to describe the journal publication process can be considered in the following categories:

1. Journal characteristics -- e.g., frequency, size, number of pages, articles, illustrations, formulas, etc.

2. Cost factors -- e.g., wages, equipment, purchased services, overhead.

3. Process factors -- description of manuscript flow through the system, unit processing times.

Values of these parameters were identified through a number of sources, including a baseline survey of journal publishing practices in the life sciences wage data from the Bureau of Labor Statistics, and discussions with a variety of publishers, printers, equipment manufacturers, and suppliers. In general the figures assembled related to 1972 - 1973 practices in the publication of life science journals.

Our modification of the model retained the processing parameters discussed above but adjusted journal and cost characteristics as appropriate to each of the years of publication and fields of science. For the most part, journal characteristics were based on our tracking survey results and cost figures were compiled from available data. Projections were derived from available data or from trends observed in the 1960 - 1974 period. Table 3.44 lists the parameters redefined for this study, along with our source of data for each.

With the parameters redefined for our purposes, we were able to run the computerized cost model to obtain journal publication costs for the even years from 1962 - 1980 for the following:

1-9. The "average" small journal in each of the nine NSF fields of science.

10. The "average" large journal.

The distinction between large and small journals was made on the basis of article pages published per year, with a small journal defined as less than 1,500 pages. "Average" refers to average values compiled individually for each of the relevant journal characteristics.

Output from the model for each run included annual publication costs, broken down into editing, typesetting and printing and distribution costs. These results are presented later in the section, following discussions of the major journal characteristics and cost factors utilized.

3.6.1.1 Number of Articles Per Journal, Pages Per Article, Characters Per Page and Kiloword Pages Per Year

This section gives data on the size of journals in the nine fields of science as defined by articles per journal, pages per article, characters per page and kiloword pages (1000-word pages). The data were derived from observations of the scholarly journals sampled from each field. These journals and their articles were observed during the even years of publication (1962, 1964, . . .) and estimates for the odd years were found by linear interpolation.

Table 3.44 REDEFINED COST MODEL PARAMETERS[1A]

Parameter	Model Ref.	Source of Data	Average Values[1B] 1962	Average Values[1B] 1980
Journal Characteristics				
Average number of journal issues per year	Z21	Journal Tracking Survey[2]	5.9	6.7
Average number of articles per journal issue	Z22	Journal Tracking Survey	11.9	11.8
Average number of subscriptions per journal	Z23	Publisher's Survey[3], Fry Study[4], other sources	5,591	8,566
Average number of copies printed per journal issue	Z24	Publisher's Survey, Fry Study, other sources	6,212	9,518
Average number of reprints ordered by author per manuscript	Z27	Author's Survey[5]	124	204
Percent of foreign subscribers	Z34	Publisher's Survey	.10	.10
Average page changes per published page	R35	Author's Survey	$4.50	$21.00
Average number of characters per published page	Z12	Journal Tracking Survey	3,876	4,196
Percent of journal devoted to manuscripts only	Z33	Journal Tracking Survey	.68	.65
Number of tables per average article	Z40	Journal Tracking Survey	1.2	1.1
Number of halftones per average article	Z41	Journal Tracking Survey	1.4	1.1
Number of line drawings per average article	Z42	Journal Tracking Survey	2.2	2.0
Number of math formula or chemical symbol inserts per average article	Z43	Journal Tracking Survey	3.6	4.6
Average number of pages of advertising per journal issue	Z44	Journal Tracking Survey	1.5	1.5
Percent of subsidiary text	Z45	Journal Tracking Survey	.10	.09
Average size of table in pages	Z46	Journal Tracking Survey	.23	.39
Average size of halftone in pages	Z47	Journal Tracking Survey	.34	.26
Average size of line drawing in pages	Z48	Journal Tracking Survey	.25	.27
Average size of math or chemical insert in pages	Z49	Journal Tracking Survey	.08	.08
Cost Factors				
Hourly wages of Secretary	R1	Bureau of Labor Statistics data, Mean Salary of Secretary II in a metropolitan area	$2.32	$5.21
[illegible] professional	R2	[illegible] BLS	[illegible]	$7.12

(continued)

Table 3.44 (cont.) REDEFINED COST MODEL PARAMETERS[1A]

Cost Factors (cont'd)				
Yearly stipend for subject editor's secretary	R3	Original model data adjusted as subject editor's stipend	$275	$775
Hourly rate of managing/subject editor	R10	Original model data adjusted by percentage change in professional, administrative, technical and clerical pay (BLS)	$4.93	$12.26
Yearly stipend for society subject editor	R11	Original model data adjusted as salary of PhD scientist	$650	$1,850
Hourly rate of author	R60	Salary of PhD scientist (various NSF sources)	$5.30	$15.24
Hourly rate of reviewer	R70	Salary of PhD scientist (various NSF sources)	$5.30	$15.24
Change for full page of advertising	R134	Original model data adjusted by general publication index	$106	$268
Price to have one halftone graphic prepared	R151	Original model data adjusted by general publication index	$3.50	$9.00
Price to have one line drawing graphic prepared	R152	Original model data adjusted by general publication index	$2.00	$4.50
Price to have one page of chemical or math symbols	R153	Original model data adjusted by general publication index	$33.50	$84.00
Price to have one page of basic text prepared	R154	Original model data adjusted by general publication index	$13.50	$33.50
Price to have one page of subsidiary text prepared	R155	Original model data adjusted by general publication index	$17.00	$43.00
Price to have one page of tabular material prepared	R156	Original model data adjusted by general publication index	$20.00	$50.50
Price to have one page of blank text prepared	R157	Original model data adjusted by general publication index	$3.50	$9.00
Printing costs-setups per issue	-	Labor and equipment costs (various sources) adjusted by general publication index	$17.00	$43.00
Printing costs-binding and covers per copy	-	Labor equipment and supply costs (various sources) adjusted by general publication index	$.07[illegible]	$.188
Printing costs-plates and collecting per page	-	Labor and equipment costs (various sources) adjusted by general publication index	$2.20	$5.55

(Continued)

Table 3.44 (cont.) REDEFINED COST MODEL PARAMETERS[1A]

Cost Factors (cont'd)				
Printing costs-per impression charge	R30	Other equipment and supply costs (various sources) adjusted by general publication index	$.0017	$.0030
Reprint costs-setups	-	Original model data adjusted	$7.89	$19.86
Reprint costs-per copy charge from printer	R86A	Original model data adjusted by general publication index	$.023	$.043
Reprint changes per copy by publisher	R86	Original model data adjusted by general publication index	$.08	$.14
Postage cost-one letter	CL	U.S. Postal Service	$.055	$.215
Postage cost-letter plus manuscripts	CLM	U.S. Postal Service	$.22	$.76
Postage cost-letter plus two manuscripts	CL2M	U.S. Postal Service	$.44	$1.49
Postage costs per pound-journal copy mailed to U.S. subscriber	-	U.S. Postal Service-second class rates	$.015	$.068
Postage costs-journal copy mailed to foreign subscribers	-	U.S. Postal Service	$.15	$.68
Rental cost of office per square foot	R50	Original model data adjusted by consumer price index for personal rent	$3.32	$5.97

1A
This table includes only those parameters modified from the original cost model. For a full list of parameters utilized, see Appendices to EPC V (King, Donald W. and John G. Yates, Editorial Processing Centers: A Study to Determine Economic and Technical Feasibility; Annex Part V: Economic Analysis of Journal Publishing in the Life Sciences (NSF-C769), July 1974).

1A
As described in the text, parameter values were identified for large and small journals, by year and field of science. The journal characteristic values given here are [illegible] of [illegible] averages of the individual values used, usually expressed in the 1960-1980 [illegible]. Costs are in current dollars.

2
See Appendices I and V.

3
See Appendix I.

4
Fry, Bernard M. and Herbert S. White, [illegible] of the Publisher-Library Relationship [illegible] Scholarly and Research Journals (NSF [illegible]), Indiana University, [illegible].

5
See Appendices I, VI and VII.

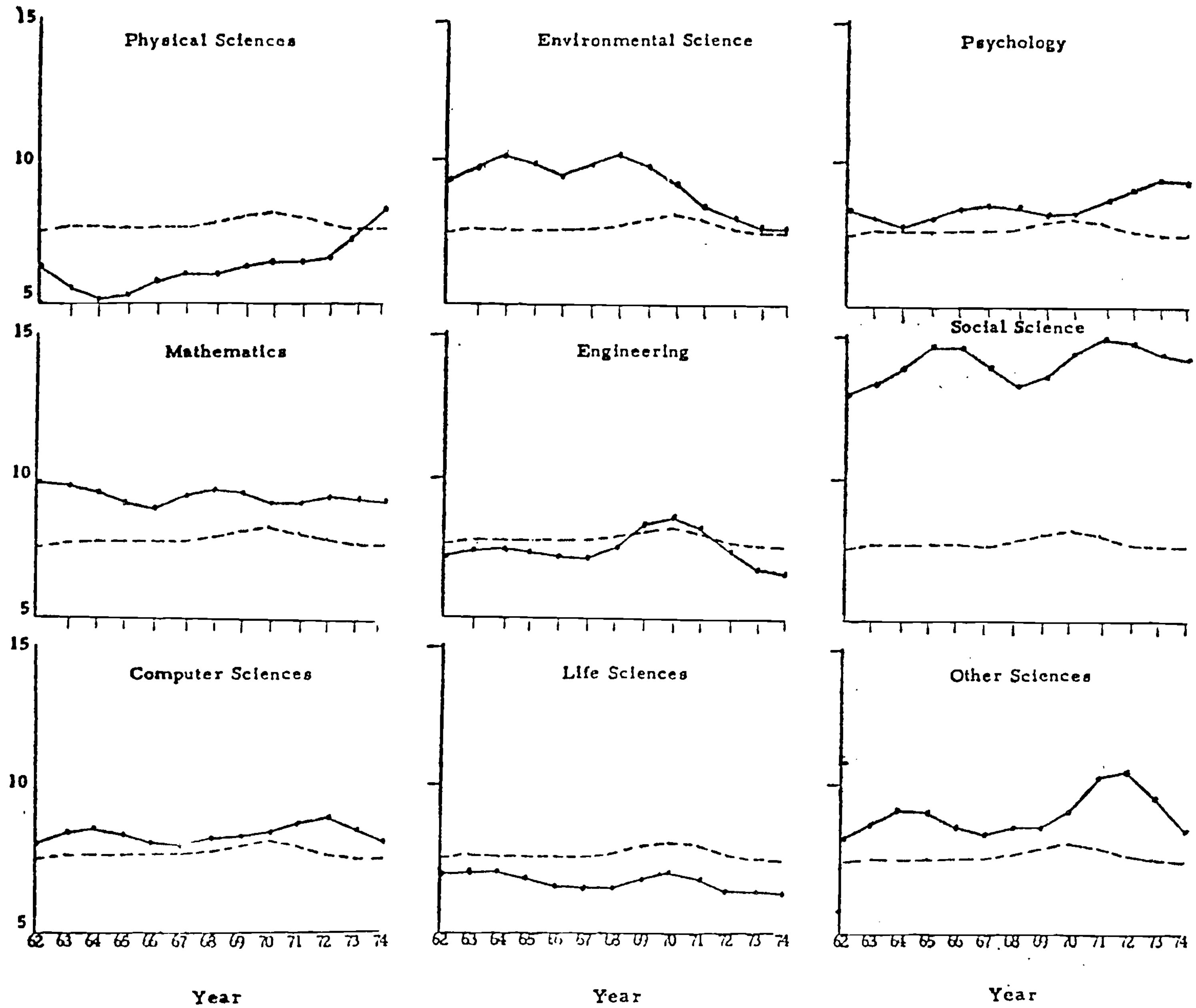
The estimates given in this section were all based on three-year moving averages. Details of the procedures employed in deriving these estimates are given in Appendix I.

The number of articles per journal per year is shown for the nine fields of science in Table 3.12 and Figure 3.10. Each of the graphs in Figure 3.10 also provides the overall journal estimates as a basis for comparison. There are substantial differences among the fields with regard to the magnitude of the average number of articles per journal and the trend of this number over time. For example, Social Sciences and Computer Sciences have a low average number of articles per journal when compared to the overall average, while Physical Sciences and Life Sciences have a relatively high average number. The trends over time are more pronounced in Environmental Sciences, Engineering and Other Sciences.

The estimated average number of pages per article is shown for the nine fields of science in Figure 3.36, again with overall journal estimates for comparison. The overall trend of number of pages per article is fairly constant over time. The Environmental Sciences journals seem to have a decreasing number of pages while the Physical Sciences journals appear to be increasing in number of pages per article over time. The Social Sciences journals apparently have substantially longer articles than journals from other fields of sciences. In order to determine the number of keystrokes necessary to compose a page, we estimate the average number of characters per page. We did not count the number of words in the sampled journals, but assumed that there are about 6.0 characters per word, and from this derived number of kiloword pages and kiloword pages per journal. Estimates for each of the fields of science are given in Table 3.45 and Figure 3.38. Kiloword pages per journal differ substantially by field of science, with the number low for journals in Social Sciences and relatively high for the Physical Sciences. The most dramatic trend over time appears to be for journals in Environmental Sciences and Other Sciences.

In the SATCOM report the number kiloword pages per year for their sample of chemistry and physics journals appears to be higher than our result. Out of 23 journals, average number of kiloword pages ranges to over 10,000 kiloword pages with the preponderance (15) under 4,000 kiloword pages. Their nine mathematics and six electrical engineering journals, on the other hand, seem to coincide closely with the results given in Table 3.45.

Figure ~.36 AVERAGE NUMBER OF PAGES PER ARTICLE BY FIELD OF SCIENCE: 1962-1974



SOURCE: Journal Tracking Survey,
Market Facts, Inc.,
Center for Quantitative Sciences

o—o Specific Field
--- All Fields

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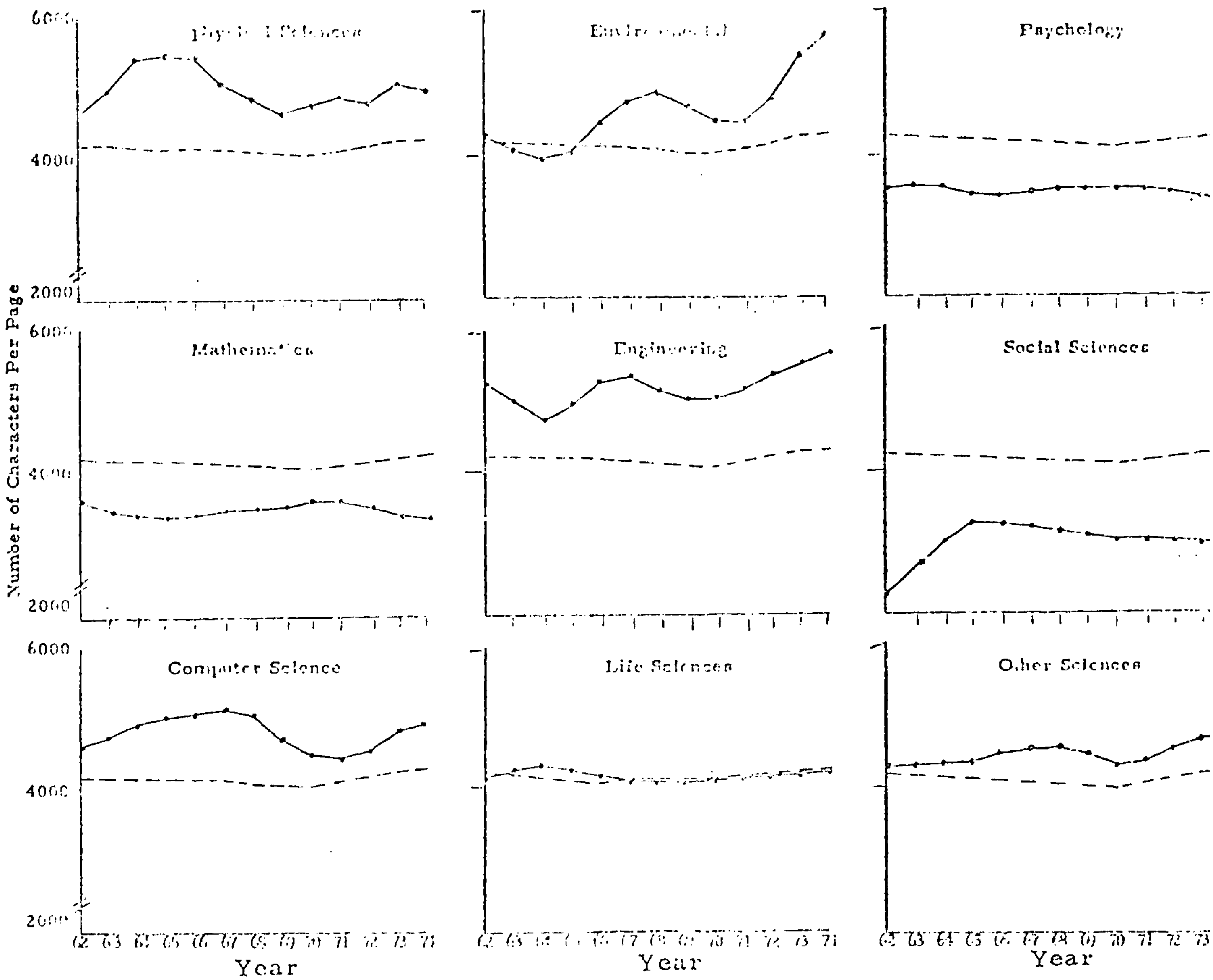
Figure 3.37 NUMBER OF CHARACTERS PER PAGE BY FIELD OF SCIENCE: 1962-1974



SOURCE: Journal Tracking Survey,
Market Facts, Inc.,
Center for Quantitative Sciences

- - - All Fields
—•— Specific Field

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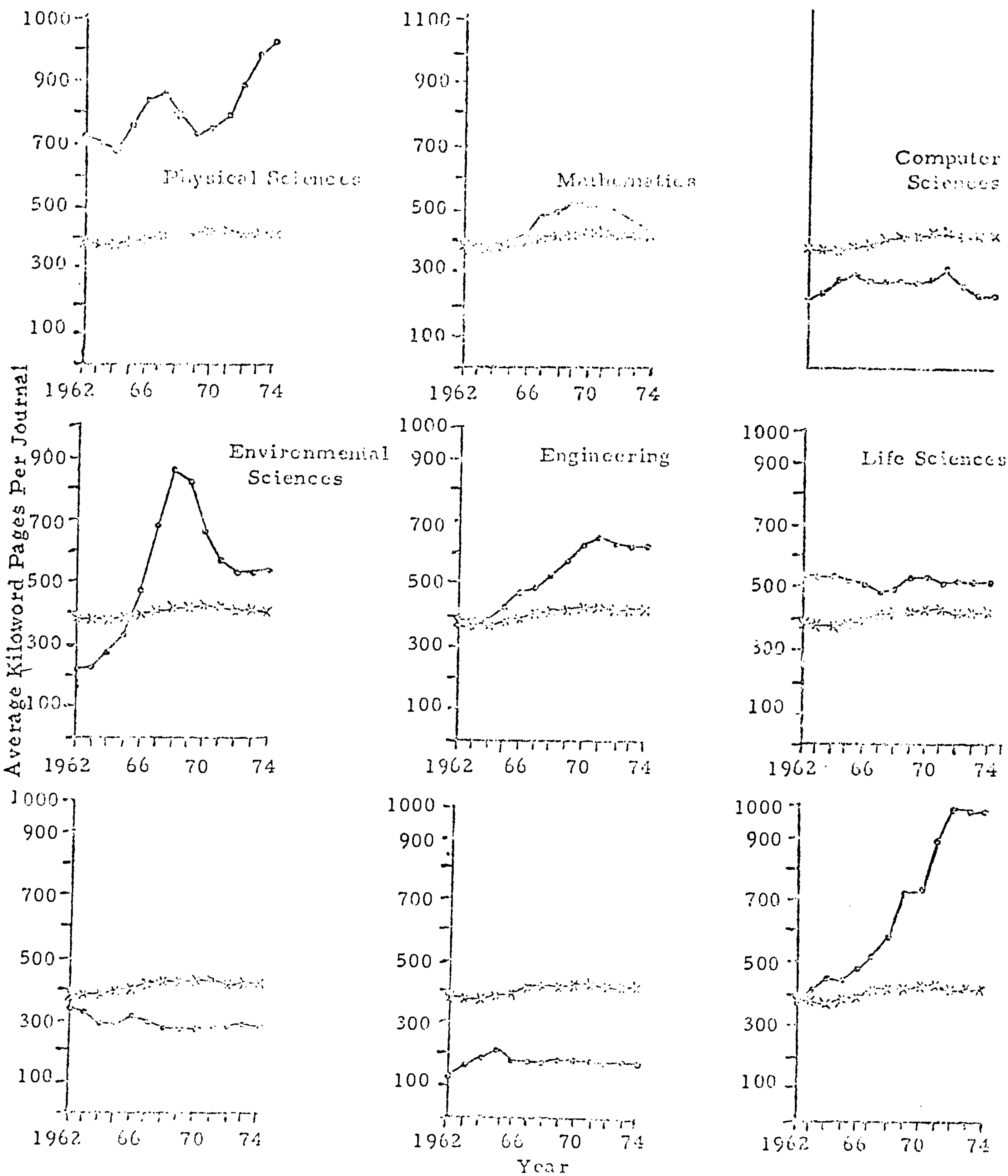
Table 5.45 ESTIMATED TOTAL NUMBER OF KILOWORD PAGES AND AVERAGE KILOWORD PAGES PER JOURNAL, BY FIELD OF SCIENCE: 1962-1974

Field of Science	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Physical Sciences	33,2[illegible]	[illegible],661	40,630	50,419	60,788	68,233	69,553	70,512	76,496	86,523	101,975	118,026	128,161
	722	705	689	764	844	853	790	735	750	794	895	984	1,025
Mathematics	12,3[illegible]1	13,292	13,734	15,153	16,541	19,009	20,965	22,432	22,696	22,743	22,931	21,586	20,943
	36[illegible]	380	383	399	424	475	499	522	516	505	499	459	436
Computer Sciences	3,331	4,148	5,102	5,403	5,300	5,450	5,857	5,971	6,408	7,078	6,055	5,738	5,491
	211	244	283	300	[illegible]79	272	279	271	291	322	263	239	229
Environmental Sciences	7,[illegible]	7,852	9,455	11,961	17,339	2[illegible]	[illegible],026	13,458	27,664	23,572	22,641	23,262	24,563
	219	231	270	312	469	[illegible]	851	816	659	561	527	579	546
Engineering	96,158	95,350	99,491	109,118	118,858	124,[illegible]	130,435	138,839	145,651	147,650	141,160	139,484	138,529
	3[illegible]	380	396	436	475	496	524	571	622	650	622	617	615
Life Sciences . . .	309,923	311,448	315,678	320,632	315,587	307,326	301,722	308,917	328,339	334,696	323,765	331,115	330,589
	547	542	541	542	526	502	485	493	524	531	508	514	509
Psychology	18,319	13,050	17,838	19,117	20,842	21,664	21,741	22,032	23,226	24,755	26,308	27,920	28,947
	333	311	288	290	302	297	279	269	270	275	283	291	287
Social Sciences	68,63[illegible]	86,467	106,757	113,559	105,935	106,156	110,871	115,705	118,242	117,895	115,306	113,763	114,551
	135	166	199	205	187	181	182	186	187	184	176	170	169
Other Sciences . .	18,083	19,076	21,213	21,409	22,960	25,559	28,932	34,645	36,191	43,790	488,391	49,476	46,291
	393	406	451	446	478	522	590	707	739	894	997	990	926
All Fields	596,291	611,125	622,167	649,356	678,315	708,668	732,871	752,118	773,411	790,965	786,085	805,106	816,728
	384	394	382	390	398	404	408	413	421	426	417	420	420

SOURCE: Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

Figure 3.38 NUMBER OF KILOWORD PAGES PER JOURNAL BY FIELD OF SCIENCE: 1962-1974



SOURCE: Table 3.45.

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3.6.1.2 Cost Factors

Th factors that have the greatest impact on reproduction costs are wages, rent, e ent, aper and postage. It is emphasized that there are other factor lso affect cost, but the discussion of these will illustrate why the cost oduction is increasing so rapidly.

The wages for secretaries; text editors, proofreaders and copy editors; managing editors; Ph.D. scientists; and union printers are given in Table 3.46. The data are also illustrated in Figure 3.39.

The current dollar wage rates increase for all personnel categories. The constant dollar wage rates for secretaries and text editors have remained about the same. This makes some sense, since there is a fair amount of turnover in these areas. The total number of hours contributed by these persons is not too great. In the other areas, where the number of hours is more, the constant dollar wages have gone up. For example, managing editor constant dollar wages have gone up from about $5.50 in 1962 to about $6.25 in 1974 which is about a 14 percent increase. Their hourly wages should remain fairly constant until 1980. Constant dollar wages of the Ph.D. scientists have increased from a little over $6.00 in 1962 to about $7.50 in 1974, which represents about a 25 percent increase. Their hourly wages should also remain about the same in constant dollars through 1980. Another increase is for union printers. Their constant dollar wages have increased from about $4.00 in 1962 to $4.60 in 1974, which is about a 15 percent increase, and their hourly wages should continue to increase to about $4.91 in 1980 which is about another 7 percent increase.

As shown in Table 3.47, the average office rental has not gone up nearly as fast as wages and some of the other cost factors. The average rental in dollars per square foot by current dollars and constant dollars is given in Figure 3.40. The constant dollar values have actually decreased rather substantially from 1960 to 1974 and should continue to do so.

Equipment and typesetting costs in current and constant dollars are shown in Table 3.48 and Figure 3.41. The Wholesale Price Index for machinery

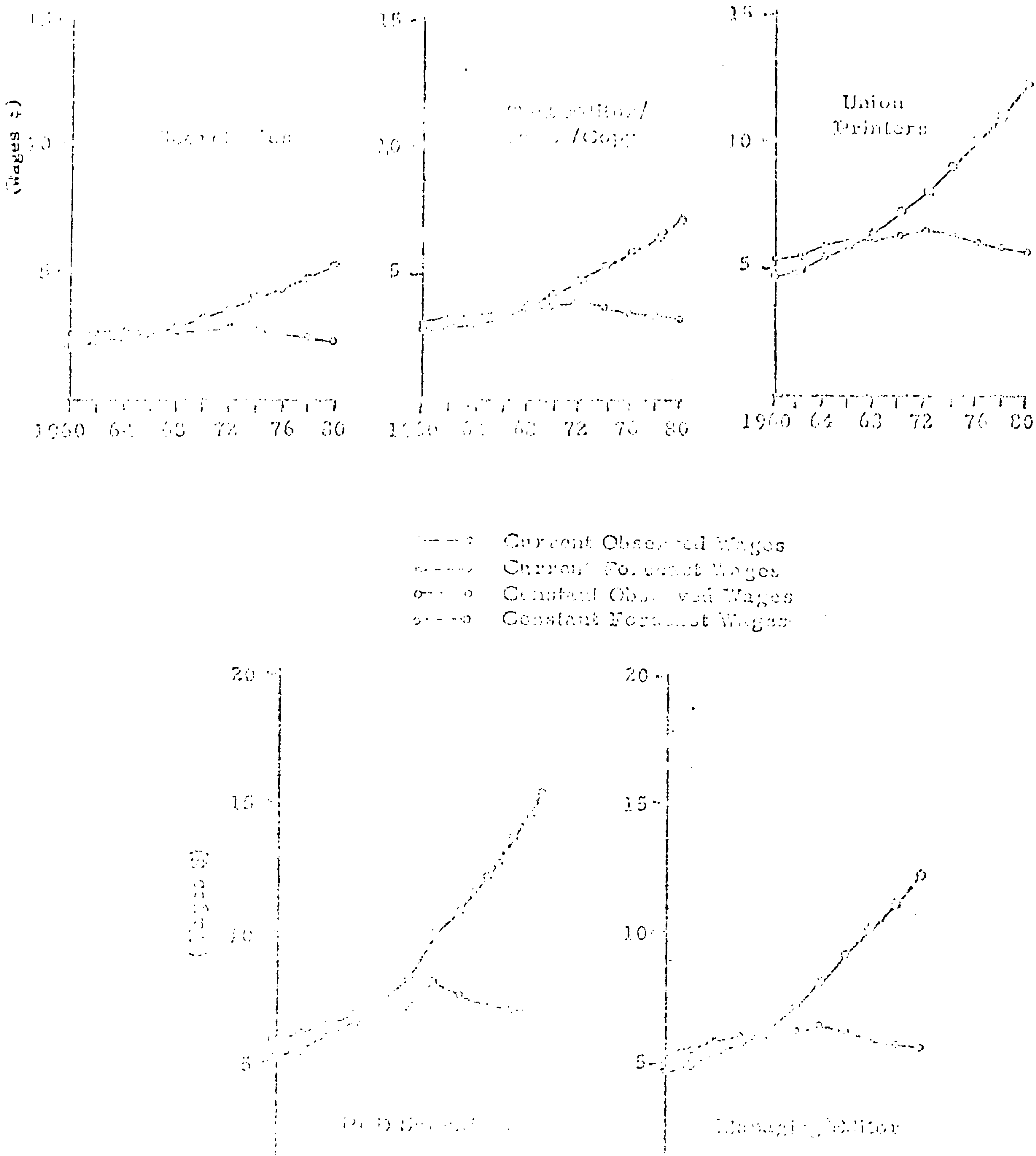
Table 3.46 AVERAGE HOURLY WAGE RATES FOR PERSONNEL ENGAGED IN JOURNAL REPRODUCTION: 1960-1980

(Current and Constant Dollars)*

Personnel	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980
Secretaries											
Current $	2.20	2.32	2.45	2.57	2.81	3.15	3.57	3.98	4.35	4.76	5.21
Constant $	2.50	2.58	2.65	2.65	2.70	2.74	2.87	2.75	2.58	2.47	2.39
Text Editor/ Proof/Copy											
Current $	2.80	2.97	3.18	3.41	3.75	4.21	4.74	5.32	5.86	6.46	7.12
Constant $	3.19	3.30	3.44	3.52	3.61	3.66	3.81	3.68	3.47	3.36	3.27
Managing Editor											
Current $	4.65	4.93	5.40	5.80	6.38	7.16	8.06	9.04	10.01	11.08	12.26
Constant $	5.29	5.48	5.83	5.99	6.13	6.23	6.49	6.25	5.93	5.75	5.62
Ph.D. Scientists											
Current $	5.05	5.50	6.00	6.60	7.50	8.25	10.00	10.87	12.17	13.62	15.24
Constant $	5.75	6.11	6.48	6.81	7.21	7.17	8.05	7.51	7.21	7.07	6.99
Union Printers											
Current $	3.30	3.41	3.63	3.85	4.27	4.97	5.89	6.69	7.95	9.18	10.70
Constant $	3.76	3.79	3.92	3.97	4.11	4.32	4.74	4.62	4.38	4.77	4.91

*GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: See Table 3.44.



Union Printers
1960 64 68 72 76 80
Current Observed Wages
Constant Forecast Wages
Managing Editor

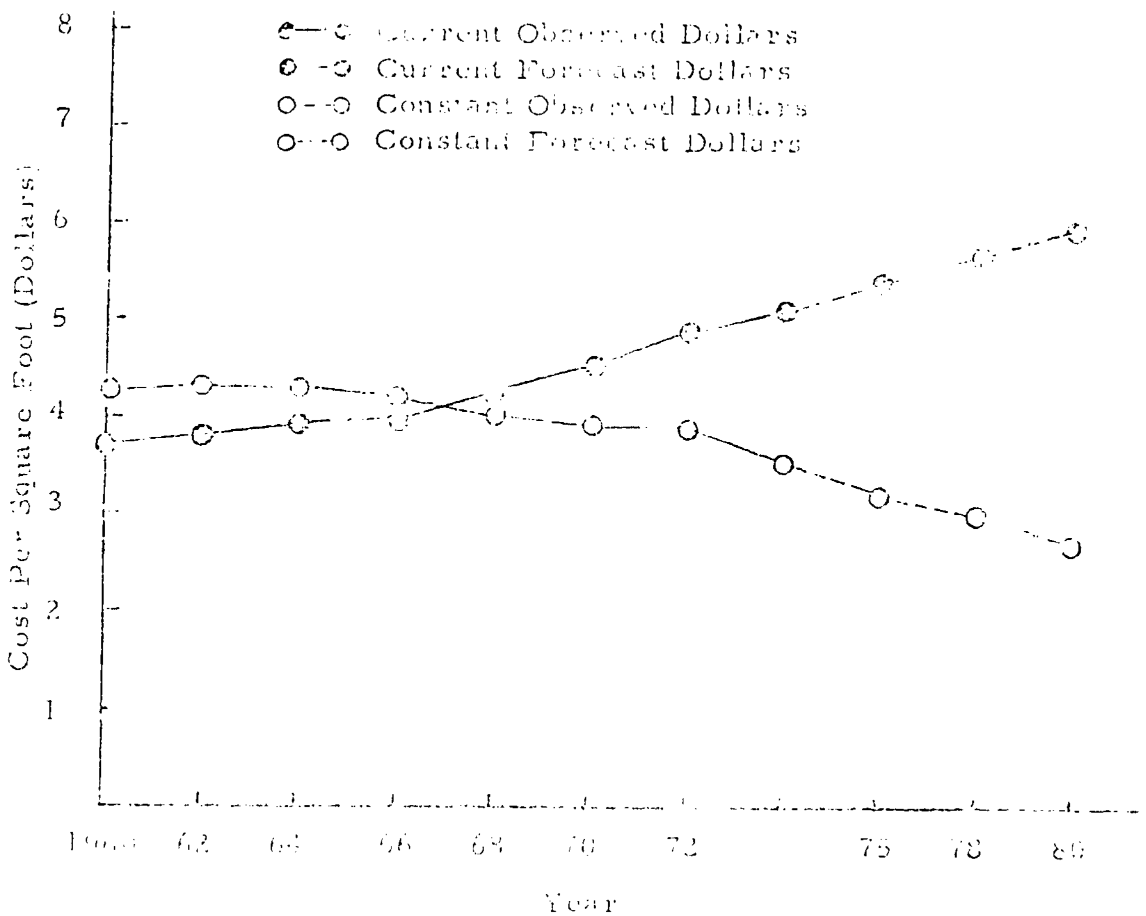
Table 3.47 AVERAGE RENTAL COSTS: 1960-1980

(Dollars Per Square Foot)

Rent	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980
Current $	3.73	3.82	3.90	4.01	4.18	4.49	4.85	5.14	5.40	5.68	5.97
Constant $	4.25	4.25	4.21	4.14	4.02	[illegible]	3.91	3.55	3.20	3.00	2.74

SOURCE: See Table 3.44

Figure 3.40 AVERAGE RENTAL COST PER SQUARE FOOT: 1960-1980



SOURCE: Table 3.47

TABLE [illegible] AVERAGE WPI MACHINERY AND EQUIPMENT WHOLESALE PRICE INDEX AND AVERAGE TYPESETTING COSTS: 1960-1980

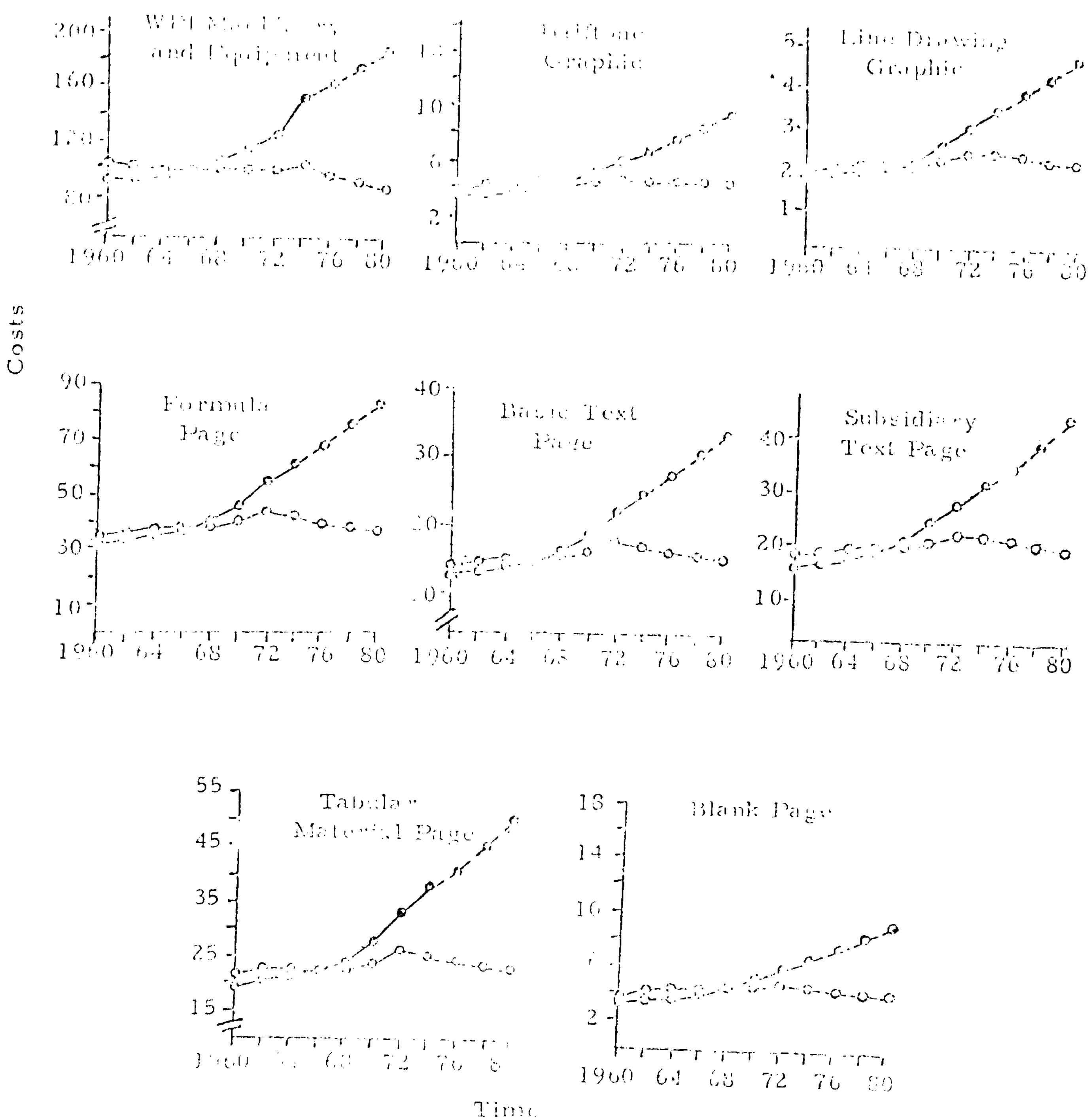
(Current and Constant 1967 Dollars)*

	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980
Wholesale Price Index Machinery and Equipment											
Current $	90.6	[illegible]	92.1	96.9	105.6	115.7	123.7	151.0	162.4	174.6	187.8
Constant $	101.1	101.6	99.5	100.0	101.5	100.6	99.6	104.4	96.3	90.7	86.2
Typesetting											
Halftone Graphic											
Current $	3.45	3.64	3.85	4.05	4.45	5.12	6.00	6.75	7.48	8.29	9.18
Constant $	3.93	4.05	4.16	4.18	4.28	4.45	4.83	[illegible]	4.43	4.31	4.21
Line Drawing Graphic											
Current $	1.73	1.82	1.92	2.02	2.22	2.56	3.00	3.37	3.73	4.14	4.58
Constant $	1.97	2.02	2.07	2.08	2.13	2.23	2.41	2.33	2.21	2.15	2.10
Title Page											
Current $	31.66	31.40	35.25	37.15	40.77	46.97	55.00	61.88	68.60	76.00	84.20
Constant $	36.04	37.13	38.08	38.34	39.20	40.84	44.26	42.78	40.66	39.47	38.63
Basic Text Page											
Current $	12.66	13.	14.10	14.85	16.30	[illegible]	22.00	24.75	27.44	[illegible]	33.68
Constant $	14.41	14.85	15.23	15.33	15.67	16.34	17.70	17.11	16.26	15.79	15.45
Subsidiary Text Page											
Current $	16.11	17.00	17.95	18.90	20.76	23.90	[illegible]	31.50	34.90	38.67	42.85
Constant $	18.34	18.90	19.39	19.50	19.96	20.78	22.53	21.78	[illegible]	20.09	[illegible]
Tabular Material Page											
Current $	19.00	20.04	21.15	22.29	24.45	28.17	33.00	37.14	41.16	45.60	50.52
Constant $	21.63	22.28	22.85	23.00	23.51	24.49	26.56	25.67	24.40	23.68	23.18
Blank Page											
Current $	3.45	3.64	3.55	4.05	4.45	5.12	6.00	6.75	7.48	8.29	9.18
Constant $	3.93	4.05	4.16	4.18	4.28	4.45	4.83	4.67	4.43	4.31	4.21

* GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: See Table 3.44

Figure 3.41 [illegible] 1960-1980



SOURCE: [illegible]

Current Observed Values
Current Forecast Values
Constant Observed Values
Constant Forecast Values

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and equipment costs in constant dollars have actually decreased slightly since 1960 to 1974, and should increase a small amount to 1980. The typesetting costs have all increased in constant dollars from 1960 to 1974 and should remain about the same until 1980.

Paper costs in current dollars have been rising substantially since 1964. However, as shown in Table 3.49 and Figure 3.42, the paper costs in constant dollars have been decreasing somewhat. This decrease is not consistent with the popular belief that paper costs are to blame for the increase in reproduction costs. A large current dollar increase was observed in the period 1972 to 1974, but the constant dollar increase during that time was not nearly as dramatic.

Table 3.49 PAPER COSTS: 1960-1980

(Per Hundred Pounds)

Paper Costs	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980
Current $	14.32	14.29	14.26	14.67	15.56	16.52	16.07	19.84	21.30	23.00	24.70
Constant $*	16.30	15.88	15.[illegible]	15.14	14.96	14.36	12.93	13.72	12.62	11.94	11.33

* Using GNP implicit price deflator (1975-1980 BPA) to obtain 1967 Constant Dollars.

SOURCE: Bureau of the Census, DOC, Statistical Abstract of the United States, 1960-1974.

Postal rates are given in Table 3.50. It is noted that the postal rates for regular publications increased a little over 100 percent from 1962 to 1974, and are expected to increase an additional 110 percent by 1980. Constant dollar figures also increase. The postal cost of a letter plus an average manuscript is given in Figure 3.43. The postal cost in constant dollars increased about 20 percent from 1962 to 1974 and is expected to increase another 22 percent by 1980. Postal costs, of course, contribute to the overall reproduction and distribution costs. Labor costs contribute more, however, and are rising at a greater rate.

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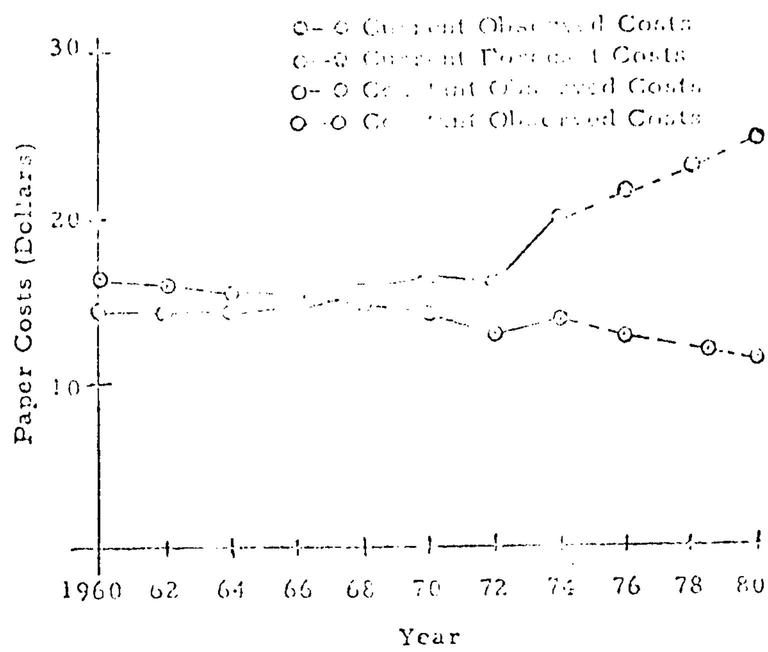
Figure ?.42 Paper Costs: 1960-1980



SOURCE: Table 3.49

3.6.1.3 Cost of Journal Reproduction and Distribution

We have attempted to validate the cost model by comparing costs determined from the cost model to costs obtained from other sources. For example, Case Institute of Technology developed a cost model for runoff costs based on 1959 data (33). By taking our 1960 data (which was the first year in which the model was applied) and reducing the amount by three percent per year we can compare the results of the two models. The Case equation for runoff cost per thousand equivalent words per copy is as follows:

$$\text{Runoff Cost} = \frac{421{,}000}{nIw} + \frac{8.15}{I^{1/2}w} + \frac{.78}{w} + \frac{7.35}{Iw}$$

where:

n is the number of copies produced

I is the pages per issue

w is the equivalent words per page

Table 3.50 POSTAL RATES 1960-1980

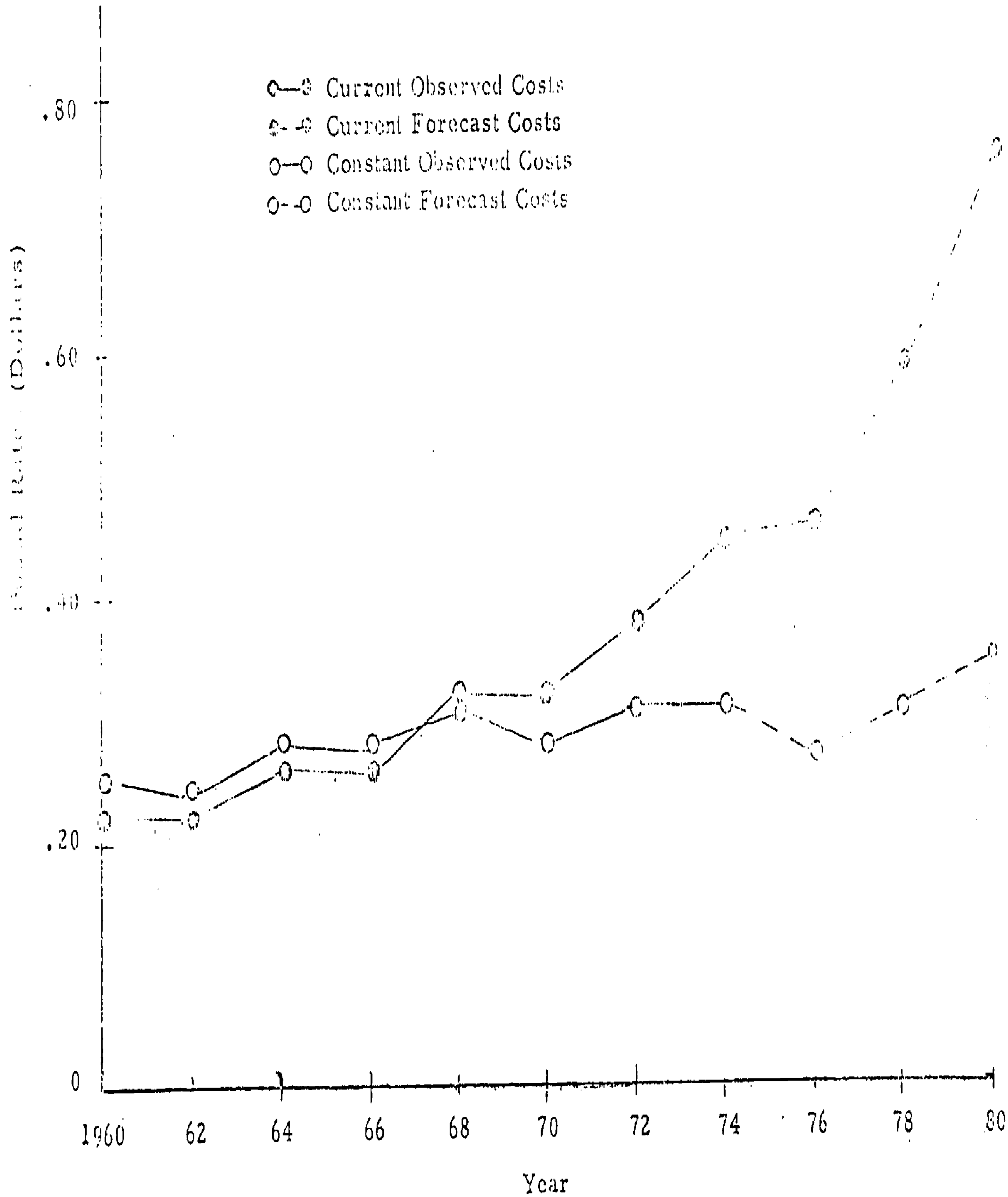
(Current and Constant 1967 Dollars)*

Postal Rates	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980
Non-Profit Publication (per pound)											
Current $	.015	.015	.017	.018	.019	.021	.025	.032	.039	.054	.068
Constant $	.017	.017	.018	.019	.018	.018	.020	.022	.023	.028	.031
Regular Publication (per pound)											
Current $	.023	.025	.027	.028	.030	.034	.042	.052	.067	.086	.111
Constant $	.026	.028	.029	.029	.029	.030	.034	.036	.040	.045	.051
First Class Letter (per ounce)											
Current $	.04	.04	.05	.05	.06	.06	.08	.10	.13	.15	.18
Constant $	.05	.04	.05	.05	.06	.05	.06	.07	.08	.08	.08
Airmail Letter (per ounce)											
Current $	.07	.07	.08	.08	.10	.10	.11	.13	.13	.14	.15
Constant $	.08	[illegible]	.09	.08	.10	.09	.09	.09	.08	.07	.07
Letter plus Manuscript											
Current $	.22	.22	.26	.26	.32	.32	.38	.45	.46	.59	.76
Constant $	.25	.24	.28	[illegible]	.31	.28	.31	.31	.27	.31	.35

* GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: See Table 3.4

Figure 3.43 POSTAGE COST OF A LETTER PLUS AN AVERAGE MANUSCRIPT; 1960-1980



SOURCE: Table 3.50

Results of this comparison are shown in Table 3.51 for the nine fields of science.

Table 3.51 AVERAGE RUNOFF COSTS FOR SCIENTIFIC AND TECHNICAL JOURNALS, BY FIELD OF SCIENCE: 1959

(Average Runoff Cost: $/Kiloword)

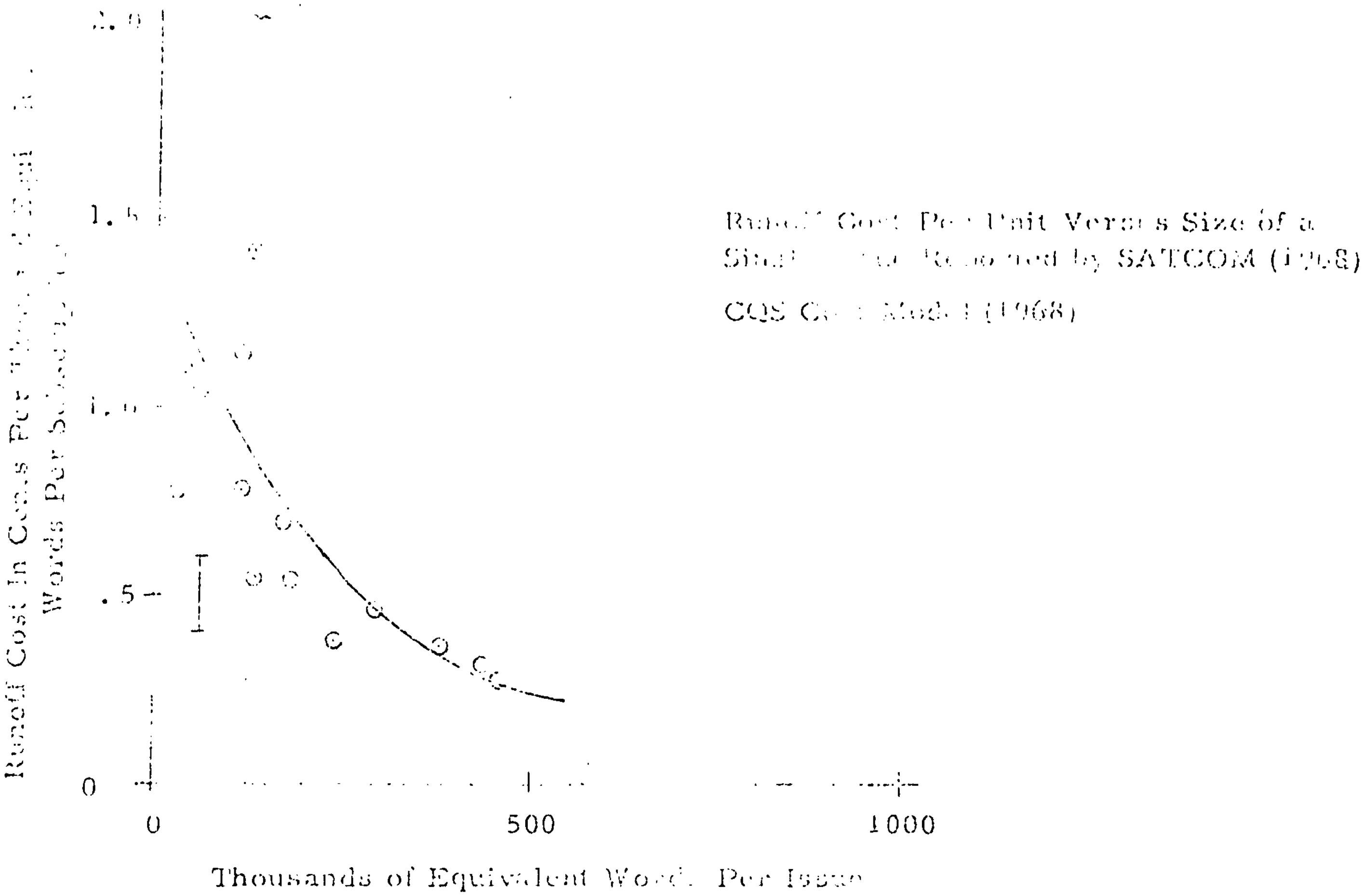
Field of Science	Case Model	EPC Model	Difference
Physical Science	.0032	.0039	.0007
Mathematics	.0042	.0052	.0010
Computer Sciences	.0035	.0038	.0003
Environmental Sciences	.0038	.0042	.0004
Engineering	.0025	.0032	.0007
Life Sciences	.0033	.0043	.0010
Psychology	.0046	.0053	.0007
Social Sciences	.0058	.0072	.0014
Other Sciences	.0032	.0036	.0004

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Overall, the estimates from our cost model appear to be about the same as those from the Case model, with the difference between the two ranging from .03 to .14 cents per kiloword.

The SATCOM report (59) gives runoff costs in 1968 as shown in Figure 3.44. Runoff cost per thousand equivalent words per copy is plotted against average size of a single issue, for journals in all fields. The solid curve is an arbitrary one drawn for reference. These data range from about .25 to 1.4 cents per kiloword depending on the number of kilowords per issue. Our results show a range of .40 to .63 cents. Our cost data are shown in the interval on the figure. It would appear that our costs are lower than those reported in the SATCOM report.

Figure 3.44 RUNOFF COST PER UNIT VERSUS SIZE OF A SINGLE ISSUE REPORTED BY SATCOM: 1968

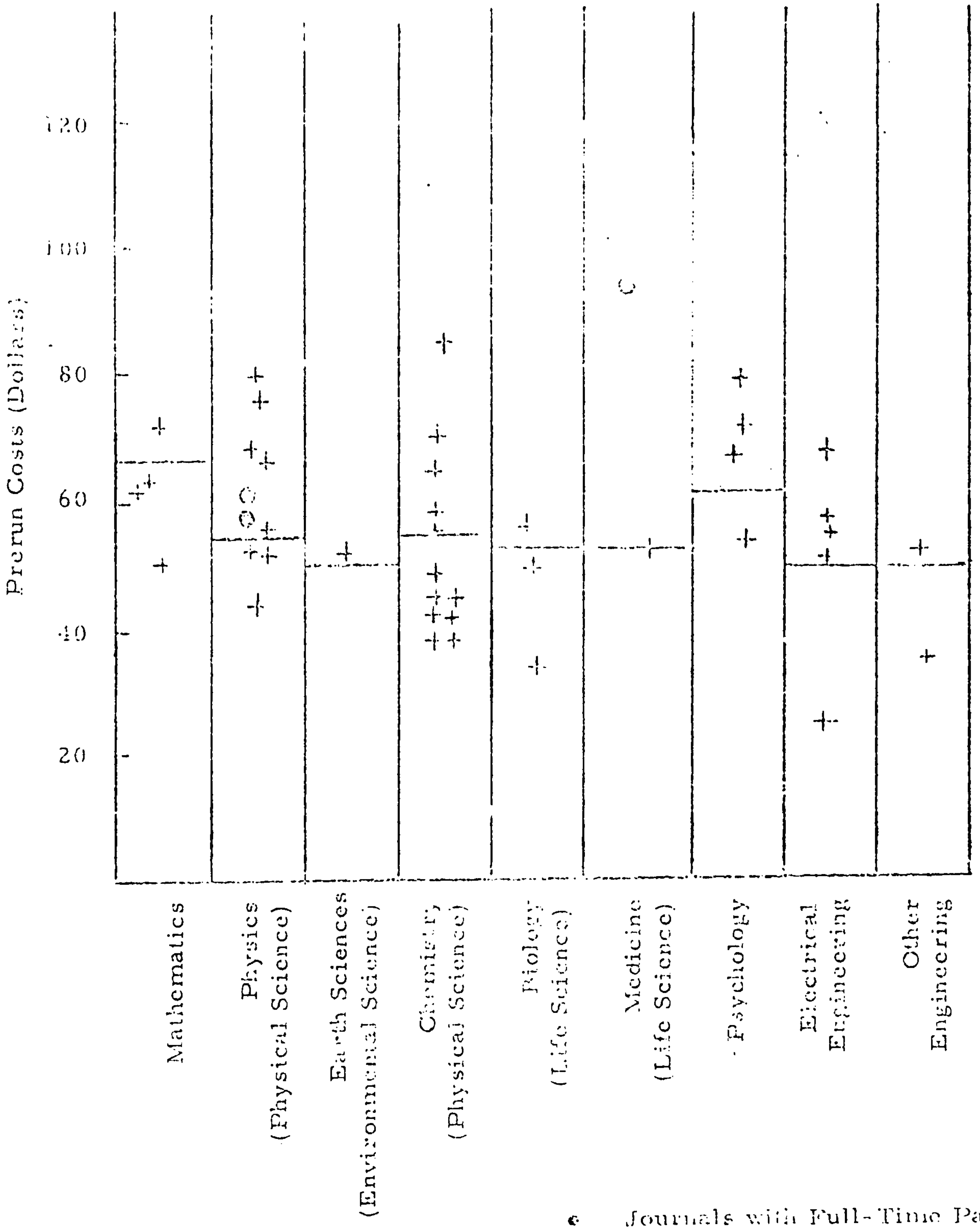


SOURCE: SATCOM

Prerun costs reported by SATCOM are given in Figure 3.45. These costs range from about $25 to $90 per kiloword page, and represent prerun costs for individual journals in various fields. For journals containing advertising or other non-research material, the figures are intended to apply to the research material only, but may not always fully realize this intention. Black dots identify journals with full-time paid editors, for which one can be sure that there are no hidden costs for technical editing. Our average costs for 1968, represented by a line across each field, appear to be fairly well in line with those reported by SATCOM.

In a 1959 study (98), total cost data were identified by the National Science Foundation for several fields of science. Their data and our equivalent data are given in Table 3.52. The National Science Foundation calculated the average cost per research kiloword for scientific journals published by professional societies to be $0.0129 in 1959. This figure increased to $0.0177 by 1962. Our estimate for 1962 is $0.0154 per kiloword.

Figure 3.45 PRERUN COSTS PER KILOWORD BY FIELD REPORTED BY SATCOM: 1968



SOURCE: SATCOM

○ Journals with Full-Time Paid Editors (no hidden technical editing costs)

+ Prerun Costs Per Kiloword

— CQS Cost Model (1968)

Table 3.57 AVERAGE COST OF REPRODUCING AND DISTRIBUTING SCIENTIFIC AND TECHNICAL JOURNALS, BY FIELD OF SCIENCE: 1959

(Dollars per Kiloword)

Data Source	Chem. (Physical)	Physics (Physical)	Math.	Earth (Env.)	Eng.	Biology (Life)	Social
NSF[1]	.0091	.0063		.0100	.0085	.0150	.0196
EPC Model[2]	.0139	.0130	.0167	.0138	.0113	.0132	.0187
Difference	.0049	.0067	.0002	.0038	.0028	.0018	.0009

SOURCE: [1] National Science Foundation, Characteristics of Scientific Journals 1949-1959 (NSF 64-20), August 1964.

[2] Cost Model, Market Facts, Inc., Center for Quantitative Sciences

For commercial journals the comparable figures quoted by NSF were $0.0268 in 1959 and $0.0394 in 1962 and for university press journals the figures were $0.0266 in 1959 and $0.0275 in 1962.

A report from the International Congress of Scientific Unions (ICSU) (128) calculated that in 1964, the average cost per kiloword for a U. S. society journal in the biological sciences was $0.0196; for a commercial journal it was $0.0286. Our 1964 estimate for the life sciences is $0.0135 per kiloword. Another ICSU (63) study, in the physical sciences, produced figures of $0.0248 per kiloword for a 1964 journal published by a professional society in the U. S. The comparable figure for commercial journals was $0.0377. Our estimate for the physical sciences is $0.0136 per kiloword. It is worth noting that both ICSU studies reported substantially greater costs in some other countries. In Germany, for example, the average cost per kiloword for a journal published by a scientific society in the physical sciences was $0.0785, more than three times the U. S. costs. In Great Britain the average cost in the physical sciences for commercial journals was $0.171 per kiloword, almost twelve times the comparable figure in the U. S.

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The estimated reproduction costs from our model are presented in Tables 3.53 - 3.61 by field for the years 1962 to 1980. Per kiloword costs shown are prerun cost, typeset cost, runoff cost per copy, and total cost per copy. Also given are the total cost per journal and the average cost per subscriber. It should be noted that our estimates are based on an overall average of subscriptions, while the number of subscribers per journal closely varies somewhat from field to field. We do not have data on the number of subscriptions by field so we cannot adjust for these differences. Since a large portion of the costs are runoff costs which will vary according to the number of subscriptions, this limitation on our model is an important one.

Table 3.53 ESTIMATED PRER[illegible], R[illegible], AND TOTAL COSTS OF A TYPICAL PHYSICAL SCIENCES JOURNAL: 1962-1980

Year	Cost per Kiloword ($) Prerun	Typeset	Runoff per Copy	Total per Copy	Total Cost Per Journal (000)	Total Cost per Subscriber
1962	43.50	18.55	.0043	.0142	51.8	11.18
1964	41.90	15.80	.0046	.0136	51.0	10.27
1966	47.92	17.88	.0041	.0134	73.0	13.54
1968	54.57	21.57	.0047	.0143	73.9	12.29
1972	70.31	29.44	.0049	.0159	104.9	15.55
1974	81.20	33.91	.0056	.0180	139.6	20.22
1976	92.71	36.56	.0061	.0194	162.2	22.07
1978	104.97	41.18	.0065	.0210	183.6	24.06
1980	115.15	45.45	0070	.0223	207.4	26.22
PERCENT CHANGE						
1962-1968 . . .	25	16	9	1	43	10
1968-1974 . . .	49	57	20	27	89	65
1974-1980 . . .	42	34	23	24	49	30

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

Table 3.54 ESTIMATED PRERUN, RUNOFF, AND TOTAL COSTS OF A TYPICAL MATHEMATICS JOURNAL: 1962-1980

Year	Cost per Kiloword ($)				Total Cost Per Journal (000)	Total Cost per Subscriber
	Prerun	Typeset	Runoff per Copy	Total per Copy		
1962	55.32	30.36	.0056	.0182	34.0	7.40
1964	56.77	30.69	.0054	.0175	36.5	7.35
1966	64.90	34.86	.0059	.0186	46.1	8.55
1968	67.68	34.68	.0058	.0177	58.6	9.75
1972	88.96	48.08	.0067	.0206	75.8	11.23
1974	104.92	57.63	.0083	.0245	79.7	11.54
1976	118.38	62.24	.0083	.0253	102.3	13.91
1978	133.01	69.22	.0089	.0273	128.3	16.81
1980	146.09	76.40	.0095	.0291	145.8	18.43
PERCENT CHANGE						
1962-1968 . .	22	14	4	97	72	32
1968-1974 . .	55	66	43	38	36	18
1974-1980 . .	39	33	14	19	83	60

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

Table [illegible] ESTIMATED PRE[illegible], [illegible], [illegible] COSTS OF A TYPICAL COMPU[illegible] [illegible]: 1962-1980

Year	Cost per [illegible] ($)				Total Cost Per Journal (000)	Total Cost per Subscriber
	Prerun	Typeset	Runoff per Copy	Total per Copy		
1962	43.22	18.26	.0042	.0140	14.9	3.21
1964	43.92	17.82	.0038	.0131	20.1	4.05
1966	47.52	17.48	.0037	.0130	21.3	3.94
1968	52.40	19.40	.0040	.0131	24.0	3.99
1972	71.50	30.12	.0047	.0159	38.7	5.74
1974	78.86	31.57	.0055	.0175	40.2	5.82
1976	92.08	35.94	.0053	.0190	49.5	6.73
1978	102.91	39.12	.0064	.0206	57.6	7.55
1980	116.45	46.75	.0068	.0223	66.5	8.41
PERCENT CHANGE						
1962–1968 . .	21	6	-5	-6	61	24
1968–1974 . .	66	81	38	34	68	46
1974–1980 . .	48	48	24	27	65	45

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

[illegible]

Year	Cost per Title ($)				Total Cost Per Journal (000)	Total Cost per Subscriber
	Prepub	Typeset	Runoff per Copy	Total per Copy		
1962	46.71	21.75	.0045	.0151	16.7	3.61
1964	47.56	21.46	.0048	.0150	21.[illegible]	4.41
1966	49.82	19.78	.0043	.0140	38.5	7.14
1968	51.03	18.03	.0040	.0129	72.0	11.97
1972	70.95	30.07	.0057	.0158	61.2	9.07
1974	71.71	24.42	.0046	.0155	63.8	9.23
1976	89.71	33.56	.0059	.0188	79.2	10.78
1978	101.15	37.36	.0064	.0204	88.0	11.54
1980	110.81	41.12	.00[illegible]	.0219	96.2	12.16
PERCENT CHANGE						
1962-1968 . .	9	-7	-11	-15	331	232
1968-1974 . .	44	35	17	20	-11	-23
1974-1980 . .	55	68	30	41	51	32

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

Table 3.57 [illegible] RUNOFF, [illegible] COST PER THOUSAND OF A [illegible]: 1962-1980

Year	Cost per Kiloword ($)				Total Cost Per Journal (000)	Total Cost per Subscriber
	Prerun	Typeset	Runoff per Copy	Total per Copy		
1962	39.19	14.23	.0035	.0124	24.0	5.17
1964	42.09	15.98	.0038	.0128	27.4	5.52
1966	45.87	15.83	.0036	.0125	35.0	6.[illegible]3
1968	51.04	18.04	.0038	.0128	44.0	7.31
1972	65.56	24.68	.0042	.0144	65.6	9.72
1974	74.42	27.13	.0050	.0163	75.6	10.96
1976	86.08	29.93	.0052	.0175	89.9	12.24
1978	97.11	33.32	.0056	.0190	102.4	13.42
1980	106.50	36.81	.0060	.0202	115.3	14.57
PERCENT CHANGE						
1962-1968 . .	30	27	9	3	83	41
1968-1974 . .	62	50	29	27	72	50
1974-1980 . .	43	36	22	24	53	33

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

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Table 3.58 ESTIMATED PRERUN, RUNOFF, AND TOTAL COSTS PER KILOWORD OF A TYPICAL LIFE SCIENCES JOURNAL: 1962-1980

Year	Cost per Kiloword ($)				Total Cost Per Journal (000)	Total Cost per Subscriber
	Prerun	Typeset	Runoff per Copy	Total per Copy		
1962	42.14	17.18	.0048	.0144	39.8	8.58
1964	43.25	17.15	.0044	.0136	40.1	8.06
1966	47.45	17.71	.0046	.0140	43.2	8.01
1968	53.16	20.16	.0050	.0144	45.8	7.62
1972	67.82	26.95	.0054	.0161	60.2	8.92
1974	77.51	30.22	.0064	.0183	69.9	10.13
1976	89.38	33.23	.0066	.0195	88.5	12.04
1978	100.75	36.96	.0071	.0211	99.6	13.06
1980	110.21	40.51	.0077	.0224	108.3	13.69
PERCENT CHANGE						
1962-1968 . .	26	17	4	0	15	39
1968-1974 . .	46	71	28	27	53	33
1974-1980 . .	42	34	20	22	55	35

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

Table 3.59 ESTIMATED PRERUN, RUNOFF, AND TOTAL COSTS OF A TYPICAL PSYCHOLOGY JOURNAL: 1962-1980

Year	Cost per Kiloword ($)				Total Cost Per Journal (000)	Total Cost per Subscriber
	Prerun	Typeset	Runoff per Copy	Total per Copy		
1962	48.25	23.62	.0075	.0168	28.2	6.08
1964	50.52	24.40	.0051	.0163	25.8	5.19
1966	56.62	26.57	.0061	.0172	30.7	5.69
1968	62.39	52.84	.0063	.0174	31.8	5.29
1972	80.86	39.98	.0072	.0199	41.3	6.11
1974	96.53	49.24	.0091	.0241	52.9	7.65
1976	106.91	50.76	.0087	.0242	50.3	6.84
1978	120.27	56.48	.0095	.0296	56.8	7.45
1980	131.91	62.22	.0103	.0281	63.8	8.07
PERCENT CHANGE						
1962-1968 . .	29	24	10	4	13	-13
1968-1974 . .	55	-7	45	39	66	47
1974-1980 . .		26	13	17	21	5

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

Table 3.60 ESTIMATED PRERUN, RUNOFF, AND TOTAL COSTS OF A TYPICAL SOCIAL SCIENCES JOURNAL: 1962-1980

Year	Cost per Kiloword ($)				Total Cost Per Journal (000)	Total Cost per Subscriber
	Prerun	Typeset	Runoff per Copy	Total per Copy		
1962	53.59	34.32	.0079	.0204	24.0	3.02
1964	53.54	27.44	.0059	.0174	18.7	3.76
1966	59.76	29.71	.0058	.0175	18.3	3.39
1968	63.29	30.29	.0061	.0173	20.3	3.46
1972	83.38	42.50	.0071	.0202	26.2	3.89
1974	45.43	48.14	.0053	.0230	29.3	4.24
1976	110.71	54.57	.0089	.0249	30.9	4.21
1978	125.03	61.24	.0098	.0218	25.8	3.37
1980	137.52	67.83	.0107	.0293	36.2	4.57
PERCENT CHANGE						
1962-1968 . .	18	-12	-23	-15	-15	15
1968-1974 . .	-28	59	-13	33	44	23
1974-1980 . .	203	41	102	27	24	8

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

Table .61 ESTIMATED PRERUN, RUNOFF, AND TOTAL COSTS OF A TYPICAL OTHER SCIENCES JOURNAL: 1962-1980

Year	Cost per Kiloword ($)				Total Cost Per Journal (000)	Total Cost per Subscriber
	Prerun	Typeset	Runoff per Copy	Total per Copy		
1962	40.83	16.20	.0040	.0132	26.3	5.67
1964	42.47	16.37	.0038	.0111	27.3	5.30
1966	46.68	16.64	.0037	.0128	36.1	6.68
1968	51.15	18.15	.0040	.0129	50.6	8.42
1972	66.48	25.60	.0046	.0150	111.4	16.50
1974	72.09	24.80	.0052	.0162	123.0	17.82
1976	87.81	31.57	.0056	.0182	144.9	19.71
1978	98.96	35.17	.0060	.0196	163.0	21.36
1980	108.03	38.33	.0065	.0209	180.7	22.85
PERCENT CHANGE						
1962-1968 . .	25	12	0	-2	92	49
1968-1974 . .	41	37	30	26	143	112
1974-1980 . .	50	55	25	29	47	28

SOURCE: Cost Model, Market Facts, Inc., Center for Quantitative Sciences.

3.6.1.4 Sources of Revenue for Journal Publishers

Sources of revenue for journal publishers include fees from subscriptions, society dues, advertising, page charges, subsidies and others. There is not much information concerning any of these sources available in the literature, although the Indiana University report (49) does give some information on sources of revenue for the 1969 to 1973 period. Revenue breakdowns for pure science, science and technology and social science journals from this study are shown in Table 3.62.

Table 3.62 PERCENT DISTRIBUTION OF REVENUE FOR SCHOLARLY JOURNALS IN PURE SCIENCE, APPLIED SCIENCE AND TECHNOLOGY, AND SOCIAL SCIENCES: 1969, 1971, 1973

(Percent)

Sources of Revenue	Pure Sciences (n=44)			Science & Technology (n=50)			Social Sciences (n=65)		
	1969	1971	1973	1969	1971	1973	1969	1971	1973
Subscriptions	49	49	51	38	40	41	50	45	46
Society Dues	27	28	28	30	30	28	30	39	39
Other Pub. Sales . .	4	4	4	6	6	6	4	3	3
Advertising	6	4	4	21	18	18	6	6	5
Page Charges	11	12	10	2	3	3	-	-	-
Subsidies	3	2	2	3	2	1	4	3	2
Miscellaneous	1	1	-	1	3	3	6	4	4
Total	100								

SOURCE: Fry, Bernard M. and Herbert S. White, Economics and Interaction of the Publisher-Library Relationship in the Production and Use of Scholarly and Research Journals (NSF GN-41398), Indiana University, November 1975.

One source of income is advertising. Naturally, scientific and technical journals do not usually have the large audiences which advertisers desire. But a great many journals, especially those which are applications-oriented, generalized, or directed towards specific trades, do publish advertisements for scientific instruments, drugs, technical equipment, and other products or services.

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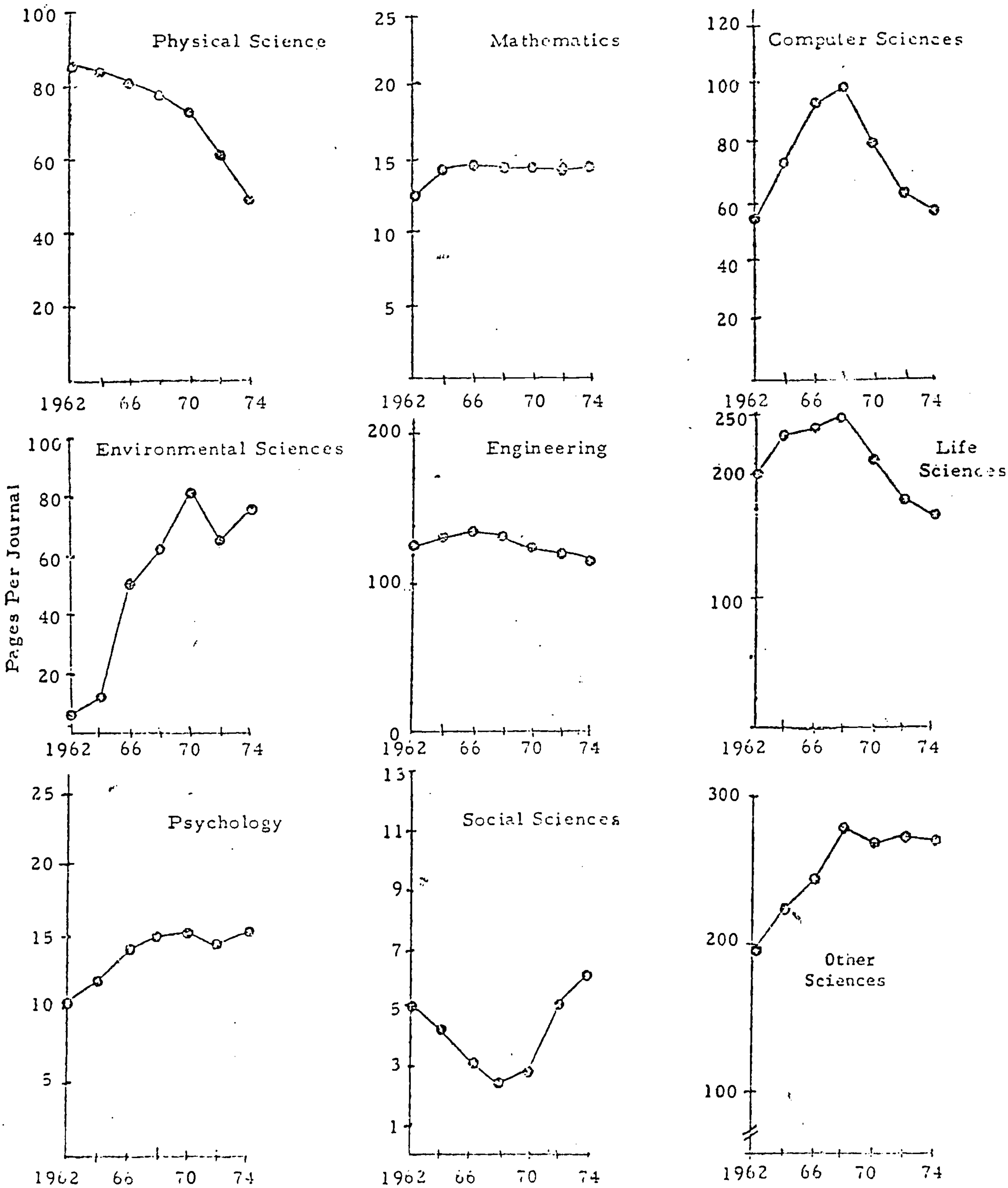
A direct measurement of the income derived from advertising was not available for our sample of journals. We did, however, count pages of advertising in each issue sampled in the journal tracking survey. From this the average number of pages of advertising per year was calculated for each field. The results are displayed in Table 3.63 and Figure 3.46. There is obviously a great difference among fields in the pages of advertising published each year. The fields which consistently publish the most advertising are the Life Sciences, Engineering, and Other Sciences, measuring in the hundreds of pages each year. The fields which publish the least advertising per year are Mathematics, Social Sciences, and Psychology.

Table 3.63 ESTIMATED PAGES OF ADVERTISING PUBLISHED PER JOURNAL PER YEAR: 1962–1974

Field of Science	1962	1964	1966	1968	1970	1972	1974
Physical Sciences . . .	87.4	86.3	81.3	78.4	71.3	60.1	49.4
Mathematics	12.6	14.4	14.9	14.7	14.5	14.3	14.6
Computer Sciences . . .	53.8	74.9	93.8	98.0	79.2	61.5	55.7
Environmental Sciences	6.6	13.2	51.2	62.7	82.8	65.0	76.1
Engineering	128.5	130.8	136.0	130.1	124.8	121.0	119.0
Life Sciences	176.3	200.8	206.5	211.6	182.2	158.2	149.4
Psychology	10.6	12.0	14.2	15.0	15.2	14.8	15.2
Social Sciences	5.1	4.4	3.1	2.5	2.9	5.3	6.3
Other Sciences	197.6	225.7	241.4	277.2	269.1	271.[illegible]	269.4

SOURCE: Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

Figure 3.46 PAGES OF ADVERTISING PUBLISHED PER JOURNAL PER YEAR: 1962-1974



SOURCE: Table 3.63.

Definite trends in advertising pages are apparent for some fields. Advertising is declining for Physical Sciences, and since 1968, for Computer Sciences, Engineering and Life Sciences. Mathematics has held fairly steady since 1962. Advertising in Social Sciences journals declined until 1968, and then rose in succeeding years. Computer Sciences advertising appears to have peaked around 1966 or 1968, and then began to decline. The trends in Environmental Sciences and Other Sciences are not so clear. Environmental Sciences advertising is somewhat confused by the outlying value for 1968, but it appears that there has been an upward trend since 1962.

Figures from the Indiana study (48) in advertising pages per year shown in Table 3.64. These are, in general, substantially lower than the results of the Journal Tracking Survey, and the discrepancy would appear to be worth looking into.

Table 3.64 ESTIMATED MEDIAN NUMBER OF ADVERTISING PAGES PER JOURNAL BY DISCIPLINE: 1969, 1971, 1973

Discipline	1969 % Who Do Not Print Advertisements	1969 Advertising Pages Per Year*	1971 % Who Do Not Print Advertisements	1971 Advertising Pages Per Year*	1973 % Who Do Not Print Advertisements	1973 Advertising Pages Per Year*
Pure Science (N=44)	64	0.4	64	0.1	64	0.1
Applied Science & Technology (N=50)	44	13.5	44	6.0	48	3.5
Social Sciences (N=65)	48	1.8	46	3.0	40	4.2

* For those journals which accept advertising.

SOURCE: Fry, Bernard M. and Herbert S. White, Economics and Interaction of the Publisher-Library Relationship in the Production and Use of Scholarly and Research Journals (NSF GN-41398), Indiana University, November 1975.

Another source of income to publisher is page charges. In 1968, Conyers Herring (59) reported that the practice of page charges had become widespread. The practice was much more prevalent among societies and non-profit organizations than with private publishers. The range of charges appeared to be betwe · $10 and $60 for societies with an average at, perhaps, about $45. Nonprofit publishers charged between $10 and $40 with an average of about $25.

To bring this information up to date, our Author Survey asked respondents to indicate the total amount they had to pay for page charges. Our results on page charges per article are only approximate, due to an ambiguity in the questionnaire; some authors reported per-page page charges, while most reported total page charges paid. Therefore, we assumed that dollar amounts of less than $100 reported for this question were actually per-page charges, and multiplied this times an average of seven pages per article to estimate total page charges. Results of the average page charge per article are shown in Figure 3.47 and Table 3.65.

From the author survey results we might conclude that the percent of authors who do not pay page charges has remained fairly constant since 1968. However, due to the shift in non-response rate for this question (from 2..9% for 1968 articles to 6% for 1975 articles), it is not safe to conclude that the apparent increase in the percent of authors who pay page charges is real. Herring found that the proportion of authors that honor their page charges is slightly decreasing over time. Unfortunately, we cannot confirm nor question this finding due to the shift in response rate.

Page charges are voluntary in many cases. Even if an author pays a page charge, there is no guarantee that the author will pay the entire requested amount, as pointed out by several of the author survey respondents. Nevertheless, our results suggest a slight increase in average page charges paid since 1970 - 1972, perhaps reflecting more stringent requirements on the part of the publishers.

3.6.2 Total Cost of Reproduction and Distribution

The total cost of reproduction and distribution, shown in Table 3.66 was arrived at using a combination of techniques. The methodology used depended on the type of literature, that is, journals, books or technical reports. In general, we felt that the most accurate approach was [illegible] the number of items by the average price since the price best represents the cost of reproduction and distribution.

Table 3.65 ANALYSIS OF PAGE CHARGE DATA FROM AUTHOR SURVEY: 1968-1975

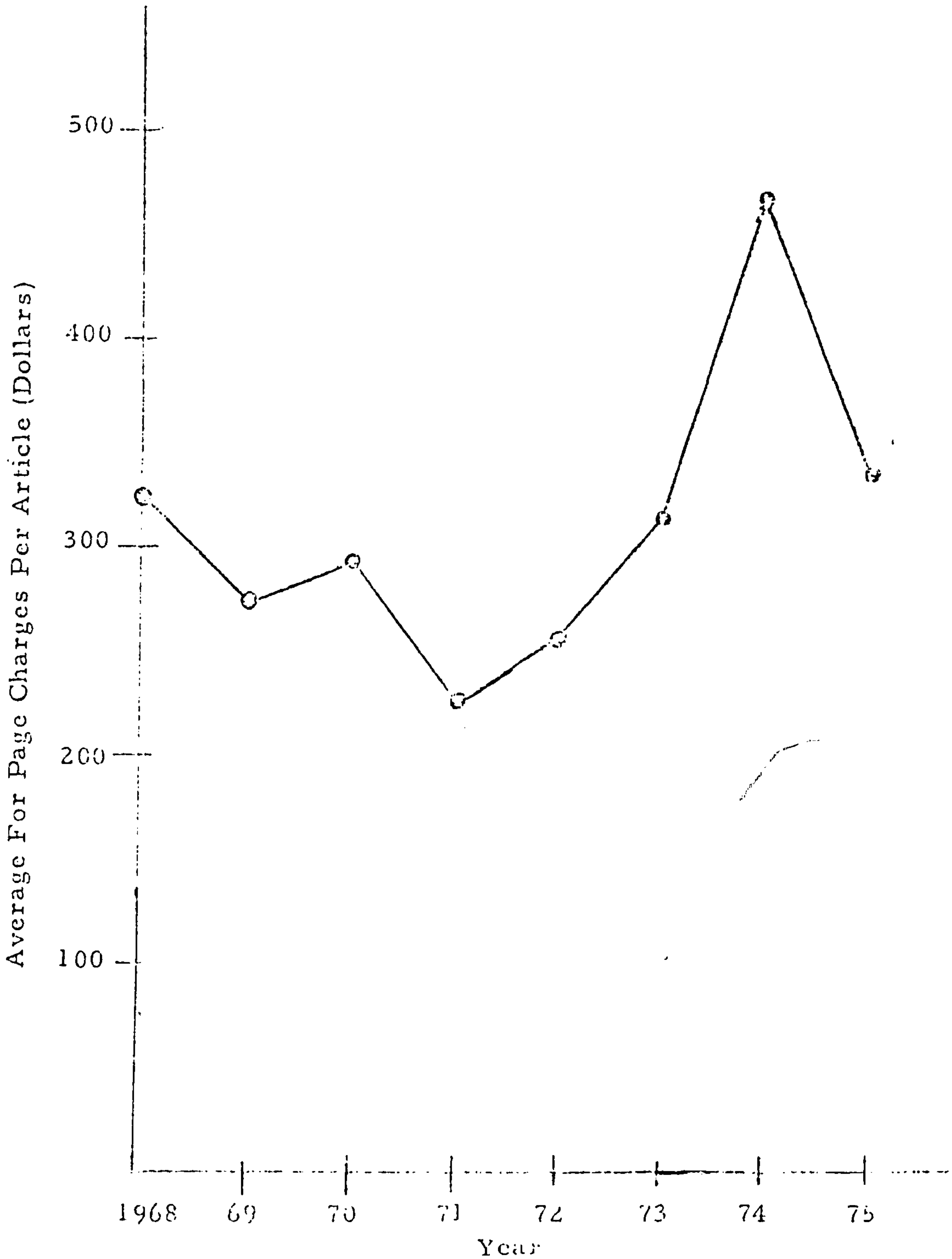
Item	1968	1969	1970	1971	1972	1973	1974	1975
Percent of authors who pay page charges	17.6	15.0	13.1	19.3	36.7	20.3	27.9	29.7
Percent of authors who don't pay page charges	57.5	63.1	61.3	66.8	52.9	65.3	66.2	64.3
Percent non-respondents to this question	24.9	21.9	25.6	13.8	10.4	14.4	5.9	6.0
Total percent	100.0	100.0	100.0	99.9	100.0	100.0	100.0	100.0
Average page charge per article for paying authors	325	275	293	226	256	311	469	335

SOURCE: Author Survey, Market Facts, Inc., Center for Quantitative Sciences.

Thus in the case of books we multiplied average price times the number of copies sold each year. This figure was then divided by 1.05 to reduce it by the profit margin reported by Publisher's Weekly (18).

For journals, we combined price and volume data for foreign, individual and institutional subscribers. We feel that the total here is conservative since, as we discussed previously, there are other sources of

Figure 3.47 PAGE CHARGES PAID PER ARTICLE: 1968-1975



SOURCE: Table 3.65

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Table 3.66 ESTIMATED TOTAL COST OF REPRODUCTION AND DISTRIBUTION OF SCIENTIFIC & TECHNICAL JOURNALS, BOOKS AND TECHNICAL REPORTS: 1960-1980

(Millions of Dollars)

Year	S&T Scholarly Journals	S&T Journals	S&T Books	S&T Reports	S&T Literature
1960	44.5	88.5	65.8	-	154.3
1961	56.8	113.2	69.6	-	182.8
1962	86.2	171.9	73.5	-	245.4
1963	94.9	189.2	77.3	0.7	267.2
1964	104.4	208.4	86.1	0.8	295.3
1965	113.8	227.4	90.7	2.0	320.1
1966	124.7	249.6	104.4	2.3	356.3
1967	147.0	294.1	118.4	4.0	416.5
1968	170.7	342.1	128.4	3.8	474.3
1969	199.7	400.3	142.5	4.9	547.7
1970	228.8	460.0	150.8	4.7	615.5
1971	254.5	512.3	166.4	5.5	684.2
1972	284.7	573.9	179.8	8.3	762.0
1973	322.3	650.8	189.7	11.9	851.4
1974	356.4	720.4	200.0	12.4	932.8
PROJECTIONS					
1975	366.1	741.1	205.6	13.3	960.0
1976	397.2	805.3	215.9	15.9	1,037.1
1977	430.1	873.4	226.3	18.7	1,118.4
1978	464.2	944.2	236.6	20.1	1,200.9
1979	500.4	1,019.5	247.0	22.5	1,289.0
1980	537.6	1,097.0	257.2	24.9	1,379.1
PERCENT CHANGE					
1960-65	156	157	38	-	108
1965-70	101	102	66	135	92
1970-75	60	61	36	183	56
1975-80	47	48	25	87	44

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

income to journal publishers which help to cover reproduction and distribution expenses.

Technical report costs are shown back to 1963 only since that was the first year for which the data were reported to us. Figures shown are only for NTIS and GPO, and should not be taken to reflect the total trend in report costs.

3.7 Numeric Data Files

Throughout this study we have been concerned almost exclusively with the communication of "information" in various "packages". These packages may be journal articles, books, technical reports, conferences, bibliographies, reviews, and so on. The package itself may be recorded in one or more of several forms; print on paper, microfilmed, computer generated, or even in the case of face-to-face transfer of an information package, not recorded at all. In any event, scientific and technical communication has been addressed in terms of package transfer mechanisms.

3.7.1 Numeric Data Bases

Numeric data bases require a somewhat different approach which created immediate problems when we attempted to fit them into the cycle of information transfer functions. Computerization of quantitative data has implications quite different from the computerization of bibliographic references. In theory, each "data file" could be considered as an information package, not unlike textual packages and treated similarly in terms of generation, distribution, presentation, and so on. However, this limited approach ignores the distinguishing features of direct access to individual factual data elements as well as the capability for computational manipulation. The data elements contained in such a numeric file are available to the scientific and technical community in a way which is functionally different from data contained in most textual information packages.

During 1975, as part of the first year's effort in developing statistical indicators, we sought to identify, within the framework of the seven functions of the information transfer cycle, measures of growth for numeric data systems. It was originally felt that growth could be measured in terms of numbers of agencies creating and/or maintaining numberic systems, volumes of data elements contained (file sizes), numbers of users with direct access, number of publications generated in the form of tabulations rather than text, annual costs and so forth.

With the possible exception of dollars expended annually, we found no satisfactory measures which could be applied to numeric data systems as a single group. Even the dollar measure was suspect due to large developmental and start-up costs as well as the inadvisability of compa g total cost to number of users, file size, and so on. These conclusions were a direct result of meetings with staff members from the National Oceanic and Atmospheric Administration (NOAA), Environmental Data System, the National Standard Reference Data System (NSRDS) of National Bureau of Standards (NBS) and the U. S. Bureau of the Census. The consensus was that all three were typical of a different class of numeric system and an alternate framework would need to be designed in order to develop statistical indicators for numeric systems.

The three distinct classes of numerical data systems are: (1) those collecting and analyzing social characteristics, the prime example of which exists in the U. S. Bureau of the Census; (2) those collecting and analyzing physical values, typified by the data bases in SRDS and (3) those monitoring (usually automatically) natural phenomena, such as the environmental systems of NOAA and NASA's satellite-recorded data. Such measures as the number of data systems in existence over time appear to have relevance largely within classes. Even more dramatically, the size, especially if measured as file size, is only relevent within class and results might be misleading if averaged across classes. For example, file sizes in NSRDS are dwarfed by those of NASA and NOAA, however they are of critical importance to a wide range of physical scientists and engineers. In 1974, UNESCO-UNISIST published a "Study on the Problems of Accessibility and Dissemination of Data for Science and Technology" (143). The study placed considerable emphasis on the need to identify categories of numerical data files. The matrix developed in that study provides the best basis we have found for grouping numerical data systems by characteristic. In all cases, the seven functions of the communications cycle (including, as is the case for textual scientific and technical information, the bypassing of some functions in some sequences) can be identified. The order of occurrence, however, may vary from those for the textual data cycle.

As with textual information, there are secondary services and products which feed on numerical data bases. These may include such services as access through commercial computer networks and the production of directories of data bases.

Computeriza ion itself has considerably altered the utility of these resources. The prime differences are the quantity of data elements which can be accumulated and manipulated; the ability to update and correct file contents as well as to manipulate them mathematically or statistically. Nonetheless, the first two classes of census and physical value data especially, have a long history. Physical value data have appeared in handbooks for centuries, and censuses were known in antiquity.

Computerization of numerical data also affects the access to it. In measuring specific functions, for example, presentation to user, we feel that the grouping of systems into classes is necessary, and in addition a cross-classification i-entifying the magnitude of the potential "audience" appears to be required. The number of users (and the growth in the number of users) of a numerical data file dealing with a narrow sub-specialty may be expected to be small and to remain small, while at the same time effectively reaching almost 100 percent of the potential users. It would not be valid to compare the magnitude of the presentation function of systems of this type with the measures for the presentation function of, say, the decennial census and all the census byproducts.

Further investigation may well identify systems which do not fit into any of the three categories and additional classes may have to be added or an alternative set of definitions created. No classification scheme will be perfect, b : the greatest problem is that a set of definitions developed to apply to today's systems will be obsolete before trend data can be applied. Harold Sackman notes:

> Today's laboriously reasoned and carefully checked classification scheme may well become obsolete tomorrow. Perhaps the greatest obstacle in the path of successful classification is the refusal to face up to the complexity of the task . . . . Exploratory empirical induction is one of the first steps, based on a continuing census of computer-based systems, periodically updated to keep up with significant changes (133).

These words are as true today as ever.

Another problem in dealing with the changes in the field of numerical data systems is the necessity of recognizing and identifying the interrelationships with the technologies of telecommunications networks, computer storage access and software capabilities.

Any consideration of numeric data files inescapably leads to Information Analysis Centers, for it is in these centers that many of the numeric data files originate and are maintained.

3.7.2 Information Analysis and Data Centers

Although formally established barely two decades ago, the Information Analysis Center (IAC) plays an increasingly important role in the information transfer chain.

By its very nature, experimental research is a fragmented activity: the scientist's attention is focused on the immediate task and he carries out an experiment (which may involve a measurement, a preparation, demonstration of a principle, etc.) without being concerned how the results may fit into the overall structure of the field or neighboring disciplines. Evaluation of these scattered results is the duty of the scientist at the next echelon, the theoretician who molds the data into a form which yields a new theory or a generally valid law of nature. By this definition, a theoretical physicist is basically functioning as an information center. As an example, the Nuclear Data Project has been responsible for laying the foundations of the nuclear shell model. The structure of the nucleus became obvious, once the scientists stopped looking at individual features and considered the whole picture.

Modern tools, such as satellites coupled with electronic data processing techniques, make it possible to collect a tremendous volume of numerical data; at times it becomes necessary to slow down the collection because we are running out of space to record them properly and to evaluate the flood of data (satellites operating continuously would use up in a few days all the film that we can produce in a year). At times, the data are so voluminous that the theoreticians do not have a chance to handle them and to evaluate them properly; this is an added argument to secure them for later use.

Thus, in addition to an examination of the formally established data analysis centers, the number of theoreticians could be used as an indicator of the growth of the scientific field in question. If sponsoring agencies, historians of science, research directors, etc. want to be able to follow the progress of a chosen area, the increase in the number of centers, theoreticians and review article authors should be an excellent indicator of the vitality of the field.

Four kinds of data centers can be identified, not all of which provide data analysis services:

1. An extension of the Special Library concept. Indexed and/or abstracted collection. Products are bibliographies which may include annotation.

2. Document collection centers where documents undergo critical review for content regarding reliability and validity of data. Products are review publications which include critical reviews of methodologies and state-of-the-art.

3. Numerical data collections with associated critical review and analysis.

4. Data collection files, unreviewed, but available to the public. Observational, monitoring data are prime examples. May produce tabulations, but basically no analysis of data.

"Data centers" differ from IAC's in that they generate solely numeric data (physics predominates), while IAC's generally add textual discussion and journal publication is the primary output. The distinguishing feature of the

IAC is that the output is different from the input, in that critical analysis, verification, etc. has been performed. This feature distinguishes them from bibliographic or library reference systems -- no matter how deep the indexing or how detailed the data items that are available via such services. Part of the IAC concept is that information generated by research must be made known to colleagues before research is considered completed. Thus, the cost of IAC's could be categorized as would page charges.

Multipurpose laboratories are good host locations for IAC's. Although most IAC's are supported by information scientists, they preferably should not be in libraries and thus too far removed from the research source. There is the potential in the future that researchers in the same discipline could send results directly to an IAC rather than into the open journal literature. The review function would then be performed along with critical evaluation of research methodology, reliability of results and relationships to similar research performed by the IAC.

There are three levels of data availability: raw data; adjusted data (which may also include some comparative analysis); and filtered, critically evaluated data. The observational data only has value until natural laws are established. Measurement data is data from a controlled (laboratory) situation.

Numbers of requests may be a valid measure in request-oriented systems. However, some centers are organized to pursue orderly progress through a series of subjects (the periodic table, for example) and do not encourage requests.

SECTION 4

THE ACQUISITION AND STORAGE OF INFORMATION

4.1 Introduction

The acquisition and storage function includes both the maintenance of personal collections by individual scientists and engineers and the more formal development of collections of scientific and technical literature by libraries and other information centers. While personal collections are important sources of information for those who maintain them, their public availability and thus their potential influence, is limited. Of much greater importance from the point of view of information flow is the acquisition and storage of bibliographic materials by institutions, particularly libraries. These collections are organized so that materials can be retrieved by a wide community of users. They also provide a permanent archive of scientific achievement.

The importance of libraries as a source of scientific and technical information has been illustrated by the results of our author survey. When asked to indicate the source of access of articles which they cited, 50 percent of the respondents identified libraries.

As with the acquisition and storage function, libraries and other information centers also play a key role in the subsequent functions of organization and control and presentation. Basic to the discussion of each of these functions is an understanding of the nature of libraries, and so this section begins with some introductory data on the various types of U. S. libraries.

4.2 Library Background Information

4.2.1 Types of Libraries

Libraries are generally classified as academic, public, or special according to the primary clientele they serve. In general, academic and special libraries play a more significant role in the dissemination of scientific and technical information than do public libraries. Two groups of libraries which fit into more than one of the three classifications and serve as important sources of STI are research libraries and Federal libraries.

Research libraries, as represented by the membership of the Association of Research Libraries (ARL) in the discussions which follow, build and maintain extensive collections of research literature. They preserve the record of the achievements of science and technology as reflected in the published literature. It is these libraries that assume the major responsibility for ensuring that research materials are available to scientists and other scholars when they are needed. Without the existence of such libraries the progress of scientific investigation would be considerably impeded. The scientist would have no obvious source to go to for a record of the scientific achievements of the past or for a wide selection of the scientific materials that are currently being produced in published form. The existence in the United States of many large and important research libraries tends to ensure that any scientific document of value is available, will continue to be available, and that serious gaps in coverage (and hence availability) are not allowed to occur.

The Federal libraries include a number of specialized libraries. Of the 2,313 Federal libraries identified in 1972, 43 percent were classified as special or technical. Among these were the three national libraries -- the Library of Congress, the National Library of Medicine, and the National Agricultural Library -- each of which provides extensive informational services to both individual scientists and to other libraries.

Closely related to libraries, information centers also play a role in the scientific and technical communication process. Like special libraries, information centers are characterized by limited subject areas; in addition, the term information center implies a greater depth of analysis and control and frequently more advanced services such as evaluation and synthesis of material (43). Information centers may also include raw data among the materials held.

The concept of an information center is sometimes more broadly interpreted to encompass any unit involved in the storage, manipulation or provision of information. This would include information analysis centers, data banks and the like. Our use of the term information center is restricted to the narrower definition previously specified, and other information service organizations are discussed under the specific function they serve.

4.2.2 Sources of Library Data

Data on libraries and information centers are available from a number of sources, the most wide-ranging of which is the Library Surveys Branch of the National Center for Educational Statistics (NCES) of the Office of Education. The Office of Education has collected and published library statistics with some regularity since the 1870's, and work currently in process involves public, school, academic, and special (Federal) libraries as well as library manpower. Under development is the Library General Information Survey (LIBGIS) program, a national library statistics program whose purpose is to develop a national library statistics data system. Such a system would provide consistent and comprehensive data on all libraries.

Other important sources of library data, all annual, are the American Library Directory (3), the Academic Library Statistics (8), prepared by the Association of Research Libraries (ARL), and The Past and Likely Future of 58 Research Libraries (46) prepared by Purdue University. The Academic Library Statistics covers all member libraries of ARL; the Purdue compilations presents data for a subset of 58 of these institutions. The Bowker Annual (18) contains summary reports and data compilations from several of these sources.

4.2.3 Number of Libraries

Table 4.1 presents the number of various types of libraries in the U. S., each of which participates to some extent in the collection and dissemination of scientific and technical information. As shown, the total number of libraries has increased 30 percent in the last ten year period, with academic and public libraries increasing 24 percent each and special libraries 40 percent. According to these figures from the American Library Directory, the number of academic libraries peaked around 1970 and has been decreasing since that time. Comparable NCES data on academic libraries, however, shows a more steady increase from 2,175 in 1964 to 2,900 in 1975, a gain of 33 percent.

Year	Academic[1] Libraries[4]	Special[2] Libraries[4]	Public Libraries[3]	Total	ARL[4] Libraries	Federal[5] S&T Libraries
1960	2,031	3,972	7,204	13,207	49	-
1961	2,028	4,317	6,487	12,832	49	-
1962	2,024	4,662	5,770	12,456	49	-
1963	2,094	5,020	5,998	13,112	72	-
1964	2,163	5,377	6,626	14,166	74	-
1965	2,416	5,542	6,952	14,910	64	508
1966	2,668	5,706	7,278	15,652	64	-
1967	2,781	5,938	7,346	16,065	70	-
1968	2,894	6,169	7,415	16,478	71	-
1969	2,931	6,419	7,543	16,893	76	-
1970	2,968	6,669	7,671	17,308	76	-
1971	2,846	6,765	7,613	17,224	78	-
1972	2,723	6,861	7,555	17,139	78	995
1973	2,705	7,198	7,870	17,773	81	-
1974	2,686	7,536	8,185	18,407	82	-
			PERCENT CHANGE			
1960-65 . .	19	40	-3	13	31	-
1965-70 . .	23	20	10	16	19	-
1964-74 . .	24	40	24	30	11	-

[1] University, College and Junior College Libraries.

[2] Special, Law, Medical and Religious Libraries.

SOURCE: [3] The Bowker Annual of Library and Book Trade Information, R.R. Bowker Company, 1961-1975.

[4] Association o rch Libraries, American Library Statistics, 1960-1972.

[5] National C r for Educational Statistics, Survey of Federal Libraries, 1972.

The ARL libraries are included in the academic library figures but are also shown separately. Growth in ARL membership was 11 percent over the 1964-1974 period. Growth in Federal scientific and technical libraries has been significant, with the number of such libraries almost doubling between 1965 and 1972.

4.2.4 Library Expenditures

In addition to the number of libraries, another reflection of the extent of library services provided is total expenditures. These are shown in Tables 4.2 and 4.3 for various groups of libraries. No figures are available for all special libraries, so data for a subset of these, i.e., Federal S&T library activities, is presented. From the tables we see that expenditures rose 229, 155 and 219 percent respectively in academic, public and Federal scientific and technical libraries in the 1964-1974 period. Constant dollar expenditures by the same groups rose 111, 63, and 104 percent. Percentage increases for 1969 to 1973 are somewhat greater for academic libraries than indicated by the Indiana study (48) (45% versus 21 to 40% for three strata). Public library data compares favorably (48% versus 47 to 53% for three strata).

Stepwise multiple regression was utilized to project expenditures for the different types of libraries. In general, the best predictor was found to be publishing revenues, with enrollments also incorporated in the determination of academic library expenditures. Projections show 28 to 40 percent increases in expenditures over the 1975 to 1980 period, suggesting that the decreasing trend in the rate of growth of expenditures observed since the mid 1960's will continue.

In order to construct a total expenditure figure for scientific and technical library activities, it is necessary to determine, for each library type, what part of the total expenditures are devoted to S&T. The chief factors in this determination would be the percentage of material expenditures for S&T and the percentage of service expenditures (circulation, reference, inter-library loan) for S&T. These figures are not widely available, but consideration of a number of partial indicators, mainly for individual libraries, suggests that around 50 percent of academic library expenditures and 10 percent

(Millions of Dollars)

Year	Academic[1] Libraries	Public[1,2] Libraries	Federal[3] S&T Libraries	Total[4] S&T Libraries	58[5] Research Libraries
1960 . . .	159	397	27[e]	146	55
1961 . . .	184	415	32[e]	166	62
1962 . . .	213	443	37[e]	188	69.
1963 . . .	247	470	43[e]	214	77
1964 . . .	276	517	48[e]	238	87
1965 . . .	320	554	53	268	101
1966 . . .	366	600	64[e]	307	113
1967 . . .	416	692	76[e]	353	134
1968 . . .	510	766	88[e]	420	150
1969 . . .	585	830	99	475	166
1970 . . .	650	923	103	520	190
1971 . . .	737	1,024	117	588	199
1972 . . .	796	1,079	133	639	205
1973 . . .	850	1,227	136	684	215[e]
1974 . . .	909	1,319	153[e]	739	237[e]
PROJECTIONS*					
1975 . . .	988	1,407	170	804	256
1976 . . .	1,043	1,486	179	849	275
1977 . . .	1,112	1,583	190	904	287
1978 . . .	1,180	1,683	200	958	315
1979 . . .	1,236	1,769	208	1,003	336
1980 . . .	1,303	1,871	218	1,057	358
PERCENT CHANGE					
1960-65 .	101	40	96	84	84
1965-70 .	103	67	94	94	88
1970-75 .	52	52	65	55	35
1975-80 .	32	33	28	31	40
1964-74 .	229	155	219	211	172

[e] Market Facts estimate.

SOURCES:

[1] *The Bowker Annual of Library and Book Trade Information*, R.R. Bowker Company, 1971, 1974, 1975.

[2] Goldhor, Herbert, "The Indices of American Public Library Statistics," April 1975 (unpublished paper).

[3] Vlannes, P.N., et.al., Report of the Ad Hoc Group: *"Federal Agency Obligations for Management, Processing and Transfer of Scientific and Technical Information, Data, and Technology*, Fiscal Years 1969-1973, Vol. III.

[4] Market Facts, Inc., Center for Quantitative Sciences.

[5] Dunn, Oliver C., et.al., *The Past and Likely Future of 58 Research Libraries, 1951-1980: A Statistical Study of Growth and Change*, 1970-71 edition.

Table 4.3 TOTAL EXPENDITURES FOR ACADEMIC, PUBLIC AND FEDERAL SCIENTIFIC AND TECHNICAL LIBRARIES: 1960-1980

(Millions of Constant 1967 Dollars)*

Year	Academic Libraries	Public Libraries	Federal S&T Libraries	Total S&T Libraries	58 Research Libraries
1960 . . .	181	452	31	166	63
1961 . . .	207	466	36	187	70
1962 . . .	237	497	41	209	77
1963 . . .	271	516	47	235	84
1964 . . .	298	558	52	257	94
1965 . . .	339	588	56	284	107
1966 . . .	378	619	66	317	117
1967 . . .	416	692	76	353	134
1968 . . .	490	736	85	404	144
1969 . . .	537	761	91	436	152
1970 . . .	565	803	90	452	165
1971 . . .	613	852	97	489	165
1972 . . .	641	868	107	514	165
1973 . . .	648	935	104	521	164
1974 . . .	628	912	106	511	164
PROJECTIONS					
1975 . . .	625	890	108	509	162
1976 . . .	618	881	106	503	163
1977 . . .	617	879	105	502	159
1978 . . .	613	874	104	498	164
1979 . . .	603	863	102	490	164
1980 . . .	598	858	100	485	164
PERCENT CHANGE					
1960-65 .	87	30	81	71	70
1965-70 .	67	37	61	59	54
1970-75 .	11	11	20	13	-2
1975-80 .	-4	-4	-7	-5	1
1964-74 .	111	63	104	99	74

*Using GNP Implicit price deflator (1975-1980 NPA).

SOURCE: [illegible], Inc., Center for Quantitative Sciences. Based on Table 4.2.

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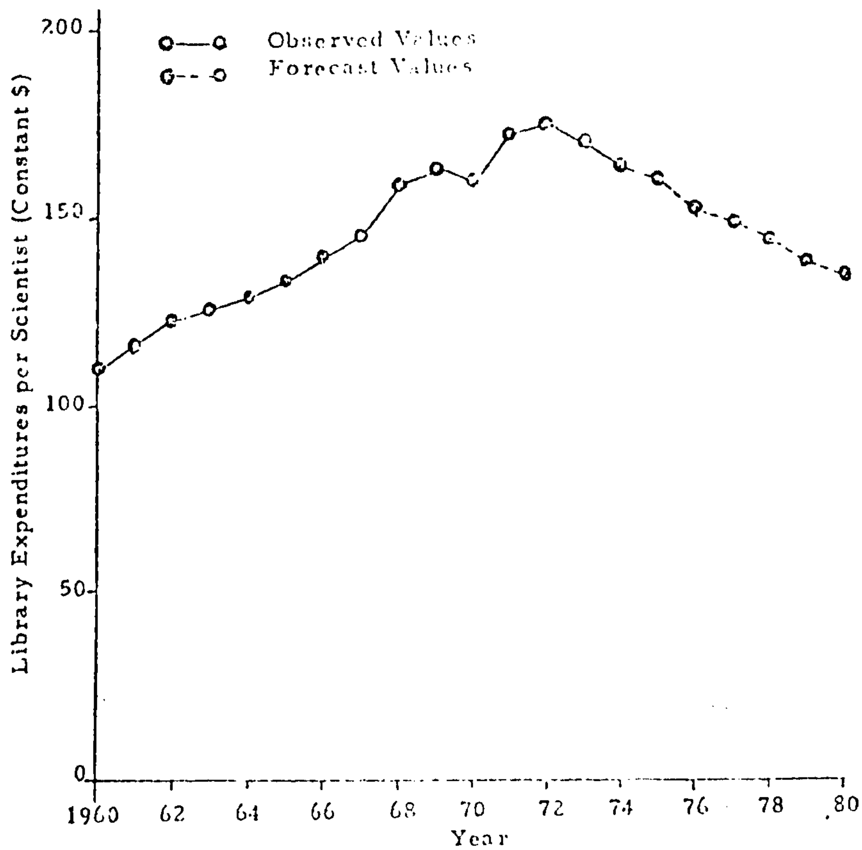
of public library expenditures are related to scientific and technical information. Adding these figures to the total expenditures for Federal S&T libraries yields the total expenditures shown in Tables 4.2 and 4.3. Again it should be noted that these figures exclude non-Federal special libraries and thus underestimate total expenditures, perhaps by as much as 20 percent.

As shown, total expenditure figures rose from $238 million in 1964 to $739 million in 1974, an increase of 211 percent. In constant dollar terms, the increase over the same period was 99 percent. Projections are based on the number of scientists and engineers as shown in Figure 4.1 (r^2 = .98). They indicate that S&T library expenditures should rise to $1,057 million in current dollars and $485 million in constant dollars by 1980.

Figure 4.1 TOTAL SCIENTIFIC AND TECHNICAL LIBRARY EXPENDITURES PER SCIENTIST - 1967 CONSTANT DOLLARS: 1960-1980



SOURCE: Table 4.4.

A data item of some interest is the average library expenditure per individual scientist. Since a major portion of library expenditures are for academic libraries, S&T graduate students as well as scientists are included in the estimates of scientific manpower. Average library expenditure per scientist using constant dollar expenditures from Table 4.3 and manpower estimates from Tables 2.5 and 2.26 are shown in Table 4.4 and Figure 4.2. The expenditure per scientist ranges from $110 in 1960 to $175 in 1972 and then remains fairly constant. The increase between 1964 and 1974 was only 28 percent, in contrast with the 99 percent increase in total constant dollar expenditures.

4.2.5 Library Holdings

Yet another indication of library services available to the scientific and technical community is the number of volumes held by libraries. Academic library holdings are shown in Table 4.5, and indicate a 90 percent growth between 1964 and 1974. Using these figures and the S&T materials budgets of other types of libraries, an approximation of the number of library volumes available per scientist (including graduate students) can be made. We estimate that this value has grown from 83 volumes in 1964 to 101 in 1974, an increase of 22 percent. Compared with a growth of 63 percent in books published and 22 percent in journals published over the same period, the scientist's access to the literature would appear to have decreased. This factor may be counterbalanced by increased access to materials via library networking.

4.2.6 Library Networks

Like other organizations involved in the communication of scientific and technical information, libraries in recent years have been faced with substantial increases in costs, volume of materials available and demand for their services. Library budgets have not been adequate to deal with these increases, and a variety of measures have been applied in attempts to close the resulting gap, i.e., to provide increased services at available budget levels. Chief among the measures taken have been the automation of technical processing and other functions and the formation of resource sharing networks. When successful, these efforts can result in lower unit service costs and increased quality of services.

Automation programs have been developed in the areas of materials acquisition, cataloging and card production, circulation, reference, and a

Table 4.4 TOTAL SCIENTIFIC AND TECHNICAL LIBRARY EXPENDITURES PER SCIENTIST: 1960-1980

Year	Total S&T Library Expenditures[1] (Constant $)* [Millions]	Number of Scientists and Science Graduate Students[2] (000)	Expenditure per Scientist[3] (Constant $)*
1960 . . .	166	1,515	110
1961 . . .	187	1,596	117
1962 . . .	209	1,694	123
1963 . . .	235	1,867	126
1964 . . .	257	2,004	128
1965 . . .	284	2,139	133
1966 . . .	317	2,269	140
1967 . . .	353	2,427	145
1968 . . .	404	2,534	159
1969 . . .	436	2,680	163
1970 . . .	452	2,828	160
1971 . . .	489	2,846	172
1972 . . .	514	2,937	175
1973 . . .	521	3,046	171
1974 . . .	511	[illegible]14	164
PROJECTIONS			
1975 . . .	560	3,189	165
1976 . . .	585	3,280	164
1977 . . .	611	3,370	164
1978 . . .	637	3,454	163
1979 . . .	665	3,530	164
1980 . . .	692	3,608	164
PERCENT CHANGE			
1960-65 .	71	41	21
1965-70 .	59	32	20
1970-75 .	24	13	3
1975-80 .	24	13	-1
1964-74 .	99	55	28

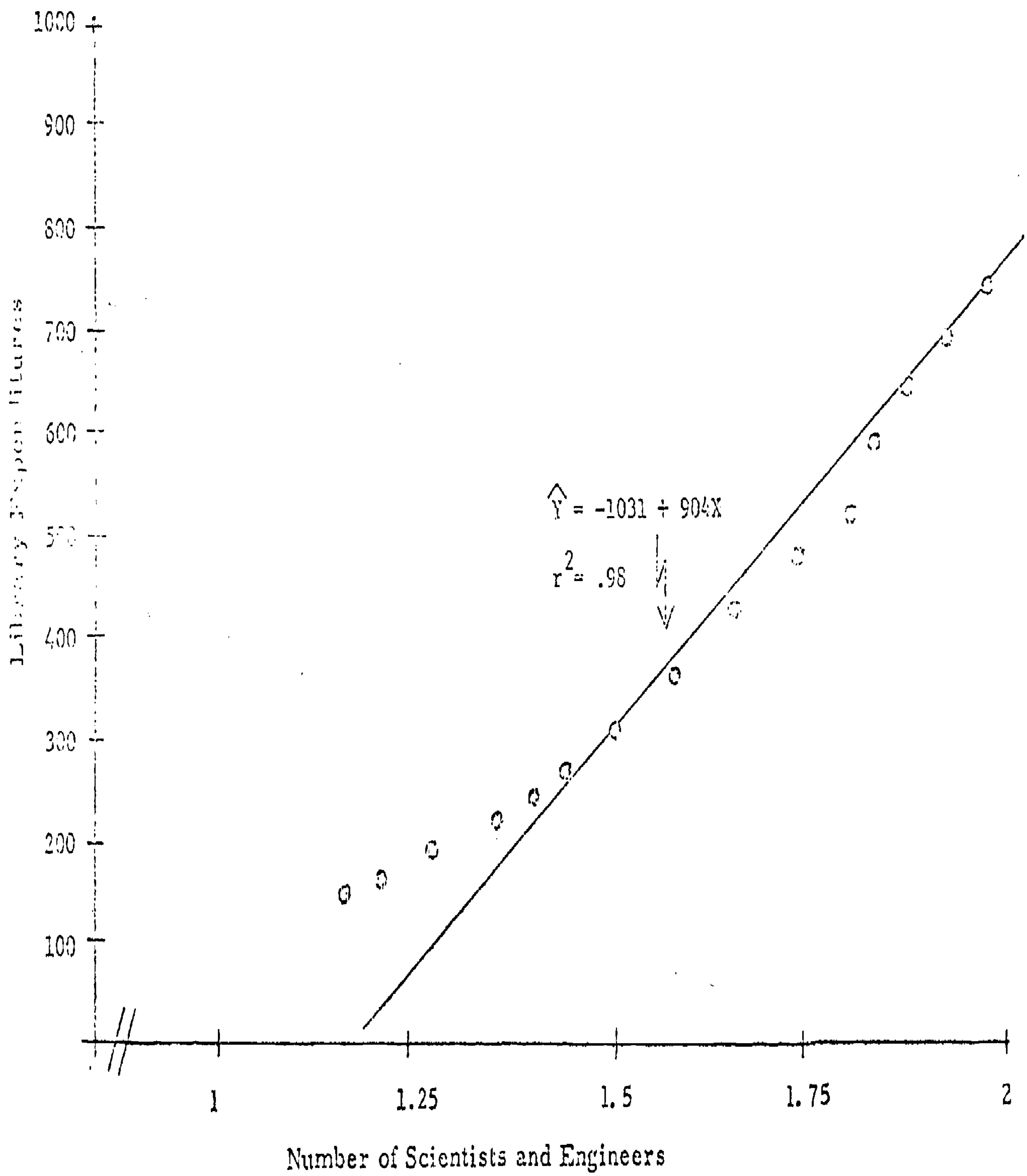
* Using GNP implicit price deflator (1975-1980 NPA) to obtain 1967 Constant Dollars.

SOURCE: [1] Taken from Table 4.3

[2] Taken from Table 2.26 and 2.5.

[3] Market Facts, Inc., Center for Quantitative Sciences.

Figure 4.2 SCIENTIFIC AND TECHNICAL LIBRARY EXPENDITURES AS A FUNCTION OF THE NUMBER OF SCIENTISTS AND ENGINEERS IN CONSTANT DOLLARS: 1960-1980



SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Table 4.5 ACADEMIC LIBRARY HOLDINGS: 1960-1974

(Millions)

Year	Academic Library Holdings [1]	58 Research Library Holdings [2]
1960 . . .	189	73
1961 . . .	201	76
1962 . . .	215	81
1963 . . .	227	84
1964 . . .	240	86
1965 . . .	265	91
1966 . . .	283	96
1967 . . .	295	101
1968 . . .	305	114
1969 . . .	329	110
1970 . . .	354	116
1971 . . .	380	121
1972 . . .	405	132 [e]
1973 . . .	430	139 [e]
1974 . . .	455	145 [e]
	PERCENT CHANGE	
1960-65 .	40	25
1965-70 .	34	27
1964-74 .	90	69

[e] Market Facts, Inc., Center for Quantitative Sciences.

SOURCE: [1] The Bowker Annual of Library and Book Trade Information, R.R. Bowker Company, 1971 and 1975.

[2] Dunn, Oliver C., et.al., The Past and Likely Future of 58 Research Libraries, 1951-1980: A Statistical Study of Growth and Change, 1970-71 edition.

number of managerial functions. Perhaps the greatest impact has been felt as a result of shared cataloging systems like the Ohio College Library Center, with which participating libraries can retrieve cataloging data produced by the Library of Congress or another library, modify it as necessary, and automatically produce tailor-made catalog cards. Such systems eliminate much previous duplication of effort, and the data base generated can serve a number of additional functions. Cooperative cataloging efforts will be further discussed in Section 5, Organization and Control.

Library networks or consortia have been in existence almost as long as libraries but have grown considerably in number in recent years. Such cooperatives may be formed to share materials, equipment, personnel, or services, but most often are concerned with the inter-library loan of materials or the shared use of automated systems. Networks are thus further discussed under Section 6.1.2, Interlibrary Loan, and Section 5.1, Library Cataloging.

4.3 Library Acquisitions

4.3.1 Acquisitions and Expenditure Data

Returning to the acquisition and storage function, Tables 4.6 and 4.7 present the materials expenditures for various types of libraries in current and constant dollars. As shown, total S&T materials expenditures increased 233 percent between 1964 and 1974, compared with an increase of 211 percent for total expenditures. Projections indicate that materials expenditures will rise to $289 million in current dollars and $132 million in constant dollars by 1980. In constant dollar terms, this amounts to a five percent decrease over the 1975 - 1980 period.

Volumes added to academic libraries and the 58 large research libraries are shown in Table 4.8. Considering the 58 percent academic research libraries, we saw in Table 4.5 that they have grown in size approximately 49 percent over the period 1962 - 1972, an average annual growth of slightly over four percent a year. Table 4.8 shows, however, that the percentage change in rate of acquisition (number of volumes added per year) is quite erratic over the period and in some years reached negative values. The

Table 4.6 MATERIAL EXPENDITURES FOR ACADEMIC, PUBLIC AND FEDERAL SCIENTIFIC AND TECHNICAL LIBRARIES: 1960-1980

Year	Academic Libraries[1]	Public Libraries[2]	Federal S&T Libraries[3]	Total S&T Material Expenditures[4]	58 Research Libraries[5]
1960 . . .	48	64	6	36	17.9
1961 . . .	56	66	7	41	20.6
1962 . . .	65	71	8	48	23.1
1963 . . .	81	71	10	58	26.0
1964 . . .	90	72	11	63	30.0
1965 . . .	111	72	12	75	36.3
1966 . . .	134	90	15	91	39.0
1967 . . .	156	104	17	105	47.9
1968 . . .	188	115	20	126	53.3
1969 . . .	213	141	23	144	57.8
1970 . . .	230	175	24	156	66.9
1971 . . .	247	184	27	169	67.3
1972 . . .	260	205	31	182	64.8
1973 . . .	283	209	31	193	66.7
1974 . . .	306	224	35	210	75.9
PROJECTIONS*					
1975 . . .	314	247	38	220	74.7
1976 . . .	331	265	41	233	79.6
1977 . . .	349	285	43	247	86.6
1978 . . .	368	307	47	261	93.0
1979 . . .	386	329	49	275	99.6
1980 . . .	404	352	52	289	106.5
PERCENT CHANGE					
1960-65 .	131	12	100	108	103
1965-70 .	107	143	100	108	84
1970-75 .	37	41	58	41	12
1975-80 .	29	43	37	31	43
1964-74 .	240	211	218	233	153

* Market Facts, Inc., Center for Quantitative Sciences.

SOURCES:

1. The Bowker Annual of Library and Book Trade Information, R.R. Bowker Company, 1971, 1974, 1975.
2. Goldhor, Herbert, "The Indices of American Public Library Statistics." April 1975 (unpublished paper).
3. Vlannes, P.N., et.al.; Report of the AD Hoc Group: Federal Agency Obligations for Management, Processing and Transfer of Scientific and Technical Information, Data, and Technology, Fiscal Years 1969-1973. Vol. III.
4. Market Facts, Inc., Center for Quantitative Sciences.
5. Dunn, Oliver C. et.al., The Past and Likely Future of 58 Research Libraries, 1951-1980: A Statistical Study of Growth and Change. 1970-71 edition.

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Table 4.7 MATERIAL EXPENDITURES FOR ACADEMIC, PUBLIC, AND FEDERAL SCIENTIFIC AND TECHNICAL LIBRARIES: 1960-1980

(Millions of Constant 1967 Dollars)*

Year	Academic Libraries	Public Libraries	Federal S&T Libraries	Total S&T Material Expenditures	58 Research Libraries
1960 . . .	55	73	7	41	20
1961 . . .	63	74	8	46	23
1962 . . .	72	80	9	53	26
1963 . . .	89	78	11	64	29
1964 . . .	97	78	12	68	32
1965 . . .	118	76	13	80	39
1966 . . .	138	93	15	94	40
1967 . . .	156	104	17	105	48
1968 . . .	181	111	19	121	51
1969 . . .	195	129	21	132	53
1970 . . .	200	152	21	136	58
1971 . . .	205	153	22	141	56
1972 . . .	209	165	25	146	52
1973 . . .	216	159	24	147	51
1974 . . .	212	155	24	145	52
PROJECTIONS					
1975 . . .	199	156	24	139	47
1976 . . .	196	157	24	138	47
1977 . . .	194	158	24	137	48
1978 . . .	191	159	24	136	48
1979 . . .	188	161	24	134	49
1980 . . .	185	161	24	132	49
PERCENT CHANGE					
1960-65 .	115	4	86	95	95
1965-70 .	69	100	62	70	49
1970-75 .	0	3	14	2	-19
1975-80 .	-7	3	0	-5	4
1964-74 .	119	99	100	113	63

* Using GNP implicit price deflator (1975-1980 NPA).

SOURCE: Market Facts, Inc., Center for Quantitative Sciences. Based on Table 4.6.

Table 4.8 VOLUMES ADDED TO ACADEMIC LIBRARIES: 1960-1974

(Thousands)

Year	Academic Libraries Volumes Added (000)	Percent Change	58 Research Libraries Volumes Added (000)	Percent Change
1960	9,400	-	2,843	-
1961	10,900	16	3,045	7
1962	12,300	13	3,369	11
1963	13,600	11	3,845	14
1964	15,000	10	4,054	5
1965	18,000	20	4,522	12
1966	20,000	11	4,992	10
1967	22,000	10	5,430	9
1968	25,000	14	6,420	18
1969	26,000	4	5,872	-9
1970	26,000	0	6,207	6
1971	25,000	-4	6,193	0
1972	25,000	0	6,800	10
1973	25,000	0	7,200[e]	6
1974	25,000	0	7,500[e]	4

[e] Market Facts, Inc., Center for Quantitative Sciences.

SOURCE: [1] The Bowker Annual of Library and Book Trade Information, R.R. Bowker Company, 1971 and 1975.

[2] Dunn, Oliver C. et.al., The Past and Likely Future of 58 Research Libraries, 1951-1980: A Statistical Study of Growth and Change, 1970-73 edition.

period up to 1968 seems to be one of general expansion, while the years 1968 - 1974 show a much slower rate of growth.

Comparison of library figures for material growth and costs with the figures for publication growth and costs is of considerable interest. Some of these comparisons must, however, be made cautiously. We cannot, for example, directly compare the estimates for number of items published with estimates for growth of libraries since the former figure represents number of titles and the latter number of volumes. There should, however, be a reasonable quantitative correlation between the two. That is, one might reasonably expect that the growth of the great research libraries, in number of volumes, should reasonably parallel the growth in the published literature measured in terms of new items.

One fact worth noting is that, at least in the period 1965 - 1972, the 58 research libraries seem to have grown at approximately the same rate as the published literature, despite individual fluctuations from year to year. Table 3.2 indicates that the number of new book titles and editions published in the United States has been increasing incrementally at an average annual rate of about 5.8 percent. In 1972 there were about 48 percent more new books published in the U.S. than in 1965. But, on the average, the 58 research libraries added 50 percent more volumes in 1972 than they did in 1965. Even allowing for the fact that the publication figure is based only on book titles and that the library figure is based on library volumes (including volumes of periodicals) the two figures are remarkably close and do give some indication that, so far at least, the major academic libraries in the United States have been able to keep up reasonably well with the exponential growth of the published literature. If we accept the UNESCO (145) figures for rate of growth of the world literature, as reflected in Table 3.1, the library rate of growth appears in an even more favorable light because the rate of growth in U.S. book production in the last decade (Table 3.2) has considerably exceeded the world production rate indicated by the UNESCO figures.

Nevertheless, while the data indicate that, over the long haul, the major research libraries have been growing incrementally at about the same rate as some major indicators of publication growth, the figures do have some disquieting aspects. Most of the rate of growth reflected in Table 4.8 applies to an expansionary period from 1965 to 1968, coinciding with a period of general economic upswing in the country. The period 1968 to 1972, however, was a period in which these libraries grew at a very much lower rate, failing in fact to match the rate of growth of the published literature. Thus economic factors seem to be threatening the ability of even the major research libraries to keep pace with the growth of the literature.

A very valuable analysis of the economics of academic libraries in the United States was published in 1973 by Baumol and Marcus. Their report, Economics of Academic Libraries (10), is based on data from the Purdue University collection of data for 58 research libraries and covers the period 1950-51 to 1968-69. Baumol and Marcus point out that the larger, more well established libraries are growing more slowly than the relatively smaller libraries (3.5 percent per annum growth as compared with a 5.4 percent per annum growth), and that all libraries in the group will tend to equalize the size of their collections in time. The difference in size between the largest libraries and the smallest libraries is now being reduced at a rate of about two percent per annum.

An approximate measure of the effect of inflation on acquisitions costs is reflected in the difference between rate of increase in materials expenditures and rate of increase in volumes added. Thus, in 1972 the 58 libraries represented added only 50 percent more volumes than they did in 1965 although their materials budgets were 79 percent greater. Baumol and Marcus show that, from 1950-51 to 1968-69, average library expenditures increased by more than ten percent per annum but inputs to the library (of materials and staff) increased only five to seven percent, the difference being absorbed by rising personnel and materials costs.

By way of comparison with the growth of the large academic libraries, Table 4.9 presents some figures relating to the growth of the Library of Congress. These figures too must be viewed with some caution because the Library of Congress counts "pieces" rather than volumes. The acquisition of the Look pictorial file in 1972, for example, caused a substantial increase in the total holdings as measured in pieces. Discounting this, however, the Library of Congress has been growing at a rather slow pace since 1965, at a

Table 4.9 GROWTH OF THE LIBRARY OF CONGRESS: 1965-1973

Year	Millions of Pieces Added	Percent Change	Titles Added: Science	Medicine	Agriculture	Technology
1965 . . .	53.311	-	7,213	2,412	1,798	8,702
1966 . . .	54.289	1.8	7,144	2,676	1,891	9,135
1967 . . .	55.457	2.2	7,541	2,852	2,095	9,613
1968 . . .	58.463	5.4	8,801	4,165	3,365	12,538
1969 . . .	59.891	2.4	12,483	4,319	4,694	[illegible],084
1970 . . .	62.954	5.1	15,387	5,172	4,883	16,375
1971 . . .	64.465	2.4	14,160	4,804	3,775	19,918
1972 . . .	71.106*	10.3	16,923	5,350	5,881	21,090
1973 . . .	72.467	1.9	14,020	5,243	5,426	16,952

*Acquisition of Look pictorial file.

SOURCE: Annual Report of the Librarian of Congress, Fiscal Years 1965-1973. Figures represent holdings on June 30th of each year.

rate in fact of a little over three percent a year on the average (a growth of about 21 percent from 1965 to 1971). This is slower than the rate of growth of the academic libraries, as indicated in Table 4.8, and may perhaps be regarded as further support of the Baumol and Marcus contention that the smaller research libraries are growing faster than the larger and that there is a tendency for the two groups to converge towards a common size.

Of particular interest in Table 4.9 are the figures relating to titles added in various fields of science. In science, medicine and technology the number of new titles added by the Library of Congress in 1973 was approximately twice the number added in 1965. Average annual increments of growth in science and technology, then, are of the order of ten percent for the period 1965 to 1973, which is substantially greater than the increments of growth of the ARL member libraries in this period, as indicated in Table 4.8. In the field of agriculture the growth rate at the Library of Congress has been even greater, with acquisitions in 1973 at a level three times above the level of acquisitions in 1965.

4.3.2 Types of Materials Acquired

Acquisition figures presented in the previous section include books, periodicals, technical reports and other items. Depending on the type of library, the proportions of the materials budget allotted to each of these categories vary significantly, and these proportions change over time as the nature of available materials and patron demand fluctuates.

Table 4.10 presents the proportion of materials budgets expended on books, serials, and other materials by academic, public, and special libraries. Taken from the Indiana study, results are given for four strata of academic libraries, three of public libraries, and two of special libraries. Overall, the greatest part of the materials budget is spent on books in academic and public libraries (54-81 percent and 80-88 percent respectively) and on serials in special librar-es (63-72 percent). Academic libraries also purchase a large volume of serials (18-46 percent), and the public libraries acquire the only significant proportion of other materials.

Table 4.10 MEDIAN PERCENTAGE OF MATERIALS BUDGET: 1969-1973

(Percent)

Strata	Year	Serials	Books	Other
		ACADEMIC LIBRARIES		
500-1000[1] (n=25)	1969 . . .	17.5	80.6	2.9
	1971 . . .	24.8	67.[illegible]	7.9
	1973	26.0	69.1	4.9
1001-2000 (n=29)	1969 . . .	27.5	70.2	2.3
	1971 . . .	31.0	65.3	3.7
	1973 . . .	34.3	61.8	3.9
2001-5000 (n=52)	1969 . . .	29.1	70.8	0.1
	1971 . . .	34.6	65.3	0.1
	1973 . . .	43.2	56.5	0.4
>5000 (n=73)	1969 . . .	33.1	66.7	0.2
	1971 . . .	39.9	59.8	0.3
	1973 . .	46.1	53.7	0.2
		PUBLIC LIBRARIES		
75K-150K[2] (n=27)	1969 . . .	8.0	87.7	4.3
	1971 . . .	8.5	84.7	6.8
	1973 . . .	9.2	81.2	8.8
150K-300K (n=35)	1969 . . .	9.5	84.5	5.9
	1971 . . .	9.2	84.0	6.8
	1973 . . .	10.3	80.4	9.3
>300 (n=46)	1969 . . .	9.4	85.7	4.9
	1971 . . .	10.1	83.6	6.3
	1973 . . .	11.0	80.4	8.6
		SPECIAL LIBRARIES		
≤50K[3] (n=22)	1969 . . .	65.1	33.5	1.4
	1971 . . .	63.2	36.7	0.1
	1973 . . .	60.5	35.7	3.8
>50K (n=16)	1969 . . .	70.5	29.4	0.1
	1971 . . .	67.3	31.9	0.8
	1973 . . .	72.2	25.7	2.1

[1]Strata based on number of periodicals held.

[2]Strata based on population served.

[3]Strata based on serials budget.

SOURCE: Fry, Bernard M. and Herbert S. White, [illegible] University, [illegible]

Between 1969 and 1973, the proportion of funds expended on serials generally increased, with an accompanying decrease in book expenditures. This reflects greater increases in the volume and costs of serials available than of books. The Indiana study reported that a majority of all libraries have been faced, especially since 1970, with increasing difficulties in maintaining present or adding new subscriptions because of budget pressures. In response to these pressures, a variety of actions have been taken, including adding no or fewer new subscriptions, dropping subscriptions, purchasing microform editions, and reallocating the materials budget. In academic libraries, adding fewer new subscriptions and reallocating the budget to periodicals at the expense of books have been the most common attempts at a solution.

4.3.3 Acquisition and Storage Costs

In addition to the materials expenditures discussed in Section 4.3.1, libraries incur a number of other costs in the process of acquiring and storing materials. Each item (book, serial, volume, etc.) must be selected, ordered, received, processed and stored, and for serials the latter three activities must be repeated for each individual issue. Costs are labor-intensive and have increased substantially over the years.

As an example, the cost of library acquisition and storage of journals was estimated in 1967 by Westat (153) and can be computed for the number of scholarly U. S. journals held by libraries.

Cost elements are subdivided into acquisition of new titles, maintenance of purchased titles and storage as follows:

1. Cost per title of acquiring a purchased title: $62.80
2. Cost per title per year of maintaining a purchased title: $38.30
3. Cost per volume per year of storing a purchased title: $0.203

The units to which these costs are attributed are estimated as follows.

The total number of new scholarly journal titles acquired each year is equivalent to the number of new institutional subscriptions taken. An

Table 4.11 ESTIMATED TOTAL NUMBER OF NEW SCHOLARLY JOURNALS ACQUIRED BY LIBRARIES, LIBRARIAN WAGE RATES, AVERAGE COST OF ACQUIRING NEW JOURNALS AND TOTAL COST OF ACQUIRING NEW JOURNALS: 1961-1980

Year	No. of New Titles Acquired (000)	Deflationary Factor[1]	Average Cost (Current $)	Average Cost (Constant $)[2]	Total Current $ Cost (Millions)	Total Constant $ Cost[2] (Millions)
1961 . . .	208	.75	47.10	52.94	9.8	11.0
1962 . . .	258	.78	48.98	54.45	12.6	14.0
1963 . . .	158	.82	51.50	56.51	8.1	8.9
1964 . . .	161	.86	54.01	58.35	8.7	9.4
1965 . . .	189	.91	57.15	60.62	10.8	11.5
1966 . . .	184	.95	59.66	61.57	11.0	11.4
1967 . . .	262	1.00	62.80	62.80	16.5	16.5
1968 . . .	236	1.05	65.94	63.40	15.6	15.0
1969 . . .	182	1.12	70.34	64.52	12.8	11.7
1970 . . .	119	1.15	74.10	64.43	8.8	7.7
1971 . . .	58	1.21	75.99	63.21	4.4	3.7
1972 . . .	113	1.26	79.13	63.68	8.9	7.2
1973 . . .	80	1.29	81.01	61.73	6.5	5.0
1974 . . .	195	1.36	85.41	59.04	16.7	11.5
PROJECTIONS						
1975 . . .	190	1.43	89.80	56.80	34.6	21.8
1976 . . .	172	1.50	94.20	55.83	16.2	9.6
1977 . . .	173	1.58	99.22	55.09	17.2	9.5
1978 . . .	172	1.66	104.75	54.15	17.9	9.3
1979 . . .	172	1.75	109.90	53.65	18.9	9.2
1980 . . .	173	1.84	115.55	53.01	20.0	9.2

1 Based on Librarians' Salaries.

2 GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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Table 4.12 ESTIMATED TOTAL NUMBER OF SCHOLARLY JOURNALS MAINTAINED, AVERAGE COST OF MAINTAINING JOURNALS AND TOTAL COST OF MAINTAINING JOURNALS: 1960-1980

Year	No. of Titles Maintained (000)	Deflationary Factor[1]	Average Cost (Current $)	Average Cost (Constant $)[2]	Total Current $ Cost (Millions)	Total Constant $ Cost[2] (Millions)
1960 . . .	2,253	.71	14.06	16.01	31.68	36.07
1961 . . .	2,461	.75	14.85	16.69	36.55	41.08
1962 . . .	2,719	.78	15.44	17.16	41.98	46.67
1963 . . .	2,877	.82	16.24	17.82	46.72	51.26
1964 . . .	3,038	.86	17.03	18.40	51.74	55.89
1965 . . .	3,227	.91	18.02	19.11	58.15	61.68
1966 . . .	3,411	.95	18.81	19.41	64.16	66.21
1967 . . .	3,671	1.00	19.80	19.80	72.73	72.73
1968 . . .	3,909	1.05	20.79	19.99	81.27	78.14
1969 . . .	4,091	1.12	22.18	20.34	90.74	83.23
1970 . . .	4,210	1.18	23.36	20.31	98.35	85.51
1971 . . .	4,268	1.21	23.96	19.93	102.26	85.07
1972 . . .	4,381	1.26	24.95	20.08	109.31	87.97
1973 . . .	4,487	1.29	25.54	19.46	114.60	87.33
1974 . . .	4,567	1.36	26.93	18.62	122.99	85.02
PROJECTIONS						
1975 . . .	4,952	1.43	28.31	17.91	140.19	88.68
1976 . . .	5,124	1.50	29.70	17.60	152.18	90.20
1977 . . .	5,297	1.58	31.28	17.37	165.69	91.99
1978 . . .	5,469	1.66	32.86	17.07	179.71	93.34
1979 . . .	5,641	1.75	34.65	16.91	195.46	95.41
1980 . . .	5,814	1.84	36.43	16.71	211.80	97.17

[1] Based on Librarians' salaries.

[2] GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

TABLE 4.13 ESTIMATED TOTAL NUMBER OF SCHOLARLY JOURNALS STORED, AVERAGE COST OF STORAGE AND TOTAL COST OF STORAGE: 1960-1980

Year	Number of Volumes Stored (000)	Deflationary Factor[1]	Average Cost (Current $)	Average Cost (Constant $)[2]	Total Current $ Cost (Millions)	Total Constant[2] $ Cost (Millions)
1960 . . .	33,795	.92	.186	.212	6.3	7.2
1961 . . .	36,915	.93	.188	.211	6.9	7.8
1962 . . .	40,785	.94	.190	.211	7.7	8.6
1963 . . .	43,155	.95	.192	.211	8.3	9.1
1964 . . .	45,570	.96	.195	.211	8.9	9.6
1965 . . .	48,405	.97	.197	.209	9.5	10.1
1966 . . .	51,165	.98	.200	.206	10.2	10.6
1967 . . .	55,005	1.00	.203	.203	11.2	11.2
1968 . . .	58,635	1.02	.207	.199	12.1	11.6
1969 . . .	61,365	1.06	.215	.197	13.3	12.2
1970 . . .	63,1[illegible]5	1.10	.223	.194	14.1	12.3
1971 . . .	64,020	1.15	.231	.194	14.9	12.4
1972 . . .	65,715	1.19	.242	.195	15.9	12.8
1973 . . .	67,305	1.24	.252	.192	17.0	13.0
1974 . . .	68,505	1.28	.260	.180	17.8	12.3
PROJECTIONS						
1975 . . .	74,260	1.30	.264	.167	19.6	12.4
1976 . . .	76,860	1.[illegible]2	.269	.159	20.6	12.2
1977 . . .	79,455	1.35	.274	.152	21.8	12.1
1978 . . .	82,035	1.39	.282	.146	23.1	12.0
1979 . . .	84,615	1.42	.288	.141	24.4	11.9
1980 . . .	87,210	1.46	.296	.136	25.8	11.8

1 Based on Consumer Price Index for personal rent.

2 GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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Table 4.14 ESTIMATED TOTAL COST OF ACQUIRING, MAINTAINING AND STORING SCHOLARLY JOURNALS: 1960-1980

(Millions of Dollars)

Year	Total Cost (Current $)	Total Cost (Constant $)*
1960 . . .	43.9	52.5
1961 . . .	53.3	59.9
1962 . . .	62.3	69.3
1963 . . .	63.1	69.2
1964 . . .	69.3	74.9
1965 . . .	78.4	83.2
1966 . . .	85.4	88.1
1967 . . .	100.4	100.4
1968 . . .	109.0	104.8
1969 . . .	116.8	107.1
1970 . . .	121.3	105.5
1971 . . .	121.6	101.2
1972 . . .	134.1	107.9
1973 . . .	138.1	105.2
1974 . . .	157.5	108.9
PROJECTIONS		
1975 . . .	194	123
1976 . . .	189	112
1977 . . .	205	114
1978 . . .	221	115
1979 . . .	239	117
1980 . . .	258	118

* Using GNP implicit price deflator (1975-1980 NPA) to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

estimate of this number was found from Table 3.19 by subtracting the previous year's circulation from the current year's. However, some new subscriptions are not accounted for in this manner because replacement of deaths and cancellations is not included. The deaths of journals over the period of time 1962 to 1974 are about two percent per year. According to the Indiana University study (48), the percentage of journal cancellations is in the neighborhood of one percent. Thus, each year we have adjusted the number of new subscriptions by a factor of 1.03. Results for the number of new subscriptions are given in Table 4.11. (Note that we do not present data for 1960 since we did not have data for 1959 to obtain the difference). As can be seen, the trend in the number of new titles acquired is quite erratic. The future trend is slightly upward.

From the number of journals acquired and the known costs, the acquisitions cost is computed for each year. The 1967 cost of $62.80 is used as a base and this figure is weighting up or down by wage increases and decreases for librarians. Costs do not include subscription costs. Average total acquisition costs and constant dollars are given in Table 4.11.

The total cost of maintaining a purchased scholarly journal title can be found by using the total number of institutional and library subscriptions. Again, the costs over 1960 to 1980 are estimated from the changes in library wages since the maintenance costs are almost exclusively labor. These costs are given in Table 4.12. The increase in total constant dollars reflects the trend in number of titles maintained as opposed to the trend in average cost which reflects wage increases of librarians.

The cost per volume of storing a purchased scholarly journal is estimated from the number of journals maintained. The median age of a cited journal article obtained from a library is 15 years. Thus, it is grossly (but conservatively) assumed that there are about 15 copies stored for each one acquired and maintained annually. Based on this broad assumption, we arrive at the storage costs given in Table 4.13. The cost index used is based on rental value, derived from the Consumer Price Index for personal rents.

The total overall costs of acquisition and storage of scientific and technical scholarly journals are shown in Table 4.14. As seen, 1974 costs are $158 million or about 30 percent of total library S&T non-material expenditures.

It is emphasized that the costs do not include subscription prices but incorporate only those labor costs incurred in libraries.

The costs shown above for library journal activities include those which make up the organization and control function as well as the acquisition and storage function. A third major category of non-material costs covers public services. In order to separate total library costs into these three categories, we assume, based on our knowledge of library costs and work by Raffel and Shishko (130), that the breakdown of non-material library costs is:

acquisition and storage	1/3
organization and control	1/3
public services	1/3

It is also assumed that other costs (administration, etc.) can be equally distributed over the three activities.

Costs resulting from this assumption applied to total library costs are shown in Table 4.15.

Table 4.15 SCIENTIFIC AND TECHNICAL LIBRARY EXPENDITURES FOR ACQUISITIONS & STORAGE, ORGANIZATION & CONTROL, AND PUBLIC SERVICES: 1960-1980

(Millions of Dollars)

Year	Acquisition & Storage		Organization & Control		Public Services	
	Current $	Constant $*	Current $	Constant $*	Current $	Constant $*
1960 . . .	37	42	37	42	37	42
1961 . . .	42	47	42	47	42	47
1962 . . .	47	52	47	52	47	52
1963 . . .	52	57	52	57	52	57
1964 . . .	58	63	58	63	58	63
1965 . . .	64	68	64	68	64	68
1966 . . .	72	74	72	74	72	74
1967 . . .	83	83	83	83	83	83
1968 . . .	98	94	98	94	98	94
1969 . . .	110	101	110	101	110	101
1970 . . .	121	105	121	105	121	105
1971 . . .	140	116	140	116	140	116
1972 . . .	152	122	152	122	152	122
1973 . . .	164	125	164	125	164	125
1974 . . .	176	122	176	122	176	122
PROJECTIONS						
1975 . . .	195	123	195	123	195	123
1976 . . .	205	122	205	122	205	122
1977 . . .	219	122	219	122	219	122
1978 . . .	232	121	232	121	232	121
1979 . . .	243	119	243	119	243	119
1980 . . .	256	117	256	117	256	117

* Using GNP implicit price deflator (1975-1 [illegible]) to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Studies.

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SECTION 5

ORGANIZATION AND CONTROL

5.1 Introduction

The organization and control function involves the description of a bibliographic item and/or its physical location, facilitating identification of, and access to, needed information. The major components of the information community involved in organization and control include libraries, the national bibliographies, and abstracting and indexing services. Libraries catalog and classify the materials they hold, describing both physical characteristics and subject content, and generally use the classification number to indicate the shelf location. The national bibliographies provide these functions on a larger scale, and may also identify libraries holding each item. Abstracting and indexing services generally work with the journal literature, assigning index terms to and abstracting individual journal articles and creating printed or machine-readable indexes. The organization and control functions performed by libraries, national bibliographies and abstracting and indexing services are discussed in the following sections.

5.2 Library Cataloging

Libraries provide access to their collections by creating catalog files, indexes to the materials in their collections. The traditional file is made up of several catalog cards for each item, filed by such entries as author, title and subject. The card catalog provides the primary means of locating materials, and nearly all items acquired are cataloged. (See Table 4.8).

In 1901 the Library of Congress began the practice of selling to libraries copies of the printed cards which were used in the Library of Congress card catalogs. This service came to be widely used, and by 1968 nearly 80 million cards were sold annually.

In 1968, the MARC (Machine-Readable Cataloging) distribution service of the Library of Congress began. This service provides machine-readable records of cataloging information on tape, and provided a major impetus for automation in libraries. By the sixth anniversary of the MARC Distribution Service, a total of 570,376 cataloging records had been created and cataloging records were distributed worldwide through about 60 tape service subscribers to thousands of user libraries. MARC records are now produced at an annual rate of over 160,000 titles per year, and will cover all of the cataloging production of the Library of Congress by 1980.

Initially, the MARC-based services provided to libraries involved the off-line production of catalog cards in an individualized format. There now exist a number of on-line cataloging systems which allow a library with a computer terminal to call up a cataloging record sheet from the data base, modify it as necessary, and produce individualized cards for their own catalog.

The major computerized cataloging service today is the Ohio College Library Center (OCLC). Libraries using the OCLC system have access not only to MARC records, but also to other cataloging records created by OCLC participants. In this way, it is estimated that up to 70 to 80 percent of a library's monographic cataloging requirements can be supported by the system, greatly reducing duplication of effort among libraries. The number of cataloging records in OCLC and the number of copies of books cataloged in 1973-1975 are as follows:

Table 5.1 OHIO COLLEGE LIBRARY CENTER PROCESSING STATISTICS: 1972/73, 1973/74, 1974/75

Item	1972/73	1973/74	1974/75
Number of cataloging records in the data base	652,114	935,314	1,420,755
Participating library source	321,242	521,797	923,545
LC/MARC source	330,872	413,517	494,419
Copies of books cataloged	572,474	1,194,267	2,555,055

SOURCE: Ohio College Library Center Annual Report, 1972/73, 1973/74, and 1974/75 editions, Ohio College Library Center, 1973, 1974, 1975.

In addition to supporting cataloging efforts, data bases such as OCLC's provide the means for facilitating other library operations. Among these are serials control, acquisitions, interlibrary loan, and remote catalog access and circulation control. These are important both to internal library processing and to the sharing of resources among libraries. In particular, as the number of libraries participating in the system grows, records of holdings information are an invaluable source for interlibrary loan. In 1975, the membership of OCLC consisted of 78 Ohio members and 11 networks containing some 36 libraries of all types and sizes.

5.3 National Bibliographies

An important element in the organization and control of the book literature is the existence of national bibliographies, comprehensive lists of materials published and/or held by libraries in a given country. The U. S. National Union Catalog is maintained by the Library of Congress and gives bibliographies and location information for items held by the Library of Congress. The number of unique main entry records added to the National Union Catalog each year is shown in Table 5.2

5.4 Abstracting and Indexing Services

Among the secondary literature sources, abstracting and indexing services play an important role in providing the intellectual analysis and organization of the scientific literature which allows it to be accessed effectively by scientists and engineers engaged in research activities. While concentrating primarily on the journal literature, A & I services treat all literature services to some extent, and provide scientists with current awareness of materials relevant to their fields of interest as well as guides for retrospective search of the world's literature.

Abstracting and indexing services are provided by a wide range of organizations dissimilar in their sources of funds and their sponsors but generally similar in product. The traditional product is a periodic publication listing items considered, often with abstracts, and accompanied by appropriate indexes. Abstracts may be indicative, informative, evaluative, or any combination of these types. Indexes also vary in type as well as comprehensiveness; the principal forms of indexes used are descriptive cataloging,

Table 5.2 RECORDS ADDED TO THE NATIONAL UNION CATALOG: 1961-1974

Year	Main Entry Records Added
1961	136,932
1962	150,200[e]
1963	163,395
1964	163,977
1965	217,936
1966	200,106
1967	210,800[e]
1968	221,575
1969	298,930
1970	341,837
1971	352,229
1972	347,200[e]
1973	354,700[e]
1974	349,300[e]

[e]Estimated.

SOURCE: Annual Report of the Librarian of Congress, Washington, D.C.: Library of Congress, 1974

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alphabetic subject, keyword, and citation indexes. In the production of the traditional product a number of organizations have produced machine readable data bases containing similar information which can be used to provide services directly. The growth of such services has been substantial in recent years, suggesting correspondingly less emphasis on the printed A & I product in the years ahead.

The key issues in the abstracting and indexing area from a user's point of view are the coverage of relevant literature, the time lag between primary and secondary literature publication, and the cost of obtaining the service. Ultimately the issue is the utility of the A & I service.

Impacting on the coverage provided are a variety of factors, including the number of services and their subject orientation, the overlap in coverage among various services, and the degree of cooperation and coordination found. Time lag is primarily a matter of internal efficiency within the individual A & I organization, but may also be related to cooperation between these organizations and the primary publishers. The cost of an A & I publication is also closely related to the degree of cooperation between primary and secondary publishers as well as among the various organizations producing A & I publications. Costs are also dependent on the level of service provided and will be affected by operational and technological changes throughout the publication process.

The following sections outline the various stages in the publication and distribution of an abstracting and indexing product, presenting available data which suggest trends in the key areas of impact. Preceding all of these sections and providing the overall framework for discussion is a section on the number of organizations providing A & I services.

5.4.1 Number of A & I Organizations

A number of attempts have been made over the years to identify various categories of organizations providing A & I services, going back at least to the first edition of Index Bibliographicus published in 1925. Of more recent interest, A Guide to U. S. Indexing and Abstracting Services in Science and Technology (85) was published in 1960 by the National Federation of Abstracting and Indexing Services (NFAIS). This compilation contained about 500 entries, and was limited to U. S. services. Three Hundred and Sixty-Five of these services were repeated in the 1963 World Guide to Abstracting and Indexing Services in Science and Technology (86), another NFAIS publication. This document contained 1855 titles from 40 countries, chosen from 3155 titles examined. In 1965 and again in 1969, the Federation Internationale de Documentation (FID) published guides to abstracting services in science, technology, medicine, and agriculture, and also social sciences and humanities. The 1969 edition contained 816 entries in the science and technology volume and 180 entries in the social sciences volume, and did not include indexing services. A comparison of this list with that of the 1963 NFAIS World Guide indicates an increase of 30 percent in the number of abstracting and indexing services over the six year period, and a combination of the two lists identifies 2671 unique entries representing world wide A & I services in all subject fields.

In an effort to merge and update data contained in these previous directories and to create a base for ongoing data collection, FID and NFAIS are currently working on a joint project to prepare a machine readable inventory of world abstracting and indexing services. The data base is scheduled for completion early in 1976. Included in the record for each service will be some 91 elements describing the service. Services listed were selected primarily from existing directories, according to criteria established by an advisory committee. Preliminary results of this project indicate a final data base containing descriptions of approximately 2100 A & I services plus approximately 200 machine readable services, some of which are cross referenced to the basic services.

Combining this known information, Table 5.3 suggests some tentative conclusions. Indications are that the U. S. accounts for a relatively small percent (20% in 1963) of the world's abstracting and indexing organizations, and that a large percentage of these organizations (82% in 1969) deal with scientific and technical literature. These figures may be available for 1974 from the world inventory file, but in general changes over the period 1965 - 1974 cannot be discussed. With respect to the total number of services, the 1974 estimate of 2100 world A & I services seems most reliable, and reflects substantially less growth in the 1969 - 1974 period than the 30 percent estimated for 1963 - 1969.

Table 5.3 NUMBER OF ABSTRACTING AND INDEXING ORGANIZATIONS: 1960-1974

Type of Organization	1960[1]	1963[2]	1969[3*]	1974[4]
U.S. Science & Technology	500	365	-	-
World Science & Technology	-	1,855	816	-
All Fields	-	-	996	2,100

*Indexing Services not counted.

SOURCES: [1]National Federation of Abstracting and Indexing Services, A Guide to U.S. Indexing and Abstracting Services in Science and Technology, 1960.

[2]A Guide to the World's Abstracting and Indexing Services in Science and Technology (Report No. 102), 1963.

[3]Abstracting Services: Volume 1, Science, Technology, Medicine, Agriculture; Volume 2, Social Sciences and Humanities, Federation Internationale de Documentation (The Hague), 1969.

[4]NFAIS estimate.

Two important sources of data on abstracting and indexing have covered a number of the major services. The two sources are the regular statistical compilations published by NFAIS since its formation in 1958 and a 1966 System Study of Abstracting and Indexing in the United States (141) by the System Development Corporation. In 1974 and 1975, NFAIS statistics covered 27 U. S. member organizations, including seven government affiliates.

SDC used as its universe the 365 U. S. organizations listed in the 1963 NFAIS directory. From these, they selected approximately 150 candidates for study, based on size and on influence in the scientific community, and used both site interviews and mail questionnaires to obtain information on 77 A & I products. Other calculations were made on the basis of 100 major organizations selected from the same directory, using data included in the directory. These hundred organizations produced about 220 publications, approximately 40 percent of the total number of abstracting and indexing publications in the U. S. and including all of the major ones. The hundred organizations were classified into five categories as follows:

Federal	10%
Societal	20%
Industrial	23%
Commercial	30%
Institutional	16%

For most purposes these hundred organizations can be considered to represent the entire universe, particularly with respect to the number of items covered.

Also of interest is the number of organizations generating machine-readable bibliographic data bases, and the number of such data bases. This information is not regularly compiled, but a number of surveys have been conducted and are expected to be updated. Sources of Information on U. S. data bases include the ASIDIC Survey of Information Center Services (152), the ASIS Survey of Commercially Available Computer-Readable Data Bases (140) and Kruzas' Encyclopedia of Information Systems and Services (70). A recent source which appears to be comprehensive is found in Volume 9 of the Annual Review of Information Science and Technology (7), which lists some 118 data bases, 90 of which are generated in the U. S. by 52 organizations. These are 1973 figures, and suggest substantial growth since the beginnings of the industry in the mid 1960's.

5.4.2 Number of Items Abstracted and Indexed

The National Federation of Abstracting and Indexing Services (NFAIS) regularly publishes data on number of items covered by their member organizations. Their most recently published statistics (published in February 1974 and February 1975) are summarized for the period 1960 - 1974 in Table 5.4. Items covered by full members increased 205 percent in this period, with U. S. government affiliates covering 80 percent more items, for an overall growth rate of 145 percent. A projection of the total number of items to 1980 is shown. It is important to note that these figures include substantial amounts of overlap, that is, duplicate coverage of a single item by two or more organizations.

In order to determine what part of total U. S. production is represented by its statistics, NFAIS has compared its 1962 and 1966 data with that compiled by SDC for a hundred major A & I organizations. The comparison suggests that NFAIS members account for about half the volume of the one hundred sample organizations. The growth rates for NFAIS members and the SDC sample organizations are similar (about 38%) over the 1962 - 1966 period.

Table 5.4 ITEMS PROCESSED BY U.S. NFAIS MEMBERS: 1960-1980

(Thousands)

Year	Full Voting Members	U.S. Government Affiliates	Total
1960 . . .	310	278	588
1961 . . .	382	294	676
1962 . . .	410	303	713
1963 . . .	448	308	756
1964 . . .	450	345	795
1965 . . .	482	402	884
1966 . . .	603	383	986
1967 . . .	598	398	996
1968 . . .	678	457	1,135
1969 . . .	758	468	1,226
1970 . . .	831	426	1,257
1971 . . .	895	481	1,376
1972 . . .	933	516	1,449
1973 . . .	910	492	1,402
1974 . . .	945	498	1,443
PROJECTIONS*			
1975 . . .	-	-	1,590
1976 . . .	-	-	1,650
1977 . . .	-	-	1,720
1978 . . .	-	-	1,790
1979 . . .	-	-	1,850
1980 . . .	-	-	1,920

* Market Facts, Inc., Center for Quantitative Sciences.

SOURCE: National Federation of Abstracting and Indexing Services, Member Service Statistics, February 1974 and 1975.

In 1962, Bourne (17) and Heller (58) estimated that total production of U. S. abstracting and indexing services was about two million items. Since this is quite close to the SDC figure for 1962, we will assume that the SDC figures represent nearly the entire universe, and in turn that NFAIS statistics represent about half of U. S. production. If this assumption holds over time, 1974 U. S. production would have been approximately three million items.

NFAIS statistics do not include any commercial organizations, which accounted for about 20 percent of the total coverage recorded by the SDC only. One of the largest of the commercial organizations is the Institute for Scientific Information (ISI) and relevant statistics for it are presented in Table 5.5.

The SDC study found that in 1962, 56 percent of the 1,856,000 items reported covered were abstracted. The remaining 44 percent were indexed only. No more recent data is available on this distinction, but it can be observed that substantial numbers of the machine readable bibliographic bases contain abstracts. This may suggest an increased proportion of items abstracted.

The number of items covered by A & I services cannot be compared directly with the volume of world literature because of overlapping coverage. A number of attempts have been made to identify both extent of coverage by A & I publications and overlap between various publications. The SDC study, considering 30 abstracting and indexing organizations, found that the number of services covering some part of each of 178 COSATI (141) subject areas ranged from two to 18, with a median of 11. The conclusion drawn was that coverage was fragmented and irregular. Other studies in the late 1960's confirmed these results.

Overlapping coverage has also been studied, and some results are suggested in Table 5.6. NFAIS is currently conducting a study of overlap in journal coverage among 14 A & I organizations, which should give some indication of recent overlap data and also of the extent of the journal literature covered. Overlap, of course, has both advantages and drawbacks, with the drawbacks primarily a matter of increased costs. Some of this is alleviated by increased cooperation, especially exchange of abstracts, between A & I organizations.

Table 5.5 SOURCE-JOURNAL ITEMS PROCESSED BY ISI: 1961-1974

(Thousands)

Year	Items Processed
1961 . . .	113
1962 . . .	124
1963 . . .	129
1964 . . .	152
1965 . . .	236
1966 . . .	274
1967 . . .	304
1968 . . .	309
1969 . . .	341
1970 . . .	362
1971 . . .	364
1972 . . .	378
1973 . . .	407
1974 . . .	401

SOURCE: Institute for Scientific Information, Science Citation Index 1974; Guide and Journal Lists.

Table 5.6 INDICATIONS OF OVERLAPPING COVERAGE AMONG SECONDARY SERVICES

Services	Degree of Overlap
Biological Abstracts (BA) versus Chemical Abstracts (CA) versus Physics Abstracts (PA)	57% of a sample covered by PA also covered by CA; 40% of a sample covered by BA also covered by CA
BA versus Excerpta Medica (EM)	52% of a sample of 95 cardiovascular, endocrine, and psychopharmacologic papers covered by BA also covered by EM
BA versus Index Medicus (IM)	54% of the serials covered by IM also covered by BA
CA versus BA	20% of 110,000 items in BA also covered by CA
CA versus Geoscience Abstracts (GSA)	20% of 6,000 items in GSA also covered by CA
CA versus International Aerospace Abstracts (IAA)	25% of 30,000 items in IAA also covered by CA
CA versus Nuclear Science Abstracts (NSA)	51% of 17,600 reports covered by NSA also covered by CA (using in this instance NSA-prepared abstracts); 58% of 27,900 journal articles in NSA also covered by CA; and 73% of 2,630 patents in NSA also covered by CA
CA versus Review of Metal Literature	55% of 18,000 items in Review of Metal Literature also covered by CA
CA versus Scien[illegible] and Technical A[illegible] Reports (STAR)	14% of 36,300 articles in ST[illegible] also covered by CA
CA versus Technical Translations	73% of 24,000 items in Technical Translations also covered by CA
PA versus NSA	54% of a sample of 2,246 articles appeared in both PA and NSA
Bibliography of Agriculture with 15 major services	No overlap greater than 20%; 54% of B of A item not covered elsewhere
BA versus CA versus EI	1% of 1,4592 journals covered monitored by all 3, 27% by 2, and 72% by only one - least overlap between EI and BA

SOURCE: Committee on Scientific and Technical Communication, National Academy of Sciences, Scientific and Technical Communication, 1969.

Annual Review of Information Science and Technology, Vol. 5, 1970 and Vol. 8, 1973.

5.4.3 Costs of Ab·tracting and Indexing

Costs of the actual abstracting and indexing process have proven difficult to identify. Bourne, in a 1970 review of the literature (15), sugg a range of $2 - $8 per abstract, with $5 as a representative figure. This would indicate creation of about 8 or 9 abstracts per person-day. For indexi Bourne found a range of $1 to $20 per indexed article, corresponding to 8 - 3(articles per person-day. These are 1968 data.

Bourne also considered total A & I service costs, and found a 1968 range of $5 to $30 per item. This data has been supplemented by contact with the individual services, and the results suggests a cost per item of $25 in 1967.

5.4.4 Sales of A & I Publications and Services

In general, it would be expected that most sales of A & I publications are made to libraries, particularly the more expensive items. The price of A & I publications depends upon the form of publication and on other types of support available to the organization, including advertising revenue levies on society membership, industrial support, and federal subsidy. Volunteer labor may also contribute to the support of A & I publications.

Subscription prices follow several different patterns, sometimes including differentials for society members or nonprofit educational institutions. Flexible pricing practices are also in use, with the price for each facility set according to such factors as the number of potential users or the library budget. Library subscription prices for selected publications are shown in Table 5.7. Price increases over both the 1963 - 1968 period and 1968 - 1973 were substantial, with larger increases observed in the latter period. The same trend is also evident, though less marked, in price per entry increases. The price per entry increases for Biological Abstracts, for example, are 167 percent from 1963-1968 and 67 percent from 1968-1973.

Table 5.7 A&I SERVICE SUBSCRIPTION PRICES: 1963, 1968, 1973

		1963[1]		1968[1]		1973[2]		Price Increase (%)	
Publication	Type of Publisher	Library Subscription Price ($)	Total Entries	Library Subscription Price ($)	Total Entries	Library Subscription Price ($)	Total Entries	1963-1968	1968-1973
Bibliography of Agriculture	Federal	10	105,409	19	111,665	95	113,000	90	400
Biological Abstracts	Society	225	100,862	600	214,000	1,000	240,000	167	67
Chemical Abstracts	Society	1,000	165,000	1,550	251,034	2,400	356,549	55	55
Index Medicus	Federal	40	130,000	72	207,000	155	207,000	80	115
Psychological Abstracts	Society	20	10,000	30	19,586	190	24,409	50	533

SOURCE: [1]Committee on Scientific and Technical Communications (SATCOM), National Academy of Sciences-National Academy of Engineering, Scientific and Technical Communication, June 1969.

[2]Individual publications.

5.5 Organization and Control Costs

Included in organization and control costs are library cataloging and processing costs (See Table 4.15) and A & I service costs. Abstracting and indexing service costs are estimated in Table 5.8 by assuming that

1. NFAIS statistics on items processed represent about 50 percent of all items processed in the U. S.

2. Ninety percent of abstracting and indexing is of scientific and technical material.

3. The average cost per item processed was $25 in 1967 and can be adjusted by changes in professional, administrative and clerical pay.

We also estimate that 75 percent of the items processed are journal articles and that, of these, about 50 percent are published in the U. S. The cost of processing articles published outside the U. S. is included in our totals since the A & I publications are U. S. products.

The two cost components of organization and control and their sum are shown in Table 5.9

Table 5.8 ESTIMATED SCIENTIFIC AND TECHNICAL ABSTRACTING AND INDEXING SERVICE COSTS: 1960-1980

Year	Items Processed by U.S. NFAIS Members[1] (000)	S&T Items Processed by U.S. A&I Services[2] (000)	Cost Per Item ($)[2]	Estimated S&T Abstracting & Indexing Costs[2] (Millions of $)
1960 . . .	588	1,058	20.00	21
1961 . . .	676	1,217	20.60	25
1962 . . .	713	1,283	21.20	27
1963 . . .	756	1,361	21.80	30
1964 . . .	795	1,431	22.50	32
1965 . . .	884	1,591	23.20	37
1966 . . .	986	1,775	23.90	42
1967 . . .	[illegible]	1,793	25.00	45
1968 . . .	1,134	2,041	26.40	[illegible]
1969 . . .	1,226	2,207	27.90	62
1970 . . .	1,257	2,263	29.60	67
1971 . . .	1,377	2,479	31.50	78
1972 . . .	1,451	2,612	33.40	87
1973 . . .	1,402	2,524	35.20	89
1974 . . .	1,443	2,597	[illegible].40	97
PROJECTIONS[2]				
1975 . . .	1,590	2,862	39.20	112
1976 . . .	1,650	2,970	41.00	122
1977 . . .	1,720	3,096	42.90	134
1978 . . .	1,790	3,222	44.90	146
1979 . . .	1,850	3,330	47.00	159
1980 . . .	1,920	3,456	49.20	173

SOURCES: [1] National Federation of Abstracting and Indexing Services, Member Service Statistics, February 1974 and 1975.

[2] Market Facts, Inc., Center for Quantitative Sciences.

Table 5.9 SCIENTIFIC & TECHNICAL ORGANIZATION AND CONTROL COSTS: 1960-1980

(Millions of Dollars)

Year	S&T Cataloging & Processing Costs		S&T Abstracting & Indexing Service Costs		Total S&T Organization and Control Costs	
	Current	Constant*	Current	Constant*	Current	Constant*
1960 . . .	37	42	21	24	58	66
1961 . . .	42	47	25	28	67	75
1962 . . .	47	52	27	30	74	82
1963 . . .	52	57	29	32	81	89
1964 . . .	58	63	32	35	90	98
1965 . . .	64	68	37	39	101	107
1966 . . .	72	74	43	44	115	118
1967 . . .	83	83	45	45	128	128
1968 . . .	98	94	54	52	152	146
1969 . . .	110	101	62	57	172	158
1970 . . .	121	105	67	58	188	163
1971 . . .	140	116	78	65	218	181
1972 . . .	152	122	87	70	239	192
1973 . . .	164	125	89	68	253	193
1974 . . .	176	122	97	67	273	189
PROJECTIONS						
1975 . . .	195	123	112	71	307	194
1976 . . .	205	122	122	72	327	194
1977 . . .	219	122	134	74	353	196
1978 . . .	232	121	146	76	378	196
1979 . . .	243	119	159	77	402	196
1980 . . .	256	117	173	79	429	197

* Using GNP implicit price deflator (1975-1980 NIA) to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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SECTION 6

IDENTIFICATION AND PHYSICAL ACCESS

6.1 Introduction

A scientist desiring information contained in the literature gains access to it by following a two-step process. In the first step, documents which contain (or may contain) the information are identified by such means as prior knowledge, a document or colleague referral, a library catalog, or an abstracting and indexing publication. Each of these means involves the linking of subject descriptors to bibliographic descriptions of documents, so that documents on a given subject can be identified. For example, a scientist reading an article in his own subscription copy of a journal will store in his memory a description of the article subject matter, just as an abstracting and indexing service will develop index terms and an abstract for the article. If the information is needed, the scientist may recall the article read in the first instance or use the A&D publication indexes to identify it in the second instance.

Clearly, the better the match between the scientist's need and a document's contents (as represented by the scientist's expression of his need and the document description, respectively), the better the results of the identification process. Two measures which have been developed to express the value of an identification method are precision and recall. Precision is the proportion of all documents identified which are judged relevant by the user, and recall is the proportion of all relevant documents which are identified by the system. In general, precision and recall are inversely related; that is, measures taken to increase precision in the identification process may have a detrimental effect on recall.

When a document has been identified as potentially useful, it still must be physically accessed. This is the second step in the identification and access process, and requires a link between a document description and a physical location in which that document is stored. In libraries, this function is generally served by the card catalog, which also is an identification source. Other sources of physical access include the publisher, the author, and personal and colleague collections. In any case, the measure of value of an access source depends on whether or not the required document is available for the scientist's use.

The Author Survey provided considerable information about the ways in which scientists identified and gained access to articles which they cited These processes are discussed in subsections 6.2 and 6.3 below, followed by a subsection on identification and access of all types of materials via libraries. The final subsection identifies known costs involved in identification and access.

6.2 Identification of Journal Articles

We have seen that the cumulative volume of journal literature available for use by the scientist is a staggering figure. Thus the process of identification of this literature, and particularly the selection of material relevant to a specific project or specialty, is a key activity.

Methods of identification of the journal literature can be classified as direct or indirect. Indirect information implies that the user first learned of an article through a formal or informal reference to it, such as an abstract in an SDI service. Direct identification would then come, not through a reference, but from initial contact with the actual article.

Within each of these identification methods, a number of further alternatives are possible. The copy of the article which the user sees may come from his own, a colleague's, or a library subscription or it may be a preprint or reprint obtained from various sources. Indirect identification may be the result of a colleague's reference; a reference in another article, book, or report; or of an abstract or index entry found in a secondary publication or output from a bibliographic data base. Costs and efficiencies of each of these methods vary substantially.

Table 6.1 and Figure 6.1 show the total number of journal articles identified by authors by direct and indirect methods, taken from the results of our Author Survey. Again, it should be kept in mind that these figures reflect that portion of total journal article use accounted for by authors

Table 6.1 NUMBER AND PERCENT OF ARTICLES IDENTI[illegible]IED, BY YEAR IN WHICH CITED: 1968-1975

Article Identification Made	1968		1969		1970		1971		1972		1973		1974		1975		Total	
	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%
Total Identifications Made	1379	100	1395	100	1531	100	1516	100	1651	100	1722	100	1806	100	1819	100	12819	100
Direct Identifications	534	39	566	41	[illegible]	34	491	32	5[illegible]	32	720	42	[illegible]	[illegible]	835	46	4975	39
Individual Subscription Copy	106	8	188	13	220	14	189	12	220	1[illegible]	356	21	[illegible]	[illegible]	453	[illegible]5	2133	17
Library Subscription Copy	244	18	206	15	144	10	128	8	137	8	156	9	141	8	1[illegible]	7	1288	10
Preprint or Reprint	184	13	172	12	158	11	174	12	167	10	209	12	241	13	2[illegible]	14	1554	12
Indirect Identifications	679	49	654	47	844	55	875	58	1019	[illegible]1	8[illegible]2	51	[illegible]29	50	[illegible]31	46	6673	52
Article, Book, or Report Reference	272	19	343	25	473	31	548	36	546	[illegible]	[illegible]	[illegible]7	496	27	505	29	3601	12
Colleague Reference	169	12	139	10	[illegible]	1[illegible]	72	12	26[illegible]	16	255	15	250	1[illegible]	191	11	1594	28
Secondary Publication or Service	238	18	172	12	222	14	155	10	205	12	148	9	15[illegible]	8	135	7	1428	11
Don't Remember or No Response	166	12	175	13	165	11	15[illegible]	10	108	7	130	8	124	7	151	8	1171	[illegible]

[illegible]: Author Survey, Market Facts, Inc., Center for Quantitat[illegible] Sciences.

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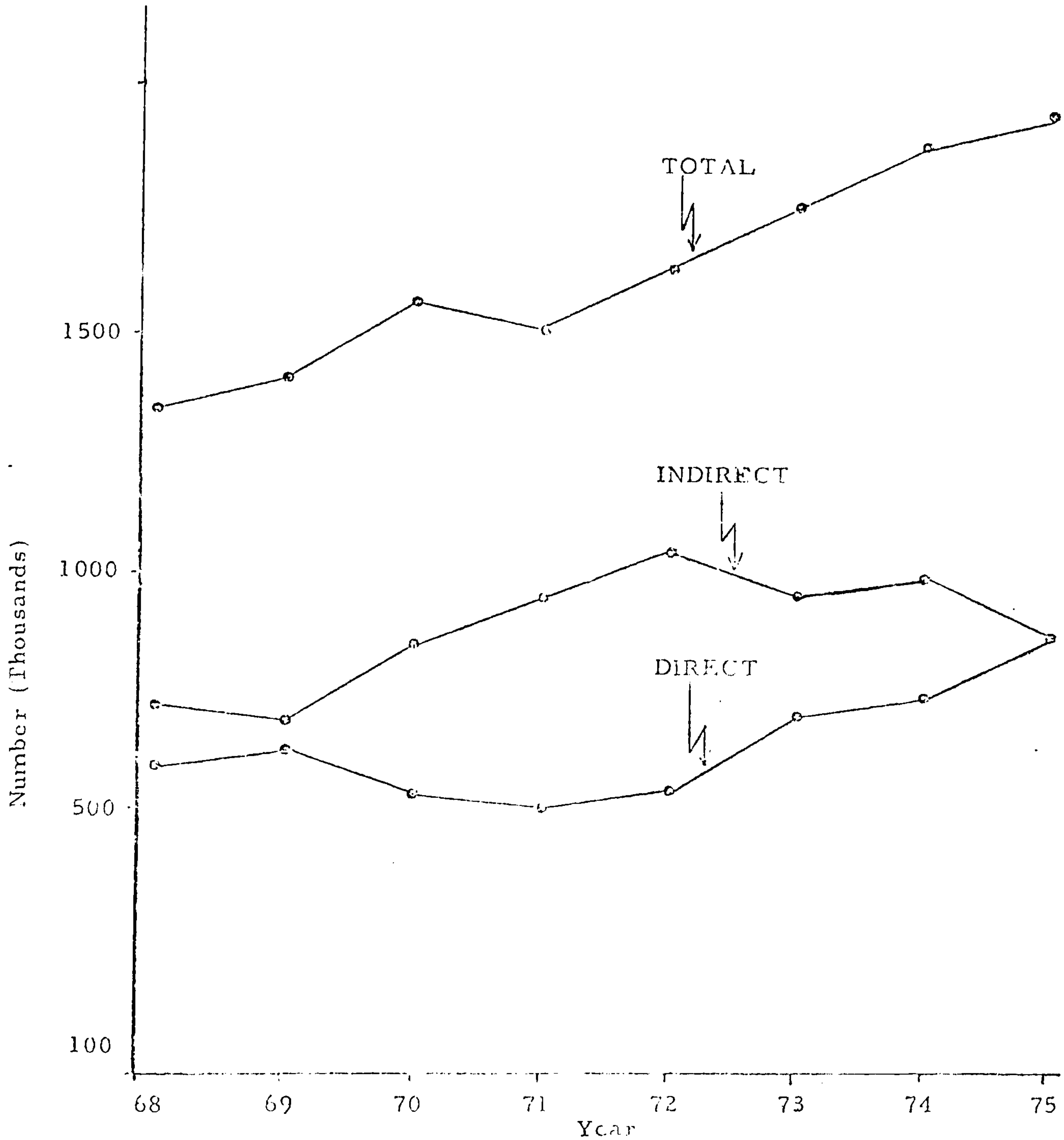
Figure 6.1 ARTICLE IDENTIFICATION METHODS: 1968-1975



SOURCE: Table 6.1

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obtaining material which they then cite in their journal articles.

Overall, indirect methods account for 52 percent of the article identifications made by authors, and direct methods account for 39 percent. Variations were observed over the 1968-75 period, with indirect procedures reported proportionally more between 1970 and 1972. The choice of indirect procedures is probably most closely related to the conduct of a special literature search of an individual topic, while regular perusal of the literature would account for most items identified directly. Thus it would seem from these results that somewhat more literature searches were conducted in the 1970 to 1972 period. This is confirmed by the results of a direct question on literature searches, which are presented in Table 6.2 and Figure 6.2. They show a relatively high proportion of literature searches to other methods over the 1968 to 1972 period. The data correspond well with that of Figure 6.1 except in 1968 and 1969. We hypothesize that this discrepancy is due to the length of the recall period for 1968 and 1969 authors, which might result in less reliable data.

6.2.1 Direct Identification Procedures

Figure 6.3 shows percentage breakdowns of the various types of direct identification procedures, including subscriptions - individual, including colleague, and library - and reprints and preprints. Overall, use of reprints and preprints account for 12 percent of total article identification, while use of subscription copies accounts for 27 percent. Included in the subscription figure is 17 percent for individual subscriptions and 10 percent for library subscriptions used. Changes in these figures over time suggest most notably that non-library methods of direct identification are gaining in importance.

6.2.2 Indirect Identification Procedures

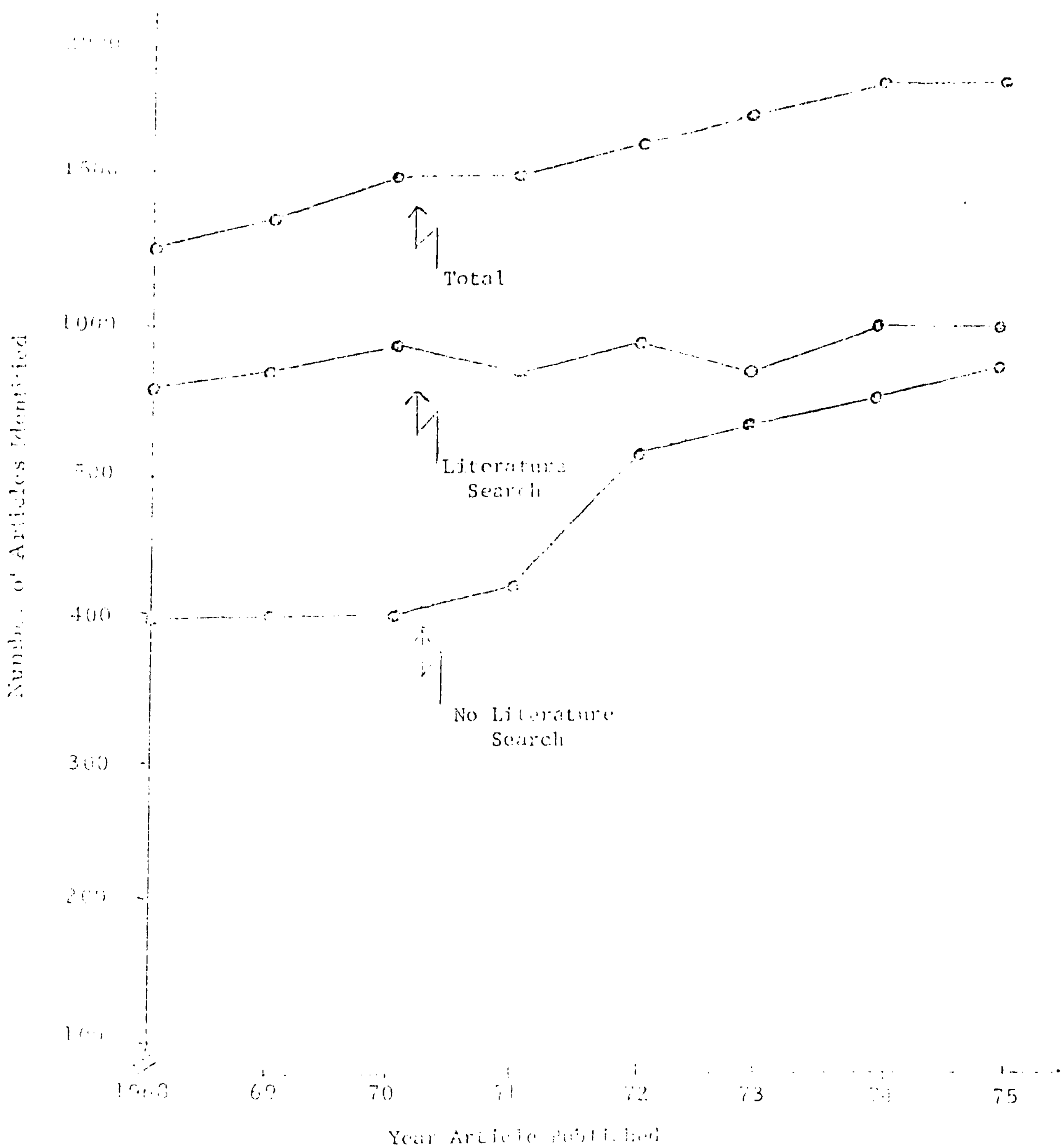
Indirect identification procedures include reference to an article by a colleague or co-worker; reference made by another article, book, or

Table 6.2 LITERATURE SEARCHES CONDUCTED BY YEAR OF ARTICLE PUBLICATION: 1968-1975

Author Response	Year of Article Publication							
	1968	1969	1970	1971	1972	1973	1974	1975
Literature Search Conducted								
Number (000)	815	840	947	882	935	871	991	962
Percent	60	60	62	58	56	50	53	52
Literature Search Not Conducted								
Number (000)	391	383	386	411	526	658	736	749
Percent	29	27	25	27	32	38	40	40
Don't Remember or No Answer								
Number (000)	151	181	187	227	195	198	132	155
Percent	11	13	12	15	12	11	7	8
Total Responses								
Number (000)	1357	1404	[illegible]	1520	1656	1727	1859	1866
Percent	100	100	100	100	100	100	100	100

SOURCE: Author Survey, Market Facts, Inc., Center for Quantitative Sciences.

Figure 6.2: LITERATURE SEARCHES CONDUCTED BY YEAR OF ARTICLE PUBLICATION: 1968-1975



SOURCE: Table 6.2

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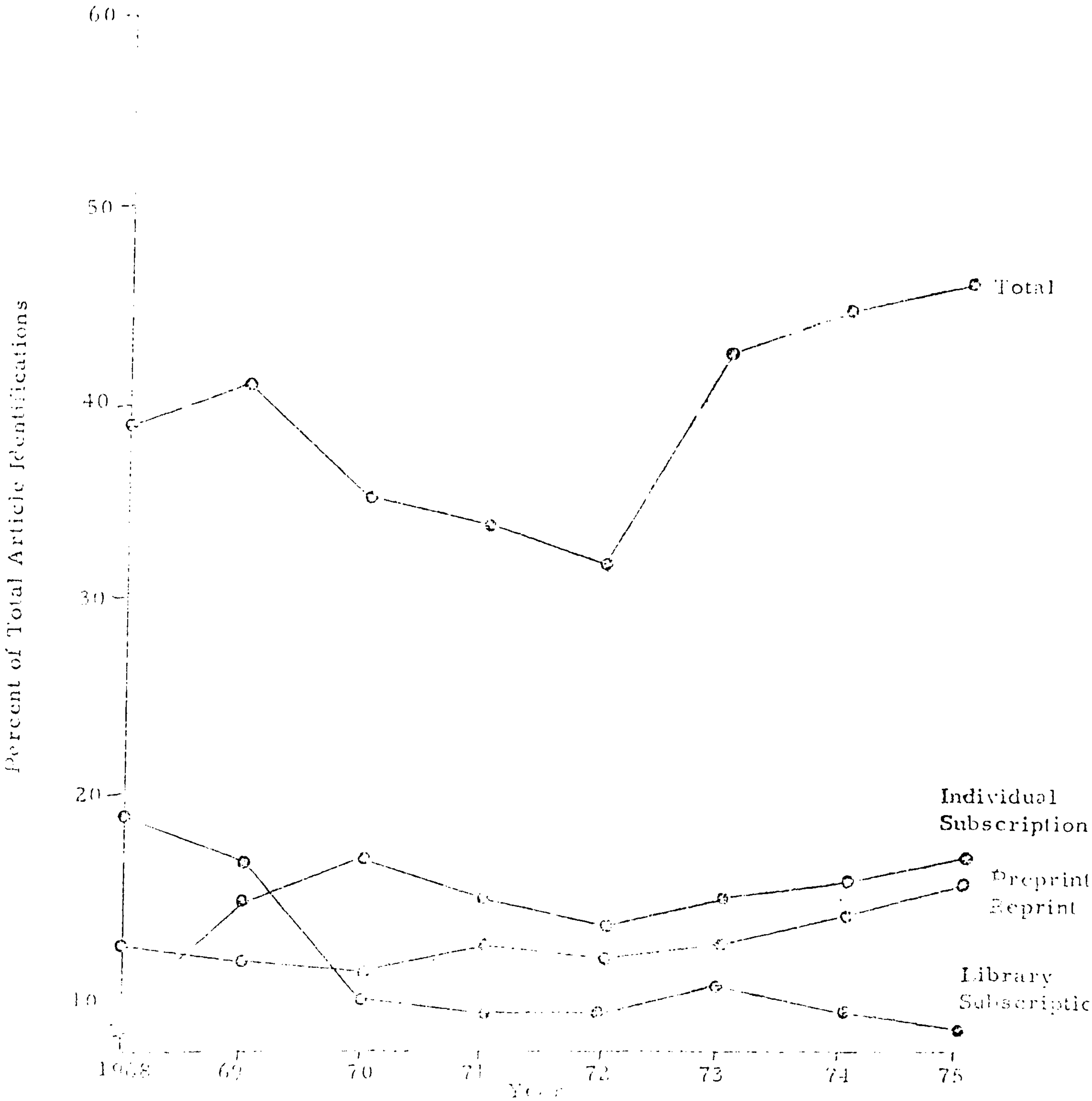
Figure 6.3 PERCENT OF TOTAL ARTICLE IDENTIFICATIONS MADE BY METHODS OF DIRECT ARTICLE IDENTIFICATION: 1968-1975



SOURCE: .

report; use of printed indexes or catalogs; use of a computerized literature search; and use of a current awareness or SDI system. The last three methods were mentioned fairly infrequently by authors and so are grouped together in Figure 6.4. This figure shows percentage breakdowns for indirect identification methods over time, reflecting overall totals of 12 percent for colleague references, 28 percent for references in published sources, and 11 percent for references in the form of abstracts or index entries. The earlier observed increase in all indirect search procedures during the 1970 to 1972 period seems to be a result of the increase in identifications via article, book or report references.

The decrease in the use of abstracts and indexes should also be noted. This figure represents mostly the use of printed indexes and catalogs, with a small number of SDI searches made over the years and a small but increasing number of computerized literature searches used.

Other sources suggest that the use of computerized literature searches, particularly via on-line systems, is expanding rapidly, so that these should play a more important role in the future. Figure 6.5 is a graph compiled by Martha Williams (152) showing the number of interactive bibliographic searches made in the U.S. The increase between 1971 and 1974 as shown is nearly 160 percent, and even more rapid growth is anticipated. The growth of commercial services may be as much as 50 to 100 percent each year. According to Anderla's projections (5), automated information will entirely replace present manual methods during the decade 1980-1990.

Our data on the decline in use of abstracting and indexing publications can be contrasted with available figures on the volume of items abstracted and indexed over the years. Information compiled by the National Federation of Abstracting and Indexing Services about their members is shown in Table 6.3. This shows an increase of 36 percent in the number of items indexed and/or abstracted annually from 1968 to 1975, contrasted with a 43 percent decline in use of these publications by authors (see Table 6.1).

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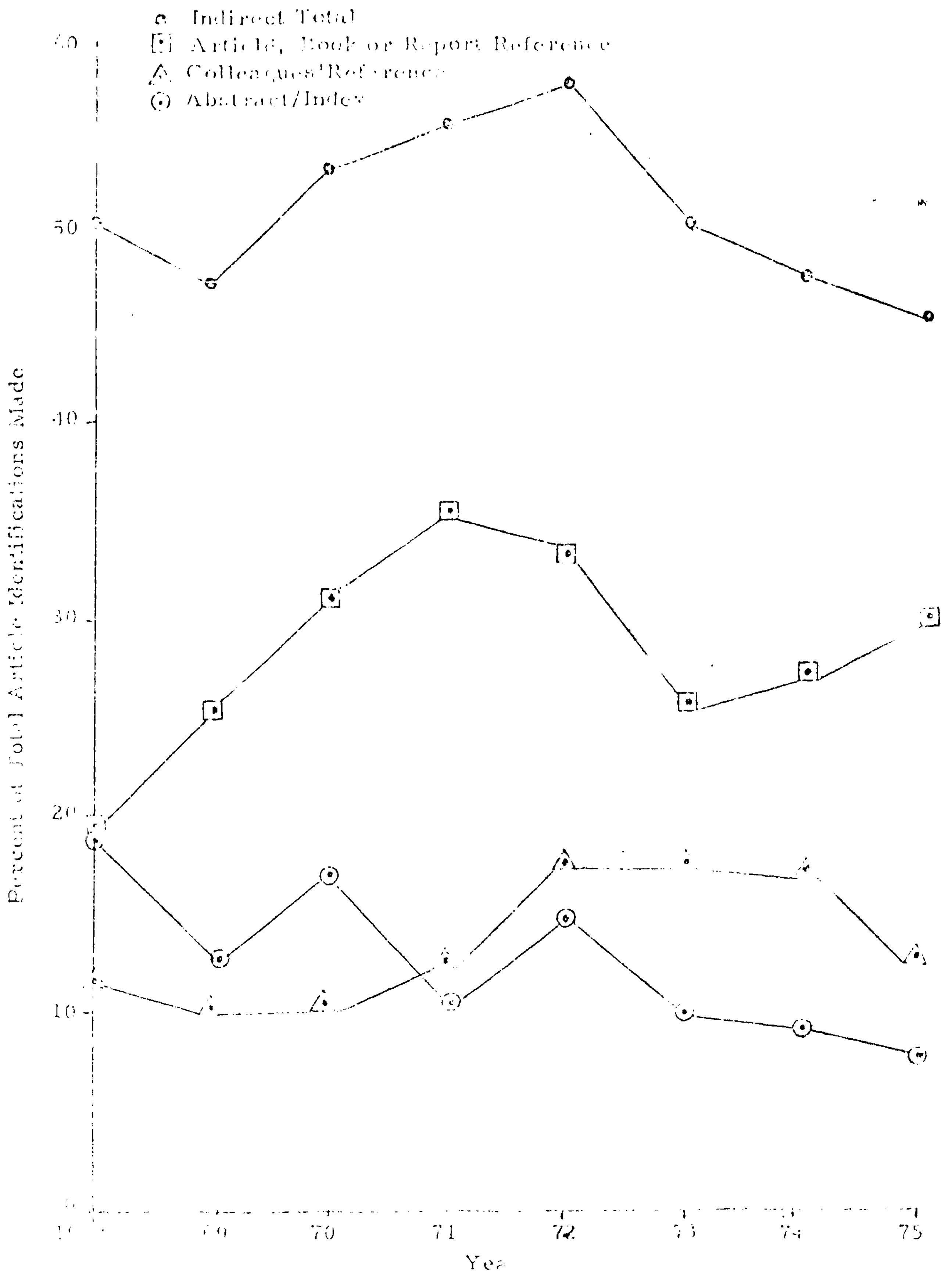
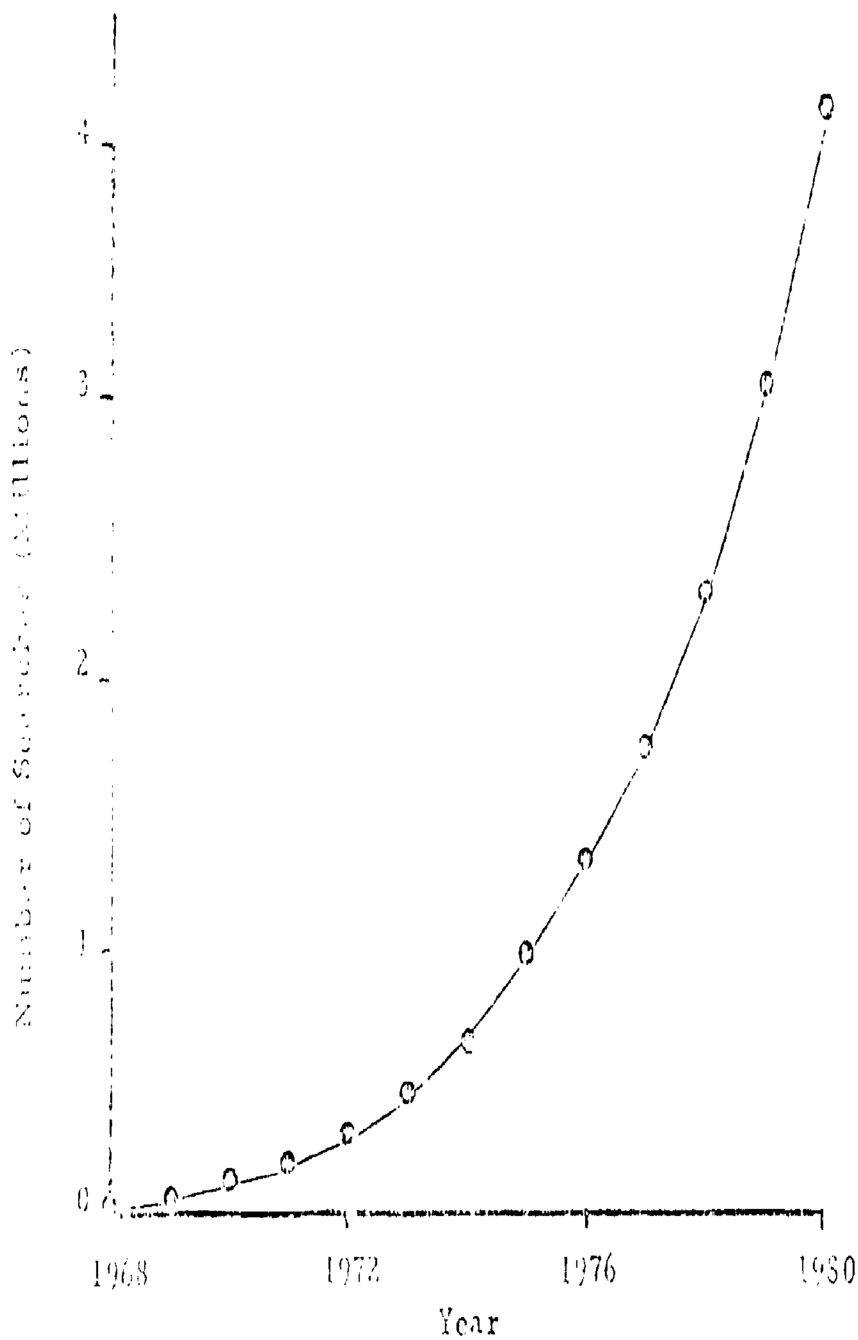
Figure 6.4 PERCENT OF TOTAL ARTICLE IDENTIFICATIONS MADE BY METHODS OF INDIRECT ARTICLE IDENTIFICATION: 1968-1975



SOURCE: Table 6.1

Figure 6.5 GROWTH OF INTERACTIVE BIBLIOGRAPHIC SEARCHING IN THE U. S.: 1968-1980



SOURCE: Table 6.10.

Table 6.3: NUMBER OF ITEMS PROCESSED BY A&I SERVICES

(Thousands)

	Year: 1968	1969	1970	1971	1972	1973	1974	1975	Total 1968-75
Number of Items Processed	1135	1226	1257	1376	1449	1402	1441	1544	N.A.
Annual Percent Change		8	3	9	5	-3	3	7	36

SOURCE: National Federation of Abstracting and Indexing Services, Member Service Statistics, February 1974 and 1975.

6.2.3 Direct and Indirect Identification Procedures by Field of Science

Significant variations were observed in the use of different identification methods by authors in the nine fields of science. These results are shown in Table 6.4 and Figure 6.6. Of special note are the greater reliance on direct methods by computer scientists, engineers, social scientists and "others". One might attribute this to less coverage by the secondary services in these areas were it not for the relatively small volume of use overall of secondary services. Another explanation would be greater importance placed on regular perusal of the literature in the fields mentioned.

Indirect identification methods include article, book or report references, colleague references, and secondary publications on services. With the exception of engineers and life scientists, the first two of these were more heavily utilized by our survey respondents. In absolute terms, life scientists accounted for 72 percent of the total identifications made via secondary publications or services.

6.3 Trends in Sources of Access

For this analysis, Author Survey responses were divided into four basic sources from which citing authors could obtain access to cited articles: library, publisher, colleague or office collection, and cited author. Responses were projected to a total population of articles cited between the years 1968 and 1975. For displays of trends in numbers of articles accessed from various sources, three-year moving averages were calculated.

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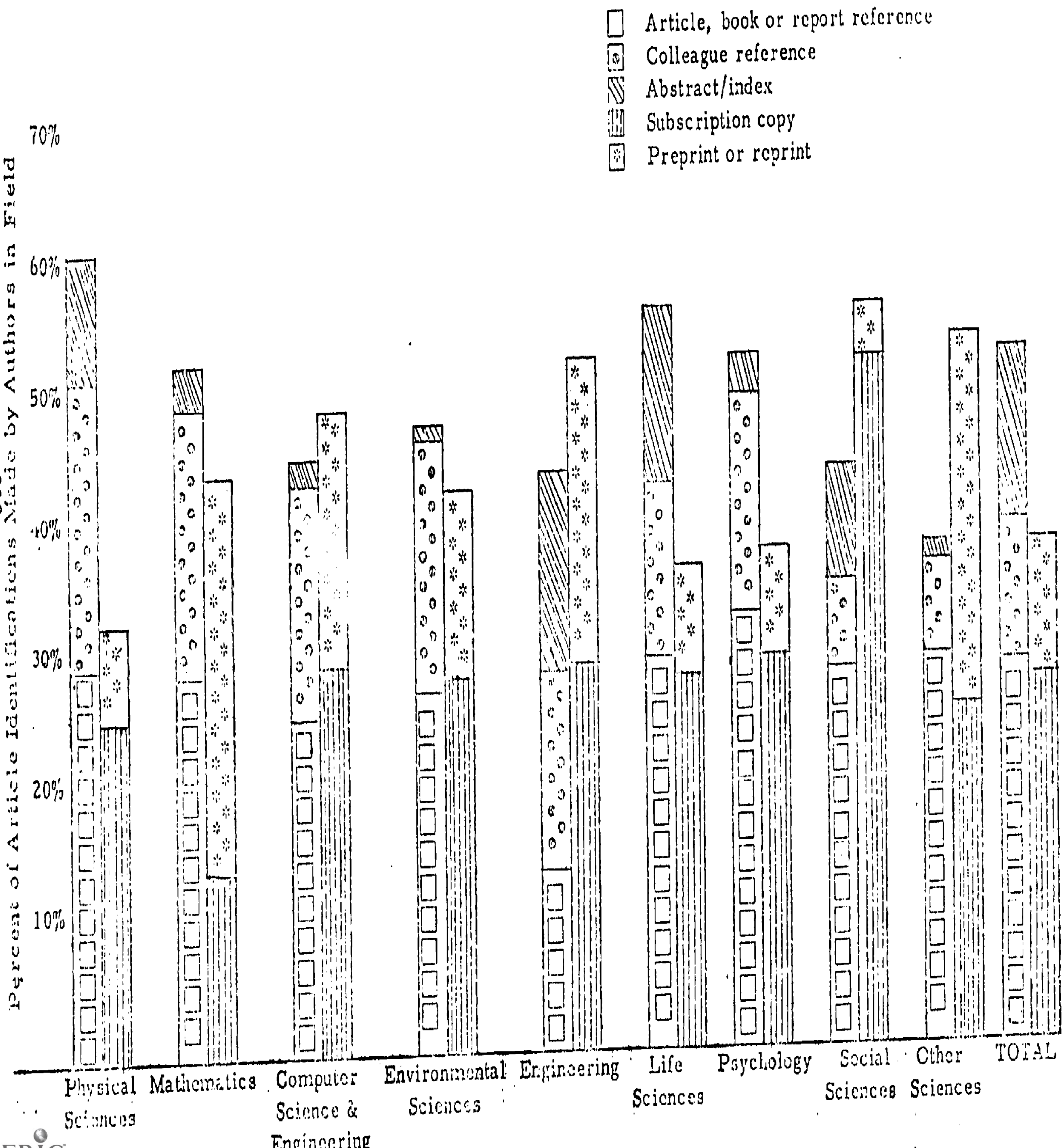
Table 6.4 ARTICLE IDENTIFICATION METHODS, BY FIELD OF SCIENCE

Identification Methods	Physical Sciences		Mathematics		Computer Sciences		Environmental Sciences		Engineering		Life Sciences		Psychology		Social Sciences		Other Sciences		Total	
	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%	(000)	%
Total Identifications Made	1,516.7	100	197.5	100	50.1	100	813.7	100	1,404.3	100	7,665.8	100	930.2	100	256.8	100	122.7	100	12,957.8	100
Direct Identifications																				
Subscription Copy	347.1	23	75.2	33	14.9	28	205.3	25	396.0	28	1,947.1	25	287.9	31	129.9	50	39.7	32	3,339.1	26
Preprint or Reprint	160.3	10	55.8	28	9.6	20	120.4	15	293.8	21	872.7	11	80.4	9	11.9	5	21.9	18	1,614.8	13
Indirect Identifications																				
Article, Book, or Report Reference	444.9	29	54.0	27	11.1	22	195.0	24	182.7	13	2,375.4	31	303.6	33	71.8	28	36.3	30	3,676.6	28
Colleague Reference	355.9	23	43.5	22	8.6	18	177.8	22	202.8	14	664.4	9	126.4	14	16.1	6	7.7	6	1,603.2	12
Secondary Publication or Service	119.2	8	5.8	3	0.9	2	12.7	1	206.9	15	1,096.1	14	49.4	5	19.7	7	3.1	3	1,512.8	12
Don't Remember or No Response	101.3	7	13.2	7	5.0	10	102.7	13	122.1	9	715.1	9	80.5	9	8.4	3	14.0	11	1,162.3	9

SOURCE: Author Survey, Market Facts, Inc., Center for Quantitative Sciences.

Figure 6.6 ARTICLE IDENTIFICATION METHODS BY FIELDS OF SCIENCE



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SOURCE: Market Facts, Inc., Center for Quantitative Sciences

Table 6.8 displays moving averages of the estimated number of times each of the four access sources was used for obtaining cited articles during the period 1968-1975. (Note that only non-self-citation articles were considered in the author survey.) Figure 6.7 graphs these estimates for the period under consideration.

Projecting from the sampled citations used in this study, the Library consistently the most often used supplier of access to cited articles used between 1968 and 1975. Access directly from authors (i.e., via author reprints and preprints) increased from 2,094,000 to 2,775,000 accesses between 1968 and 1975. This represents an annual increase of approximately 4.1 percent. Access to cited articles via colleagues or office collections rose from 1,411,000 to 1,565,000 in the same period, an overall increase of 11 percent.

Access via publishers, including individual user subscriptions and the purchase of reprints from publishers, appears to follow a quite different trend. The rate of increase differs between 1968-1972 and 1972-1975. For the first period the annual rate is 12 percent, while for the latter years it is 28 percent. Together, there is an overall increase of 232 percent between 1968 and 1975 article accesses.

Based on overall increases, library use, as measured by access to cited articles, is not increasing as rapidly as the other types of use. This is demonstrated in Figure 6.8, "Relative Use of Sources of Access to Cited Articles, by Year of Citing Article", plotted from Table 6.5 percentage data. While literature use, as measured by total accesses to cited articles, increased at an annual rate of approximately 4.8 percent between 1968 and 1975, the proportional use of libraries for access to cited articles is decreasing while the proportional use of publishers is increasing.

These trends are somewhat surprising, given current concerns about the health of journal publishing and assumptions that individual users are able to easily obtain journal article information directly from libraries. We are unable to draw more concrete conclusions based on the limited set of questions in the author survey; neither was it possible to determine the possible effects of recall bias on responses.

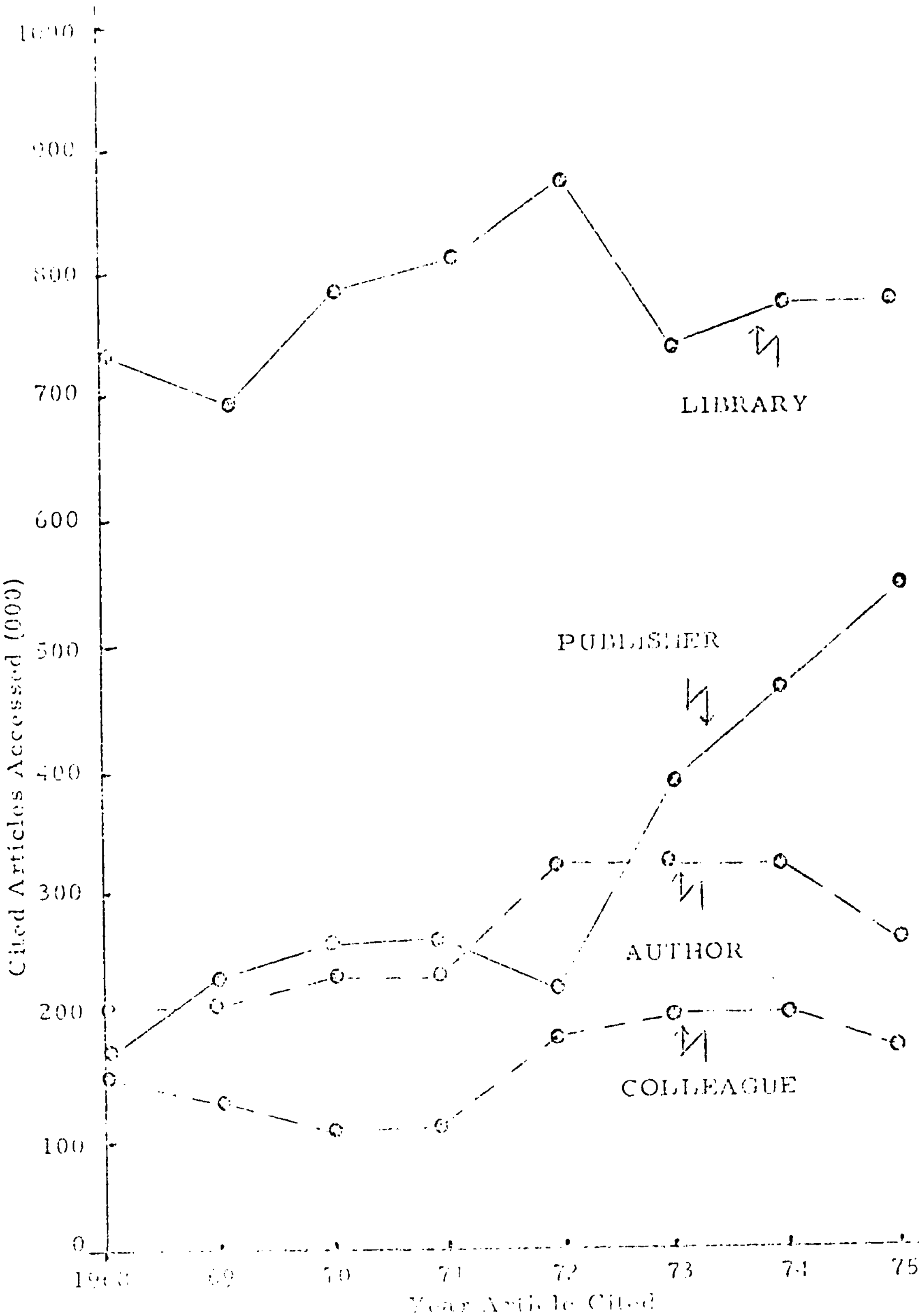
Table 6.5 RELATIVE USE OF SOURCES OF ACCESS TO CITED ARTICLES, BY YEAR OF CITING ARTICLE

(Thousands of Articles Cited, Three-Year Moving Averages)

Source of Access	Year of Citing Article															
	1968		1969		1970		1971		1972		1973		1974		1975	
	Articles	%	Articles	%	Articles	%	Articles	%	Articles	%	Articles	%	Articles	%	Articles	%
Library	723.8	59	697.0	54	797.9	56	811.3	56	866.1	56	732.6	45	791.4	45	733.2	45
Publisher	158.8	13	241.1	19	279.9	20	278.0	19	246.8	15	306.1	24	455.2	26	526.7	30
Colleague/ Office	141.1	11	122.5	10	105.8	7	107.5	7	167.9	11	206.6	13	202.1	11	156.5	9
Author	209.4	17	218.8	7	250.1	17	257.6	18	319.1	20	316.7	19	325.8	19	277.5	16

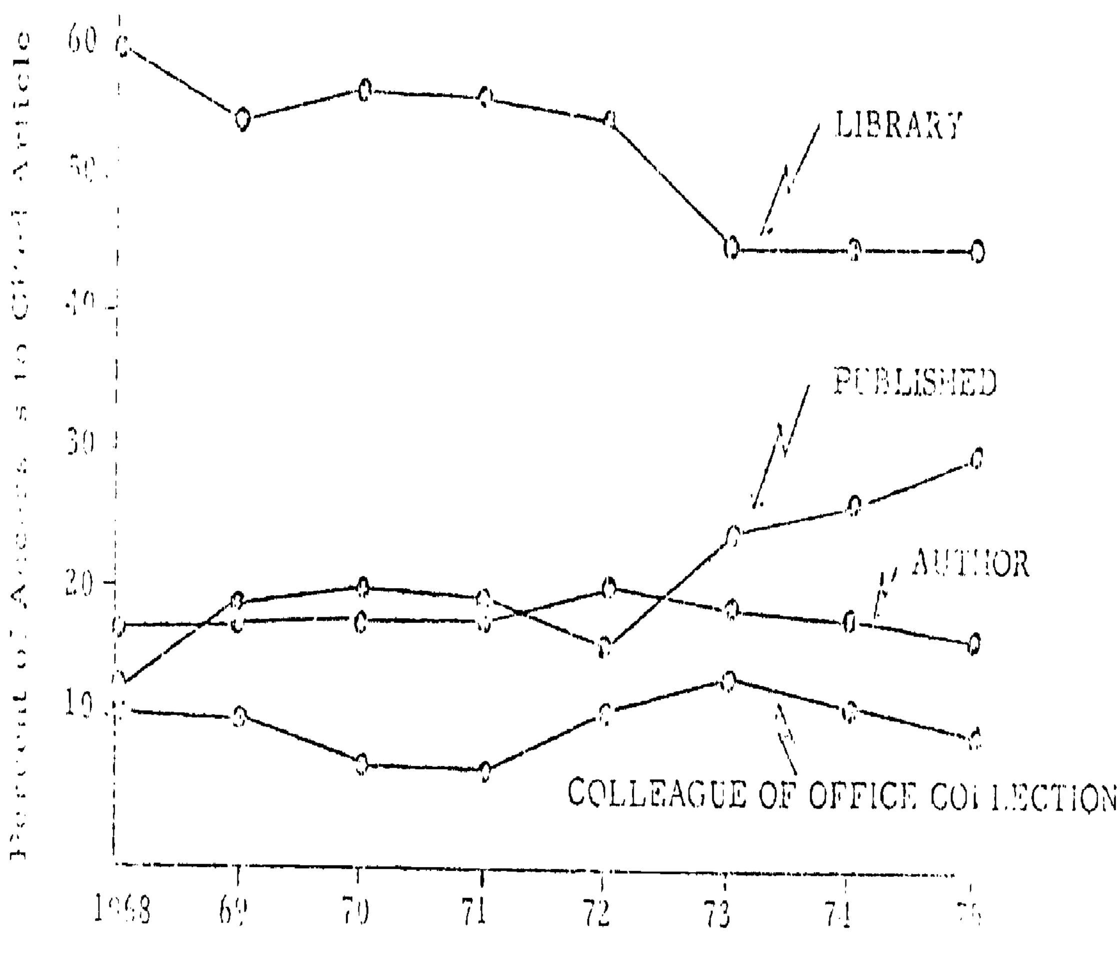
SOURCE: Author Survey, Market Facts, Inc., Center for Quantitative Sciences.

Figure 6.7 RELATIVE USES OF SOURCES OF ACCESS TO CITED ARTICLES, BY YEAR OF CITING ARTICLE, IN CONSTANT DOLLARS: 1968-1975



SOURCE: Table 6.5

Figure 6.8 RELATIVE USE OF SOURCES OF ACCESS TO CITED ARTICLES BY YEAR OF CITING ARTICLE IN PERCENTAGES: 1968-1975



SOURCE: Table 6.5

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Given these considerations, the following conclusions are drawn:

1. The library continues to be the most important source of access for non-self-citation articles cited by authors of scientific and technical articles.

2. Cited authors are more important sources of access than are the citing author's colleagues or office collections, when no differentiation is made on the basis of article form.

3. The importance of publishers as a source of access is on the rise, both proportionally and in absolute terms.

4. Proportional use of libraries as a source of access has declined since 1968, though this decline may be levelling off.

Another access factor identified by the Author Survey was the use of subscription versus non-subscription forms of access. A user might obtain a subscription issue from a variety of sources; from a colleague who subscribes, from a library which is a subscriber to the journal, or from his or her own subscription. A non-subscription source would be anything else: a reprint, a preprint, a photocopy obtained from a colleague, etc. Table 6.6 and Figure 6.9 show the trends in the use of subscription versus non-subscription sources. It appears that since 1968 the use of subscriptions for obtaining access to cited articles has risen nearly proportional to the rise in the total number of articles cited. At the same time, the access via non-subscription forms (reprints, preprints, etc.) has remained fairly constant, with only a slight rise since 1968. Unless these trends are based on a recall bias of respondents, it appears that the formal and informal exchange of reprints and preprints is decreasing in importance relative to the use of subscription sources.

Figure 6.10, "Relative Use of Subscription and Non-Subscription Forms, by Field of Science", shows some variation among the different fields of science. Because of the variation in the number of respondents to the Author Survey among the nine fields of science, these figures should be viewed with some care, but we feel that the general picture is indicative of the relative importance of these access forms. In all fields, subscriptions are more important than non-subscription forms. Also, in all

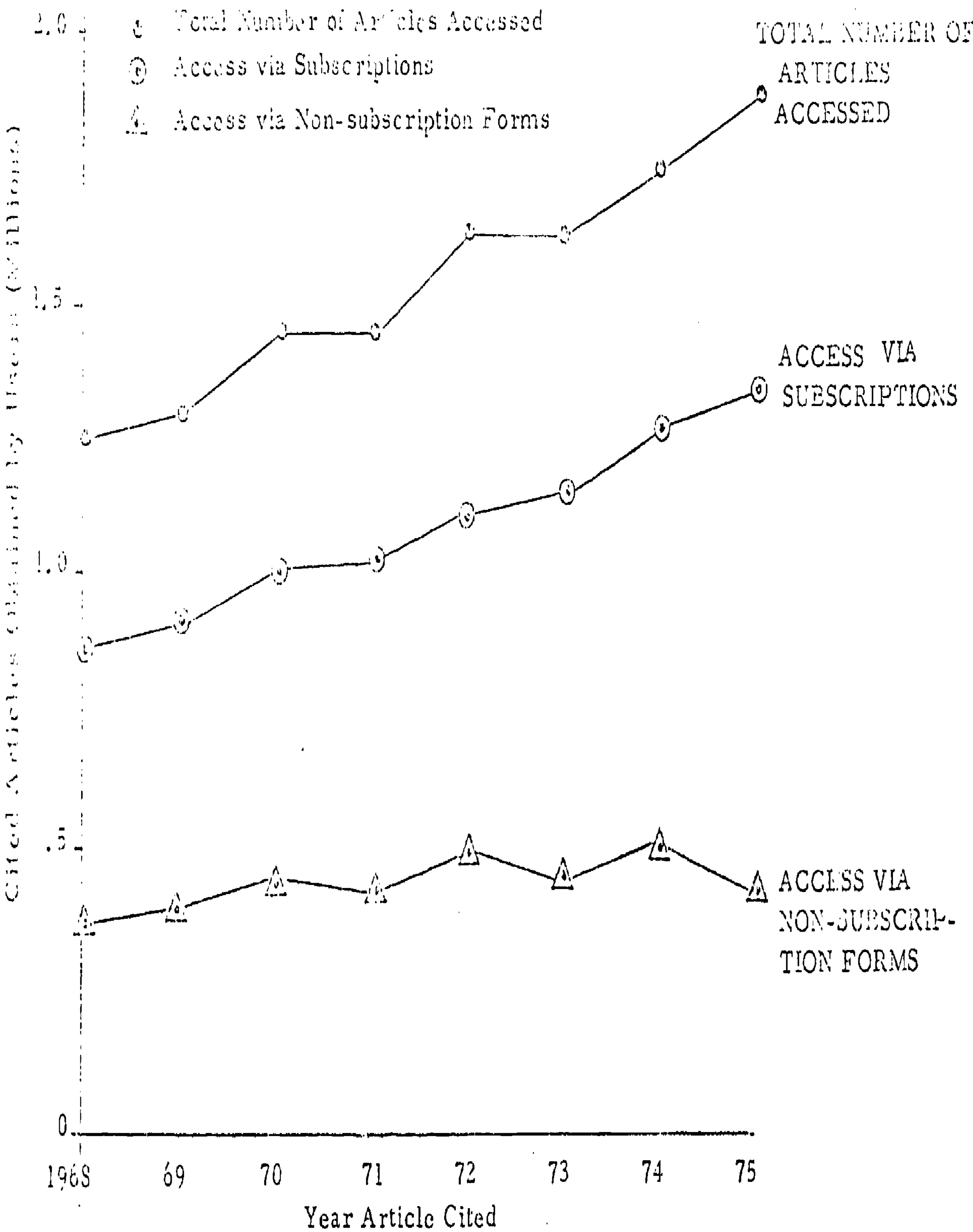
Table 6.6 TRENDS IN THE USE OF SUBSCRIPTION AND NON-SUBSCRIPTION SOURCES: 1968-1975

(Thousands of Articles Cited, Three-Year Moving Averages)

Form of Access	Year of Citing Article 1968	1969	1970	1971	1972	1973	1974	1975
<u>Subscription</u>								
User's Own	155.8	229.5	260.1	258.2	236.6	384.5	453.6	524.3
From Library	723.6	660.7	736.2	748.3	826.4	716.6	771.8	773.1
From Colleague/ Office Collection .	11.4	21.6	22.9	34.0	44.4	58.0	62.1	56.4
Subtotal	890.8	911.8	1,019.2	1,040.5	1,107.4	1,159.3	1,287.5	1,353.8
<u>Non-Subscription</u>								
Reprints	293.7	285.0	268.5	240.0	268.7	268.0	285.7	251.7
Other Forms	85.6	109.5	174.4	182.3	239.1	220.4	217.1	161.8
Subtotal	379.3	394.5	442.9	422.3	507.8	488.4	502.8	413.5

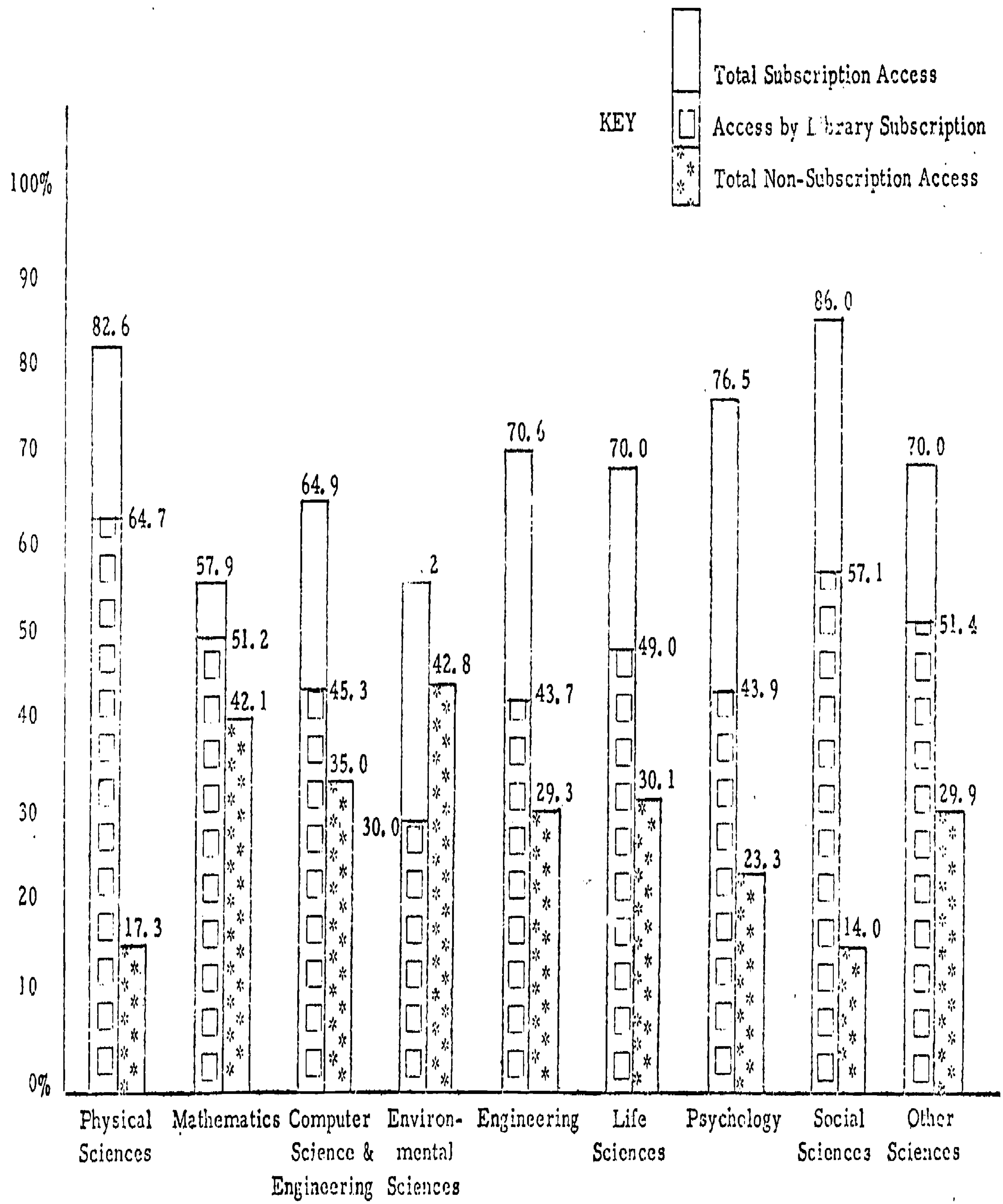
SOURCE: Author Survey, Market Facts, Inc., Center for Quantitative Sciences.

Figure 6.9 TRENDS IN THE USE OF SUBSCRIPTION AND NON-SUBSCRIPTION SOURCES: 1968-1975



SOURCE: 6.6

Figure 6.10 RELATIVE USE OF SUBSCRIPTION AND NON-SUBSCRIPTION FORMS, BY FIELDS OF SCIENCE



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

cases except one (environmental sciences), library subscriptions are more important than non-subscriptions.

A final consideration of access sources concerns the types of subscriptions. It has been shown above that library subscriptions are consistently one of the most (if not the most) important forms of access for a user obtaining access to a cited article. Figure 6.11, "Trends Among Uses of Various Types of Subscriptions" shows how libraries relate to other subscription sources. It appears that, while the library is the most important source for use of subscriptions, it has declined proportionally to user subscriptions, especially since 1972. Again, this is a somewhat surprising finding. We would normally speculate that, as individual subscription prices rise, users would turn to institutional subscriptions. Perhaps authors of scientific and technical articles are not typical of all users of scientific and technical literature. Or perhaps this finding may be due to the different ages of cited articles obtained from various subscription sources (e.g., see Table 8.10, "Most Frequently Employed Channels for Identification and Access"). More research and analysis is necessary to support or reject these hypotheses.

Given these above considerations concerning the form of cited articles obtained by citing authors, we suggest the following conclusions:

1. Not surprisingly, subscriptions are consistently the most important methods for obtaining access to cited articles when compared with non-subscription forms of access.

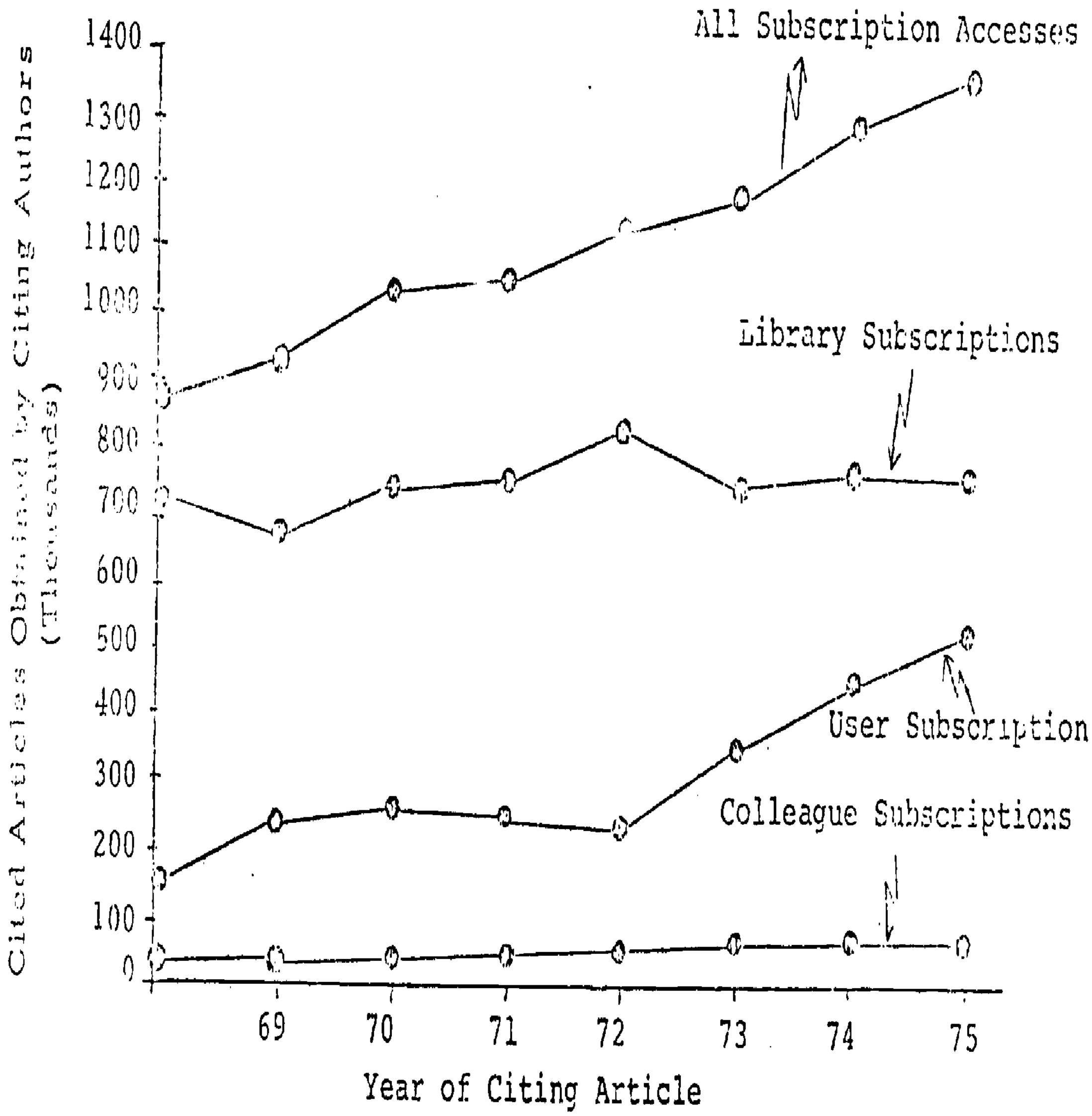
2. Relative use of subscription vs. non-subscription forms of access differ among fields of science.

3. Authors' (user's) own subscriptions appear to be gaining in importance relative to library subscriptions for obtaining access to cited articles.

6.4 Identification and Access in Libraries

We have seen that libraries play an important role in the provision of journal articles and, similarly, they serve as a major source of other types of materials. Libraries assist in the identification and access

Figure 6.11 TRENDS AMONG USES OF VARIOUS TYPES OF SUBSCRIPTIONS: 1968-1975



SOURCE: Table 6.6.

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function by providing for in-house use of materials, circulation, inter-library loan, and reference services. Data on most of these activities are generally available only for individual libraries.

6.4.1 Circulation and In-Library Use

Circulation includes those materials checked out of libraries for use elsewhere. In general, periodicals and other materials do not circulate so that circulation statistics represent mostly book use. At the MIT Science Library (76), it was found that the mean circulations per year for each circulatable volume was 1.10. If this relationship holds constant over time and for all academic libraries, the volume of S&T circulation can be estimated. For example, if half the items in academic libraries (Table 4.5) are circulatable S&T books, total annual circulation volume would go from 104 million in 1960 to 250 million in 1974, an increase of 140 percent. This is equivalent to an average annual increase of 6.5 percent.

An index of public library circulation is compiled by the Library Research Center of the Graduate School of Library Science (53) of the University of Illinois for a sample of American public libraries. The 1960-1974 increase for this index has been 25 percent, an average annual increase of 1.6 percent. Scientific and technical circulation of public library books is assumed to be a small part of total S&T library circulation.

Circulation figures were compiled in the 1972 Survey of Federal Libraries (81). Science and technical libraries accounted for about 12.5 million circulations in 1972.

In-house use of materials is thought to be related to circulation. Morse (76), again at the M.I.T. Science Library, found that for each item circulated about four books and seven periodicals are consulted in the library.

6.4.2 Interlibrary Loan

Interlibrary loan is the process by which library material is made available by one library to another for the use of an individual patron. All types of materials, including periodicals (or photo copies of periodical articles) are loaned. 1972 estimates of interlibrary loan volume, as shown in Table 6.7, total about 6.7 million requests with about 63 percent of these actually filled (i.e., successfully handled) by the lending library. From these figures, we estimate the volume of scientific and technical requests in these libraries to be about 2.6 million with a fill rate of 71 percent.

Table 6.7: ESTIMATED VOLUME OF INTERLIBRARY LENDING IN 1972 FOR ALL TYPES OF LIBRARIES

Type of Library	Loan Requests Received	Fill Rate (%)	Total Loans Filled
Academic	1,850,000	68	1,258,000
Public	2,235,000	52	1,165,000
Special	387,000	81	314,000
Regional Medical* . .	600,000	79	474,000
Federal	1,098,000	67	735,000
State	500,000	50	250,000
Total, All Libraries	6,670,000	63	4,196,000

SOURCE: Palmour, Vernon E. et.al., Resources and Bibliographic Support for a Nationwide Library Program, 1974.

*Palmour, Vernon E. et.al., Access to Periodical Resources: A National Plan (NSF GN-35571), February 1974.

The characteristics, costs, and magnitude of interlibrary loan (ILL) in academic libraries have also been investigated. Palmour's estimates of the total number of ILL requests made, with projections to 1980, are shown in Table 6.8. About 48 percent of the requests analyzed were for

Table 6.8 TOTAL ACADEMIC INTERLIBRARY LOAN REQUESTS: 1966-1980

(Thousands)

Year	Total Academic ILL Requests
1966	1039
1967	1191
1968	1488
1969	1750
1970	2122
1971	2217
1972	1790
1973	2238
1974	2393
1975	2549
1976	2705
1977	2860
1978	3016
1979	3172
1980	3327

SOURCE: Palmour, Vernon E., Access to Periodical Resources: A National Plan, Association of Research Libraries, 1974.

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periodicals, and about 60 percent for scientific and technical materials. Cost figures derived from a sample of twelve libraries showed an average borrowing cost of $7.61 per request and average loan processing costs of $2.12 for unfilled requests and $4.67 for filled requests, or a total cost of $13.43 per completed request.

An important factor in the increase of interlibrary loans has been the formation of library networks or consortia, formalizing traditional cooperation among libraries. The Directory of Academic Library Consortia (40), compiled in 1971, identified 124 academic library networks, 80 percent of which listed expanded interlibrary loan service among their activities. More recently, the Indiana study (48) identified the number of consortia to which sampled academic, public and special libraries belonged. Results indicated an average of 1.5 to 2.3 consortia for academic libraries (in four strata), 1.1 to 1.6 consortia for public libraries (three strata) and 1.8 to 2.4 consortia for special libraries (two strata).

Of particular importance are the networks which involve libraries from more than one state. Based on the entries in the Directory, nearly 80 percent of the multistate networks had been founded since 1966. The literature suggests that this trend is increasing, particularly with the emphasis currently placed on networking by the National Commission on Libraries and Information Science and other library agencies. As involvements in consortia increase, so does access to materials via interlibrary loan.

6.5 Identification and Access Costs

Identification and access costs are made up of library service costs, the cost of time spent by scientists in identifying and accessing materials, bibliographic data base search costs and photocopying costs. Estimates of these figures are shown in Table 6.9.

Library service costs were taken from Table 4.15 and represent all services provided, including circulation, in-library use, interlibrary loan, and reference. To identify the scientists' costs, we assume (arbitrarily)

Table 6.9 IDENTIFICATION AND ACCESS COSTS

(Millions of Dollars)

Year	Library Service Costs	Data Base Search Costs	Scientists Costs	Photocopying Costs	Total Current	Total Constant*
1960	37	-	377	31	445	507
1961	42	-	440	31	513	577
1962	47	-	477	31	555	617
1963	52	-	520	35	607	666
1964	58	-	555	35	648	700
1965	64	-	616	38	718	762
1966	72	-	681	39	792	817
1967	83	-	757	43	883	883
1968	98	10	829	46	983	945
1969	110	12	925	47	1,094	1,003
1970	121	16	1,018	52	1,207	1,049
1971	140	20	1,093	58	1,311	1,091
1972	152	26	1,165	59	1,402	1,128
1973	164	35	1,291	65	1,555	1,165
1974	176	46	1,428	65	1,715	1,185
			PROJECTIONS			
1975	195	71	1,580	71	1,917	1,213
1976	205	95	1,748	75	2,123	1,258
1977	219	128	1,924	81	2,352	1,306
1978	232	174	2,099	85	2,590	1,345
1979	243	240	2,291	89	2,863	1,398
1980	256	332	2,481	96	3,165	1,452

* GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

that a scientist spends, on the average, one hour per week locating materials*. Costs are then computed similarly to the calculation of assimilation costs (see Section 7).

In addition to scientists' time, another element of search costs is for the use of machine-readable bibliographic data bases. These costs were derived as shown in Table 6.10. The number of searches is taken from estimates shown in Figure 6.5, with an annual growth rate of 33 percent after 1975. A cost of $100 per search, or $20 million for 200,000 searches was assumed for 1971. Then, based on a cost model developed by Westat (66), the $20 million were divided into $9.6 million ($48 per search), plus $7.8 million fixed computer costs and $2.6 million other fixed costs. If the number of organizations searching data bases remains constant, so should the fixed costs. Per search and other fixed costs were adjusted by professional, administrative, and clerical pay levels, and computer costs were assumed to remain at $7.8 million. Total costs for each year were then computed as per search costs times the number of searches plus fixed computer and other costs.

Photocopying costs calculated were restricted to copies made of journal articles, in both libraries and offices. The procedure used to estimate photocopy costs was as follows (See Table 6.11). The number of photocopies made of cited articles has increased very slightly from 1967 to 1974 as determined in the Author Survey. The trend line over this period of time is given in Figure 6.12. This trend line is used to estimate the number of photocopies prior to 1967 and after 1974. The line is as follows:

$$Y = 636 + 9.48\ X$$

where: Y is the estimated number of photocopies (in thousands) and
X is the year (0 = 1967, 1 = 1968, . . .)

To convert to the total number of photocopies, we assume that the number of photocopies is about 50 times the number of cited articles which are photocopied. The number of pages photocopied is found by multiplying the number

*Estimates in the literature range from "a small portion" of 2 hours per week to 3.3 hours per week.

Table 6.10 DATA BASE SEARCH COSTS:* 1968-1980

Year	No. of Data Base Searches (Thousands)	Cost Components (Millions of $)			Total Cost (Millions of $)	Cost Per Search ($)
		Per Direct Search Cost	Fixed Costs			
			Computer	Other		
1968 . . .	10	0.4	7.8	2.2	10.4	1,040
1969 . . .	50	2.1	7.8	2.3	12.2	244
1970 . . .	120	5.4	7.8	2.4	15.6	130
1971 . . .	200	9.6	7.8	2.6	20.0	100
1972 . . .	300	15.3	7.8	2.8	25.9	86
1973 . . .	450	24.3	7.8	2.9	35.0	78
1974 . . .	610	34.8	7.8	3.1	45.7	75
1975 . . .	1,000	60.0	7.8	3.2	71.0	71
1976 . . .	1,333	84.0	7.8	3.4	95.2	71
1977 . . .	1,769	116.8	7.8	3.5	128.1	72
1978 . . .	2,353	162.4	7.8	3.7	173.9	74
1979 . . .	3,129	228.4	7.8	3.9	240.1	77
1980 . . .	4,162	320.5	7.8	4.1	332.4	80

* Current dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

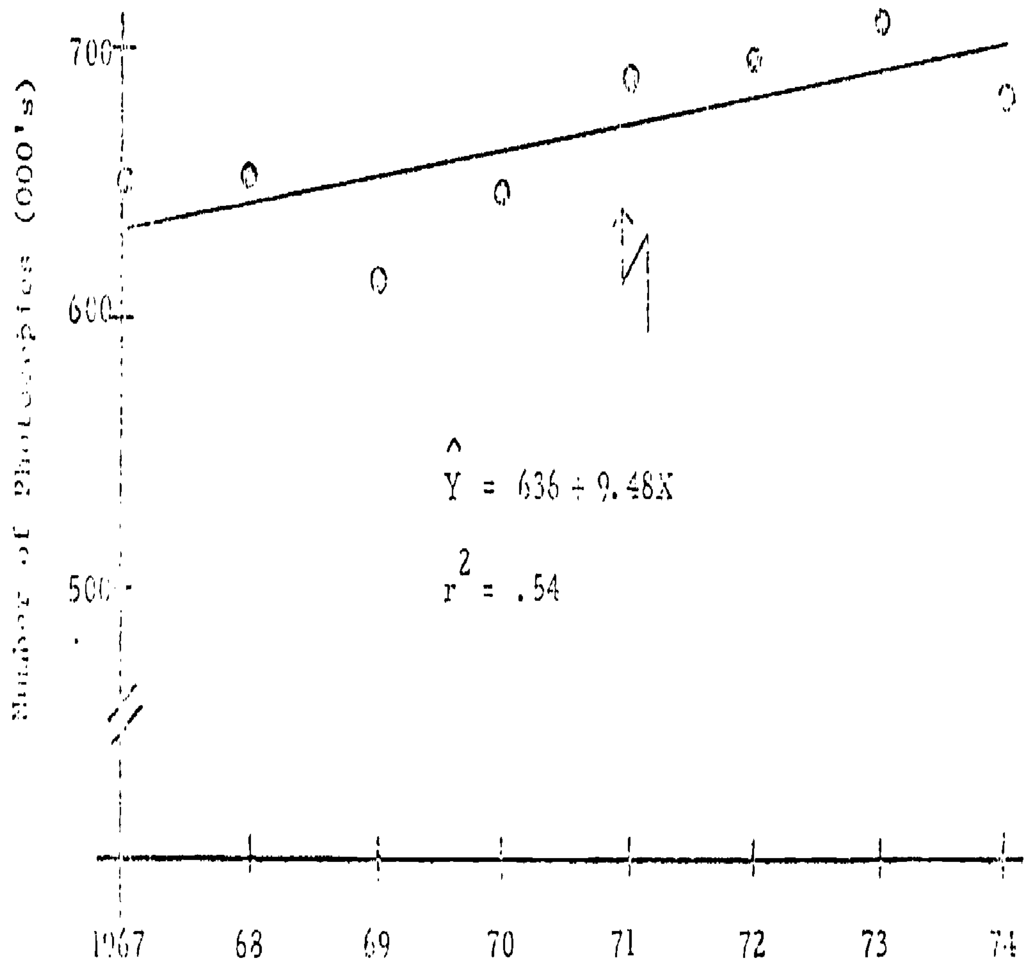
Table 6.11 ESTIMATED NUMBER OF PHOTOCOPIES, NUMBER OF PAGES PER COPY, AVERAGE COST PER PAGE AND TOTAL COST: 1962-1980

Year	Number of Photocopies (Millions)	Number of Pages/Copy	Total Number of Photocopy Pages (Millions)	Average Cost/ Page (Current $)	Average Cost/ Page (Constant $)*	Total Current $ Cost (Millions)	Total Constant $ Cost* (Millions)
1962 . . .	29.5	7.6	224.2	0.14	0.16	31.4	35.9
1963 . . .	30.0	7.7	231.0	0.15	0.16	34.6	37.0
1964 . . .	30.4	7.7	234.1	0.15	0.16	35.1	37.5
1965 . . .	30.9	7.7	237.9	0.16	0.17	33.1	40.4
1966 . . .	31.3	7.7	241.0	0.16	0.17	39.6	41.0
1967 . . .	32.6	7.7	251.0	0.17	0.17	42.7	42.7
1968 . . .	32.7	7.8	255.1	0.18	0.17	45.9	43.4
1969 . . .	30.8	8.0	246.4	0.19	0.17	46.8	41.9
1970 . . .	32.4	8.1	262.4	0.20	0.17	52.5	44.6
1971 . . .	34.5	8.0	276.0	0.21	0.17	58.0	46.9
1972 . . .	34.8	7.7	268.0	0.22	0.18	59.0	48.2
1973 . . .	35.6	7.6	270.6	0.24	0.18	65.0	48.7
1974 . . .	34.2	7.6	259.9	0.25	0.17	65.0	44.2
1975 . . .	35.5	7.7	273.4	0.26	0.16	71.1	43.7
1976 . . .	35.9	7.7	276.4	0.27	0.16	74.6	44.2
1977 . . .	36.4	7.7	280.3	0.29	0.16	81.3	44.8
1978 . . .	36.9	7.7	284.1	0.30	0.16	85.2	45.5
1979 . . .	37.3	7.7	287.2	0.31	0.15	89.0	43.1
1980 . . .	37.8	7.7	291.1	0.33	0.15	96.1	43.7

*GNP implicit price deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Figure 6.12 NUMBER OF PHOTOCOPIES MADE OF CITED ARTICLES AS A FUNCTION OF TIME



SOURCE: Market Facts, Inc., Center for Quantitative Sciences

of photocopies made times the average number of pages per manuscript found in the journal tracking survey for each year (1962 to 1974). The cost is estimated to be $0.25 per page and is adjusted by secretarial wage levels.

SECTION 7

ASSIMILATION AND USE OF INFORMATION

7.1 Introduction

The final stage in the information transfer process, Assimilation by User, is one of the most intangible. This is the stage at which information (as opposed to documents) may be transferred. That is, a document may be studied and its contents assimilated by a user. At this point the user, having identified and obtained access to the document, is informed; i.e., the state of knowledge of the user on the subject matter of the document is altered. This "new" information may be used to generate new ideas and research, it might be forgotten, or it might simply affect the user's future behavior in some subtle, difficult to detect manner.

An understanding of the role information plays in research is important to an understanding of the context in which scientific and technical information is assimilated. It seems important, therefore, that the study of information transfer should take research stage into account. Egan and Henkle (47) writing in 1956, outlined eight stages in the research process and identified the types of information source that might be most useful at each stage. The stages identified were:

1. Perception of the problem;
2. Definition of the problem;
3. Formulation of the hypothesis;
4. Choice of method of investigation;
5. Choice of techniques to be used in gathering and analyzing evidence;
6. Search for evidence or data;
7. Conclusions concerning original hypothesis;
8. Discussion of consequences.

Garvey and Griffith (50) considered the research stage in their study of psychologists in an academic department and a government laboratory. They found that in the first phase of a research project psychologists obtained ideas and defined problem areas in two ways, through the literature and in conversations with colleagues, occasionally supplementing one approach with the other. The psychologists appeared to regard information-gathering more important in the last two stages of their projects and considered information most valuable in the final stage when they were trying to interpret data. They were anxious in this stage to consult someone who could understand their results. In general they maintained contacts with colleagues throughout the research process although some withdrew in the second stage to work alone.

Allen (2) investigated scientists and engineers on research and development teams and found that the proportion of total time spent in three modes of information-gathering (literature search, consultation with technical staff, and consultation with external sources) varied over the duration of projects. Information-gathering reached its maximum early in the project, declined in the middle phase, and increased slightly in the final stage. For scientists, written channels predominated throughout, challenged by verbal channels only in the second stage. Literature was an effective means of generating ideas and helped determine the manner in which the ideas would be assessed. Scientists spent most of the time devoted to literature search actually reading rather than searching for materials. Engineers also had a surge of information-gathering activity early in the projects. For them written channels were still secondary to verbal channels. Written channels were strongest, however, in the early phase, declining continuously in the last two phases. There were two periods of heavy use of oral channels: one peaking early in the project in which contacts were usually established with internal sources, the second in the final third of the project in which both internal and external sources were contacted.

We are dealing in this presentation primarily with formal scientific communication. Both formal and informal forms of scientific communication have their respective costs, benefits, and sociological implications at each stage of the research cycle, according to Garvey and Griffith (50). Scientific journals, as part of this formal system and being, for the large part "quality controlled", perform functions not only of communication but also respond to the developing and shaping of scientific disciplines. Also, being formal channels, they function in a quasi-free market economy in which it is assumed that journal quality and worth are indicated by subscriber willingness to pay.

Garvey, Tomita, and Woolf (52) are among the researchers who have put the use of scientific information into the context of the performance of research. They examined how information use changes over successive stages of research projects. When sources of obtained information were investigated over all stages of research, local colleagues, students, and journals were the most important sources. When formal and informal sources were examined for the types of information needs which they satisfied best, they seemed to complement each other perfectly:

> Journals are most useful in providing information needed to place a scientist's work in proper context with similar work already completed and to integrate his findings into current scientific knowledge.....local colleagues and students are superior providers of information needed to select a design for data collection, to design equipment or apparatus or to choose data-gathering technique.

In reality, a high proportion of documents has low demand, while a small proportion has high demand, according to King and Palmour (69). This was pointed out in the American Psychological Association studies (4). Few user studies, unfortunately, measure demand and actual readership of documents, although studies such as those described by MacKenzie and Buckland use library circulation data on specific ooks as an aid in the determination of loan policies (72).

Actual data on trends in this Assimilation stage is difficult to come by, especially as an input to the development of scientific information indicators. Studies such as those dealing with scientific innovation and "critical incidents" do not generally generate longitudinal data of the type requir for this report. Therefore, it is necessary to turn to citation analysis studies, which provide a second-order record of the volume of information assimilated.

7.2 Citation Analysis

Citation analysis has been used in a number of ways to describe science and scientific communication. One of the most significant uses has been to describe trends in the development of scientific disciplines and sub-disciplines, as in the work of Price (121). Price has shown how the study of article production and citations can help identify core areas, or "research fronts", which, when studied over time, give an indication of the relative influence and importance of authors and disciplines.

Price and Gursey (127) have also shown that the population of source authors and cited authors can be subdivided into groups of "transient" and "continuing" authors. Only a certain percent of authors are cited at least once, and an even smaller percent are cited continually. Both percents seem related to author productivity, i.e., those authors who are continually cited have a higher likelihood of being continuous publishers. However, in Little Science, Big Science, Price (121) warns against using "numbers of papers published" as an absolute measure of author performance. Individual journal and article quality must also be taken into account.

Cole and Cole (34) studied physicists and their status based on number and pattern of their citations in the Science Citation Index and found that sheer volume of publishing has little relation to building a reputation; having "a few solid papers" need not be a strike against one.

In the field of chemistry, Small (137) focused on the relationship between citation rates and subject orientation, reviewer rating, author affiliation, and NSF funding. He concluded that the specific field of chemistry followed the general scientific trend in that a core of books and articles was the focus of concentrated interest. Small does, however, point out that many cited items are older items, and that scientists do not necessarily consult a book or report each time it is cited. This is evidence that raw citation data would not be a perfectly accurate indicator of the time spent by scientists in "assimilating" the literature.

Bush, Hamelman, and Staaf (30) used citations to papers appearing in specific economics journals from other journals in the same discipline.

Garfield of the Institute of Scientific Information (49) discusses the use of citations to individual journals (unweighted, and weighted by the number of published papers to produce an "impact factor") to evaluate journals. Houghton (61) describes their use as an aid to journal selection by librarians. In recent years, citation figures have drawn increased attention as a quantitative input to the evaluation of both individual scientists' and research programs' output, as reported by Wade (149).

Another significant use of citation data, particularly important as an indicator of the "health" of scientific communication and research, is the comparison of U.S. and non-U.S. journal citation patterns. Narin and Carpenter (78), working with a data base drawn from Science Citation Index have examined trends in the utilization of scientific journals through an analysis of cross-citation between journals and disciplines in different countries. Using as an indicator the ratio of percent of citations to percent of publications, it was found that the United States is generally the most highly cited country with the United Kingdom next. The U.S. scored particularly high in the fields of physics, chemistry, and molecular biology, while in three areas the U.S. did not score as the most highly cited; systematic biology, psychology, and engineering.

Output from the Computer Horizons' (78) study is displayed in Table 7.1 and Figure 7.1; the latter selectively plots citation-to-publication ratios for the United States, United Kingdom, and USSR.

We should note that the process for defining Field of Science is different for the particular results, so that a direct comparison between Computer Horizons' and Market Facts' data is not possible by field. It should be obvious, however, that significant differences do exist between various disciplines.

Also, the report points out that the relatively low ratios for the Soviet Union may not be due to the relative quality of soviet scientific literature, but to a possible lack of availability of soviet literature outside that country.

Table 7.1 CITATION-TO-PUBLICATION RATIOS, BY FIELD OF SCIENCE AND COUNTRY: 1965-1972

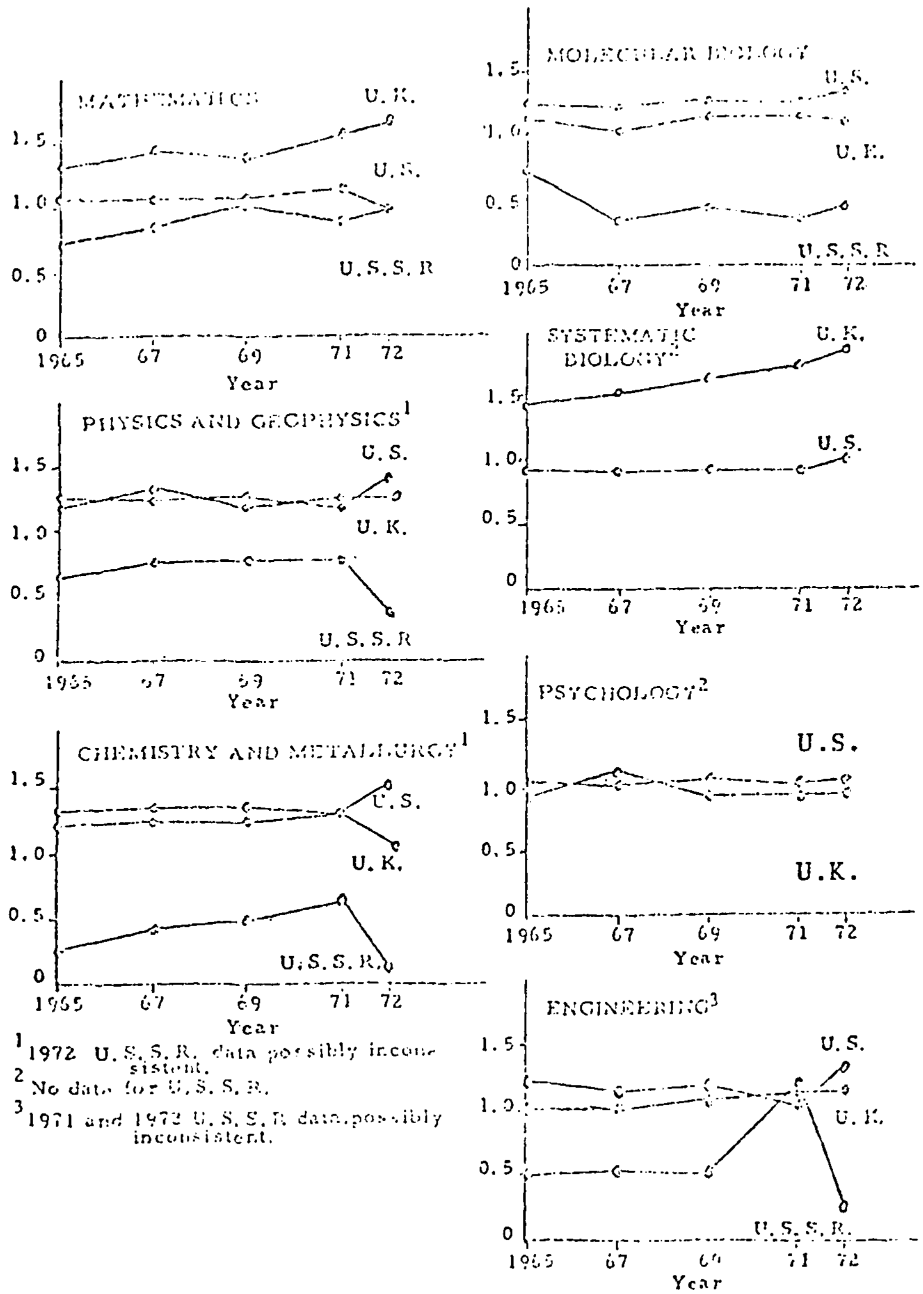
Year	United States	United Kingdom	[illegible]	France	USSR	Japan	Other
			Mathematics (SCI)				
1965	1.09	1.33	[illegible]	0.79	0.73	0.81	0.79
1967	1.05	1.44	[illegible]	0.75	0.81	0.94	0.85
1969	1.08	1.39	0.76	0.67	1.00	0.93	0.77
1971	1.10	1.54	0.66	0.73	0.69	0.93	0.69
1972	0.98	1.62	[illegible]	0.56	0.95	0.35	0.71
			Physics and Geophysics (SCI)				
1965	1.28	1.23	[illegible]	0.50	0.68	0.73	0.85
1967	1.24	1.29	[illegible]	0.46	0.75	0.63	0.87
1969	1.26	1.25	[illegible]	0.52	0.76	0.61	0.85
1971	1.20	1.23	1.15	0.57	0.76	[illegible]	0.81
1972	1.39	1.23	0.90	0.55	0.39*	0.71	0.86
			Chemistry and Metallurgy (SCI)				
1965	1.34	1.21	0.93	0.79	0.25	0.70	0.90
1967	1.35	1.38	1.02	0.56	0.41	0.66	0.80
1969	1.36	1.26	1.02	0.56	0.50	0.61	0.81
1971	1.31	1.31	1.09	0.53	0.66	0.61	0.77
1972	1.51	1.07	1.45	0.62	0.14*	[illegible]	0.75
			Molecular Biology (SCI)				
1965	1.29	1.19	0.61	0.35	0.75	0.72	0.76
1967	1.27	1.07	0.62	0.45	0.35	0.68	0.77
1969	1.28	1.17	0.62	0.37	0.47	0.68	0.79
1971	1.25	1.17	0.62	0.38	0.37	0.70	0.77
1972	1.32	1.12	0.79	0.35	0.16	0.54	0.76
			Systematic Biology (SCI)				
1965	0.98	1.46	1.07	0.79	-	0.93	0.82
1967	0.96	1.54	1.27	0.87	-	0.90	0.80
1969	0.97	1.65	1.11	0.88	-	1.05	0.78
1971	0.94	1.75	1.13	1.00	-	0.94	0.81
1972	1.01	1.86	1.00	0.92	-	0.86	0.73
			Psychology (SCI)				
1965	1.02	0.94	-	-	-	-	0.90
1967	1.02	1.13	-	-	-	-	0.86
1969	1.06	0.91	-	-	-	-	0.82
1971	1.04	0.92	-	-	-	-	0.78
1972	1.05	0.94	-	-	-	-	0.74
			Engineering (SCI)				
1965	1.21	1.03	0.84	0.62	0.51	0.94	0.81
1967	1.18	1.05	0.97	0.60	0.57	0.85	0.85
1969	1.20	1.10	[illegible]	0.69	0.54	0.88	0.85
1971	1.08	1.12	0.71	0.62	1.18*	0.70	0.78
1972	1.34	1.13	[illegible]	0.32	0.29*	0.91	0.76

Note: Numbers not included for countries with less than 1 percent of publications.

*Indicates data possibly affected by changes in [illegible]. All 1972 data [illegible].

SOURCE: [illegible]

Figure 7.1 CITATION TO PUBLICATION RATIOS BY FIELD OF SCIENCE



[1] 1972 U.S.S.R. data possibly inconsistent.
[2] No data for U.S.S.R.
[3] 1971 and 1972 U.S.S.R data, possibly inconsistent.

SOURCE: Computer Horizons, Inc., Further Development of Indicators of the Quantity and Quality of the Scientific Literature, 197[illegible].

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The above Computer Horizons' results referred to frequency of citation; the same study also showed a levelling-off during 1971-1972 of the number of U.S. publications, accompanied by a somewhat complementary rise in the numbers of publications attributable to smaller countries.

The Computer Horizons' study goes on to investigate the relationship between the previously discussed citation-to-publication ratio and individual country's publication volume for 1972 publications. In this analysis of a quality indicator, citations between different fields of science were eliminated, and the citation-to-publication measure of different countries was "standardized" by dividing by the ratio of country x's share of publications in the discipline under study. Results of this analysis of 1972 data

> "...reveals that U.S. publications are cited far more frequently by scientists throughout the world than those of any country, even after allowance is made for the larger quantity of U.S. publications" (78)

Table 7.2, "U.S. Standing as Indicated by Citation to Publication Measure", displays these results. Further studies will investigate the relationship between publishing volume and frequency of citation.

Meadows (74) discusses the consequences of using averages to describe citation characteristics, which should be kept in mind when using average citation figures as a measure of the useage of scientific and technical literature. First, the number of references which authors cite in their articles may vary considerably over time, changing with the subject field and with the journal sample under consideration. Second, the number of references which an author makes to other articles in his or her own article depends a great deal upon the age of the cited item, with recent literature being much more frequently used than older literature. This also may differ with the authorship of the cited literature. An author's own or co-worker's journal articles may be cited when they are newer simply because they contain directly relevant research information. This point will be discussed when data on article transfer channels is presented.

Table 7.2 U.S. STANDING AS INDICATED BY CITATION TO PUBLICATION MEASURE*

Citing Country	Cited and Citing Field							
	Math	Eng	Phys	Chem	M.Bio	Med	S.Bio	Psy
U.S.	1.34	1.49	1.53	1.87	1.53	1.61	1.38	1.09
U.K.	1.08	1.00	1.40	1.47	1.31	1.03	.74	.86
W. Germany	1.10	.89	1.24	1.20	1.21	1.02	.79	.93
France	.88	1.16	1.23	1.33	1.27	1.19	.78	1.03
USSR	.64	.38	.66	.83	1.06	1.00	.56	.62
Japan	1.08	1.18	1.43	1.46	1.31	1.45	.86	1.02
World	1.24	1.20	1.32	1.47	1.41	1.34	1.12	1.06
Non-U.S.	1.11	.96	1.22	1.31	1.30	1.13	.88	.95

* Based on incomplete data for 1972 publications supplied by Institute for Scientific Information to Computer Horizons.

SOURCE: Computer Horizons, Inc., Further Development of Indicators of the Quantity and Quality of the Scientific Literature (NSF-C627, Amendment #4), February 1974.

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We found in the journal tracking survey that the total number of items cited pe   le has been fairly constant since 1962, while articles as a porportion of items has increased slightly, as shown in Table 7.1:

Table 7.3: ESTIMATED NUMBER OF ITEMS CITED PER ARTICLE: 1962-1974

(All Fields of Science Combined)[1]

Year	Total Number of Items Cited Per Article	Number of Articles Cited Per Article	% of Items Cited Per Article Which are Articles
1962 . . .	16.4	9.1	55
1964 . . .	14.9	8.7	58
1966 . . .	15.9	9.6	60
1968 . . .	14.5	8.4	58
1970 . . .	15.3	10.3	67
1972 . . .	15.9	10.5	66
1974 . . .	16.5	10.9	66

[1]"Items" includes journal articles plus books, monographs, disserations, conference proceedings, etc.

SOURCE: Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

"Items" includes anything which an author may reference in an article: books, articles, technical reports, films, computer programs, cases, laws, statutes, pamphlets, etc. These estimates are based on observations of more than 3,000 individual articles.

Journal articles cited per article may be thought of as a measure of the use of the periodical literature, especially when compared with how many other items per article are cited. In the table shown above, it appears that the relative use of journal articles (cited as references in the published literature) has increased slightly since 1962, when all fields are considered together. Table 7.4 displays the number of all items and articles

Table 7.4 ESTIMATED NUMBER OF ITEMS CITED PER ARTICLE, BY FIELD OF SCIENCE: 1962-1974*

Field of Science		1962	1964	1966	1968	1970	1972	1974
Physical Sciences	Total Items	10.1	8.2	15.6	13.5	14.5	13.5	18.7
	Articles	7.9	6.1	12.6	10.1	11.9	10.0	12.9
	(%) Articles	78.0	74.0	81.0	75.0	82.0	74.0	69.0
Mathematics	Total Items	13.7	8.4	8.0	7.8	8.8	7.5	9.5
	Articles	9.3	5.4	4.8	5.0	5.6	4.7	6.0
	(%) Articles	68.0	64.0	60.0	64.0	64.0	63.0	63.0
Computer Sciences	Total Items	7.5	7.5	10.2	7.4	6.9	8.7	9.7
	Articles	3.6	2.9	6.2	3.5	3.5	3.9	4.4
	(%) Articles	49.0	38.0	61.0	48.0	51.0	45.0	45.0
Environmental Sciences	Total Items	13.4	14.1	14.7	13.9	22.2	12.8	15.8
	Articles	9.1	10.0	10.9	8.9	16.2	9.7	12.2
	(%) Articles	68.0	71.0	74.0	64.0	73.0	76.0	77.0
Engineering	Total Items	6.2	6.7	9.8	8.7	12.1	10.2	13.9
	Articles	3.9	4.0	6.2	5.2	7.5	6.2	10.6
	(%) Articles	63.0	60.0	63.0	60.0	62.0	61.0	76.0
Life Sciences	Total Items	15.5	15.1	13.4	13.2	15.0	15.1	14.0
	Articles	11.6	11.8	11.0	10.4	12.0	13.0	11.3
	(%) Articles	75.0	78.0	82.0	79.0	80.0	86.0	80.5
Psychology	Total Items	11.5	10.8	12.6	14.8	14.8	15.2	13.7
	Articles	7.7	5.7	8.2	8.9	10.2	9.3	9.2
	(%) Articles	67.0	52.0	65.0	60.0	69.0	61.0	60.0
Social Sciences	Total Items	38.2	30.9	40.0	32.2	23.7	35.3	28.8
	Articles	5.7	4.6	4.9	4.0	6.5	9.1	7.3
	(%) Articles	14.0	15.0	12.0	13.0	28.0	25.0	26.0
Other Sciences	Total Items	10.5	12.0	19.1	9.8	11.1	14.9	16.1
	Articles	6.2	8.4	13.4	6.4	6.1	7.9	10.3
	(%) Articles	60.0	70.0	70.0	65.0	55.0	53.0	64.0
All Fields	Total Items	16.4	14.9	15.9	14.5	15.3	15.9	16.5
	Articles	9.1	8.7	9.6	8.4	10.3	10.5	10.9
	(%) Articles	55.0	58.0	60.0	58.0	67.0	66.0	65.0

*"Items" includes journal articles plus books, monographs, dissertations, conference proceedings, etc.

SOURCE: Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

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cited per article by field. Also given in this table is the percent of items cited per article which are journal articles. For most fields, the percentage of journal articles among all citations is in the range 60 to 80 percent, with Physical Sciences, Life Sciences, and, to a lesser extent, Environmental Sciences on the high end, and Computer Sciences and Social Sciences on the low end. Social Sciences is low because of the influence of a number of law journals in the sample, in which the ratio of journal articles to total numbers of laws, statutes, and cases is especially low. We would also expect Social Sciences to be low in this regard due to the importance of books and monographs relative, say, to the natural sciences.

Meadows (74) suggests an average of twelve to fifteen references for each published article. Our estimates are slightly higher when all fields of science are combined, ranging from 14.5 to 16.5 for the period 1962 through 1974. Our data for individual fields of science also demonstrate field differences for the number of total items and articles cited per article.

The actual significance of the variations in types and numbers of items cited per article across time and across fields of science is difficult to determine. We have assumed that it shows generally that journal article authors in some fields make heavier use of the journal literature than authors in other fields. What this signifies about substantive differences in the role played by scientific and technical journals in different fields we cannot say.

The number of technical reports cited per article was also counted in the journal tracking survey, but the results of this analysis showed that the average number of technical reports cited per journal article is usually less than 1.0 for most combinations of field of science and year. We had hoped to detect a change in the percentage of items which are technical reports, possibly correlating this with NTIS sales, but the data are inconclusive. It appears that there are still barriers to acknowledgement of technical reports to the "open" journal literature. A better indicator of assimilation of information contained in technical reports may be the citation of technical reports by other technical reports.

7.3 The Cost of Assimilation of Scientific and Technical Literature

There is not a great deal of data on the cost of reading (or assimilating) scientific and technical literature. The special appendices to the SATCOM (59) report which were prepared by Conyers Herring reported several studies that provide some evidence concerning these costs in the early 1960's; we did not identify any further information. However, chances are that the amount of time spent by scientists reading journal articles or books has not changed too much. What has changed is their labor costs.

The SATCOM gives a good summary of what is probably the best source of information, the study prepared by Case Institute of Technology in 1960 (33). In this study, the operations researchers measured the proportion of time spent by physical scientists in scientific and technical information communications activities. This measure was established by use of a random alarm mechanism (RAM) which rang at random times during the day at which time scientists recorded the activity in which they were engaged. They found, from a sample of 297, that chemists working for research departments read journals on an average of 3.3 percent of the time while others read an average of 1.4 percent of the time. The corresponding proportion of time for a sample of 404 physicists was 2.7 percent and 1.0 percent respectively. The average for all physical scientists would be about 2.0 percent of their time spent reading journal articles.

Overall, the average time spent reading journal articles was 2.0 hours per week. An earlier study (33) had estimated 2.7 hours per week for chemists. The American Chemical Society reported that industrial chemists spent 5.8 hours per week using primary journals and 2.7 hours per week using books. We will assume from this that scientists spend about one-half the amount of time reading books as they do reading journals. If one assumes that the average time reading journals is in proportion to the production of journal articles, we can make gross estimates of the costs incurred annually in reading journal articles. Thus, physical scientists would read journal articles on an average of 41.6 hours per year. They, in turn, produced an average of 0.043 articles per scientist in 1962 whereas the scientific and engineering communities as a whole produced 0.086 articles per scientist in that year. Thus, we assume that overall the average annual time devoted to reading journals is 83.2 hours. It is further assumed that this number remains reasonably constant over the years.

The estimate of the amount of time reading books is one-half that of journal articles, based on the study mentioned above. Thus, we will assume that scientists and engineers spend an average of 41.6 hours per year reading scientific and technical books. As a very gross estimate of the amount of time spent reading scientific and technical reports, we will assume that every copy ordered from NTIS and GPO is read for two hours on the average. Any total generated from this number is likely to be highly conservative since there are many more reports than those distributed by these agencies, and copies distributed are likely to have multiple readings.

Even though these estimates are based on old data obtained in a limited field, we feel that the overall order of magnitude of costs is not out of line. The funds expended in reading scientific and technical literature are substantial and, like the expenditure in writing articles, should be considered when studying the overall journal system.

If one assumes 41.6 hours per year reading journals, in 1974 there would have been an accumulated total of 110 U.S. scientist-hours spent, on the average, reading each U.S.-published article. (This number assumes that all articles are read the year published. Of course many articles read in 1974 were old articles and many articles published in 1974 will be read in the future.) Similarly, if one assumes 20.8 hours per year reading books in 1974, there would have been an accumulated total of about 2,400 scientist hours spent for each book copy distributed. These figures do not seem unreasonable. Technical reports are assumed to be read two hours for each copy distributed.

The total costs for literature assimilation derived from these gross estimates are given in Table 7.5. Since the costs reflect both an increase in salaries (above the GNP implicit price deflator) and an increase in number of scientists, the current dollar costs have increased 307 percent from 1960 to 1975 and should increase 59 percent from 1975 to 1980. Even in constant dollars this increase is 126 percent from 1960 to 1975. Thus,

Table 7.5 ESTIMATED TOTAL COST OF ASSIMILATION OF THE BOOK JOURNAL, AND REPORT LITERATURE: 1960-1980

(Millions of Dollars)

Year	Books	Journals	Reports	Total
1960	327	654	-	981
1961	352	705	-	1,057
1962	382	763	-	1,145
1963	416	832	-	1,248
1964	444	887	-	1,331
1965	493	986	-	1,479
1966	545	1,090	31	1,666
1967	606	1,212	50	1,868
1968	663	1,325	[illegible]	2,026
1969	740	1,480	58	[illegible],278
1970	814	1,628	70	2,512
1971	875	1,750	84	2,709
1972	932	1,863	125	2,920
1973	1,033	2,066	159	3,238
1974	1,143	2,285	156	3,584
PROJECTIONS				
1975	1,264	2,528	205	3,997
1976	1,398	2,796	235	4,430
1977	1,540	3,079	273	4,892
1978	1,679	3,358	306	5,343
1979	1,833	3,666	345	5,844
1980	1,985	3,970	384	6,339
PERCENT CHANGE				
1960-65	50	51	-	51
1965-70	65	65	-	70
1970-75	55	55	193	59
1975-80	57	57	87	59

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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the impact of the magnitude of likely costs in this activity and the enormous increase in costs over time may have real implications on the future of journal systems and should not be ignored in planning or systems design.

SECTION 8

TOTAL COST OF COMMUNICATING SCIENTIFIC AND TECHNICAL INFORMATION

8.1 Introduction

In this section we present estimates of the total cost of communicating scientific and technical information, the relative use of the various journal article transfer channels, the median age of cited articles, and estimates of the cost effectiveness of individual article transfer channels in terms of cost per use.

We have seen that there are six functions involved in the transfer of information from originator to user, and that each function has certain costs associated with it. We have also seen that there are several forms used in the formal transfer of scientific and technical information, chief among them being articles and books.

Table 8.1 shows the 1960-1980 trends in total cost of communication of information, subdivided by books, journals, technical reports and other media. The cost for each was calculated by determining the composition, recording, reproduction, and other costs associated with each. The highest costs are associated with journals which account for 63 and 66 percent of total communication costs in 1960 and 1980 respectively. It is pointed out that the estimated cost of producing scientific and technical journals is based on extrapolating costs of scholarly journals to the number of scientific and technical journals published in the United States that were reported by the British Library Lending Division. Scientific and technical books, on the other hand, account for a range of 28 percent to 23 percent during the 1960-1980 period. The increasing percentage of total costs accounted for by journals is a result not only of increasing numbers of journals and articles, but also the increasing costs associated with producing and distributing them.

Figure 8.1 shows the estimated and projected 1960-1980 trends in costs associated with journals and books, accompanied by constant 1967 dollar values estimated using the GNP deflator and our projection of that deflator. For both current and constant dollar values, the journal costs are increasing much faster than book costs.

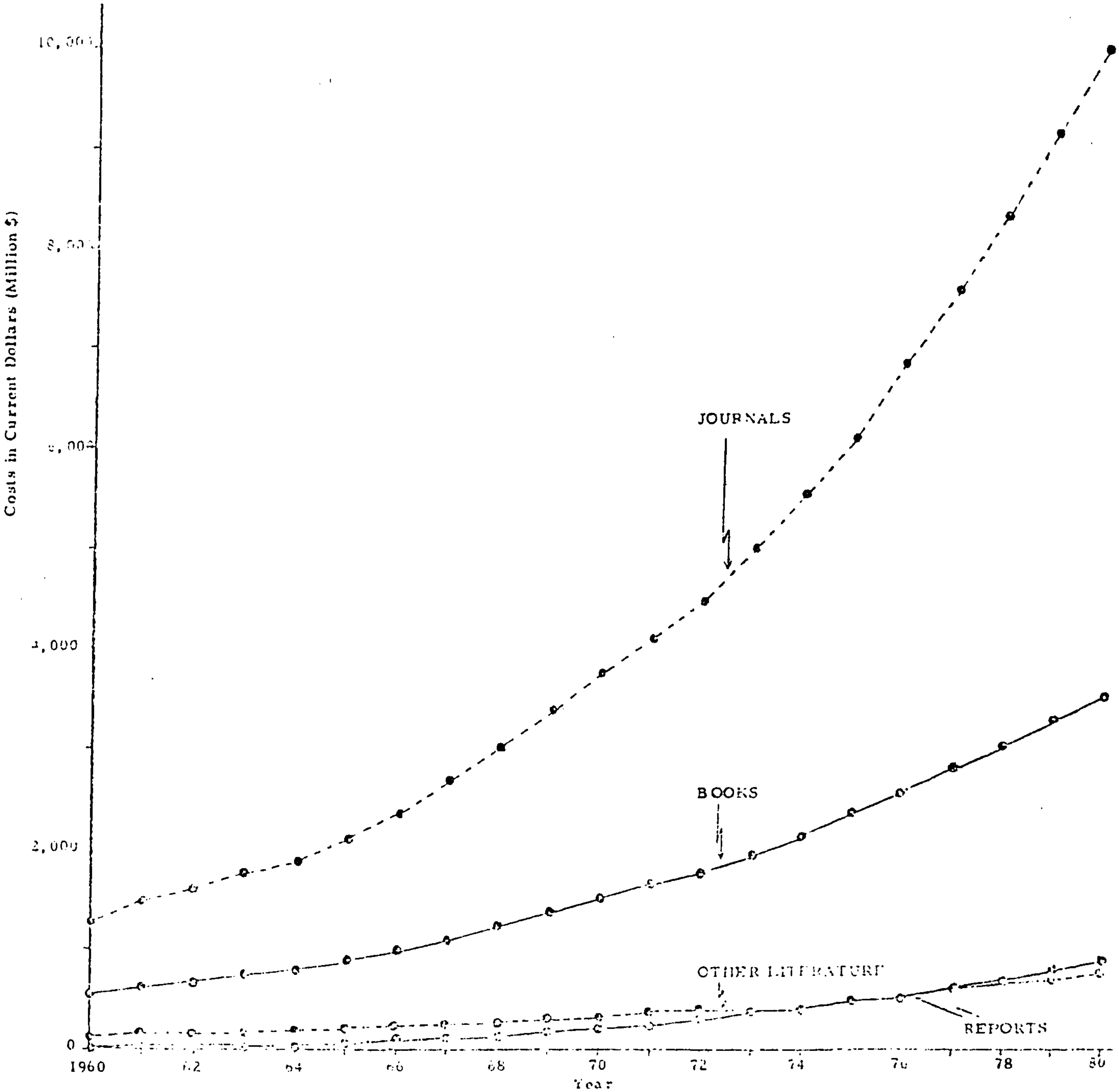
Table 8.1 ESTIMATED TOTAL COSTS OF COMMUNICATING SCIENTIFIC AND TECHNICAL INFORMATION, BY MEDIUM: 1960-1980

(Millions of Dollars)

Year	Books	Journals	Reports	Other Literature	Total
1960	571	1,277	22	141	2,013
1961	631	1,461	26	143	2,264
1962	688	1,616	28	157	2,490
1963	752	1,788	32	165	2,737
1964	817	1,897	34	177	2,925
1965	901	2,105	57	214	3,279
1966	1,004	2,384	105	219	3,712
1967	1,116	2,724	135	235	4,212
1968	1,235	3,042	133	264	4,673
1969	1,376	3,410	175	306	5,267
1970	1,519	3,789	205	334	5,846
1971	1,660	4,145	239	360	6,402
1972	1,777	4,491	305	365	6,939
1973	1,953	5,034	364	400	7,751
1974	2,144	5,559	388	433	8,525
		PROJECTIONS			
1975	2,352	6,114	471	494	9,431
1976	2,570	6,852	539	543	10,504
1977	2,807	7,572	619	597	11,595
1978	3,039	8,304	693	648	12,684
1979	3,288	9,108	781	707	13,889
1980	3,538	9,943	877	770	15,128
		PERCENT CHANGE			
1960-65 . . .	58	72	159	52	63
1965-70 . . .	69	80	260	56	78
1970-75 . . .	55	72	130	48	61
1975-80 . . .	50	67	86	56	60

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

DOLLARS: 1960-1980



SOURCE: Table 8.1

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Table 8.2 and Figure 8.2 show the estimated 1960-1980 total costs of communicating scientific and technical information, subdivided by function. The function accounting for the largest portion of total costs is assimilation, with 49 percent and 42 percent of the total in 1960 and 1980 respectively. Composition and recording ranks second over the latter years of the 1960-1980 period, and accounts for a range of 17 percent in 1960 to 23 percent in 1980. The identification and access function also represents significant costs, somewhat more than 20 percent of the total throughout the period.

These three major functions -- assimilation, composition and recording, and identification and access -- are made up primarily of scientists' labor costs. Significantly, these labor costs are rising faster than the funds expended on research and development. In current dollars, assimilation, composition and recording, and identification and access costs are projected to rise 59, 73 and 65 percent respectively while total R&D funding is expected to rise only 41 percent. These factors point to a need for reducing costs associated with the scientists' preparation and use of the literature.

As a further breakdown, the costs of communicating scientific and technical information can be shown by function for each of the four media types. This is done in Tables 8.3, 8.4, 8.5 and 8.6. Significant differences can be observed between the various media; in particular, overall growth is greatest for the technical report literature, with journals also showing substantial increases in costs based on the volume of activity. Throughout, the functions of composition and recording, identification and access, and assimilation account for the majority of the costs, with publication and distribution also playing an important role, especially for journals.

8.2 Relative Use of Journal Article Transfer Channels

As we mentioned previously, there are a variety of ways in which a user might obtain a journal article (or a copy of an article). Section 6.3 described physical access, which is one of the simplest ways of describing the path an article takes from an author to a user. Consider the following flow model where A = Author, P = Journal Publisher, L = Library, C = Colleague or office collection, and U = User:

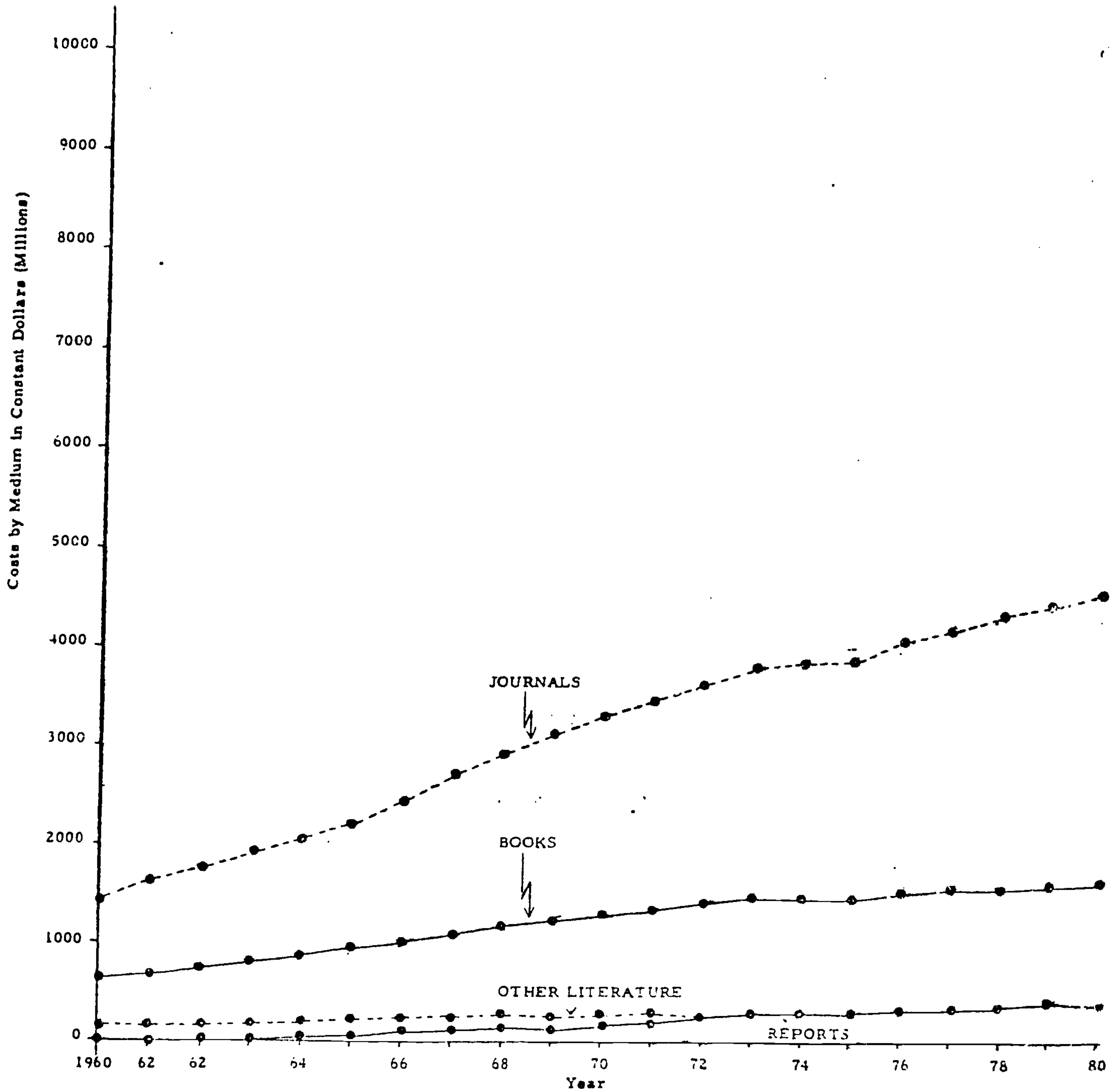
Table 3.[illegible] ESTIMATED TOTAL COSTS OF COMMUNICATING SCIENTIFIC AND TECHNICAL INFORMATION, BY FUNCTION: 1960-1980

(Millions of Dollars)

	[illegible]tion & [illegible]	Reproduction & Distribution	Acquisition & Storage	Organization & Control	Identification & Access	Assimilation	Total
1960	337	[illegible]	37	58	445	982	[illegible]
1961	304	183	42	67	513	1,056	2,264
1962	[illegible]	245	47	74	555	1,145	2,490
1963	482	267	52	81	607	1,248	2,737
1964	[illegible]	295	58	90	648	1,331	2,939
1965	597	320	64	101	718	1,479	3,279
1966	711	[illegible]	72	115	792	1,666	3,712
1967	[illegible]	416	83	128	883	1,868	4,212
1968	939	474	98	152	983	2,026	4,673
1969	1,065	548	110	172	1,094	2,278	5,267
1970	1,202	616	121	188	1,207	2,512	5,646
1971	1,342	684	149	218	1,311	2,709	6,402
1972	1,464	762	152	239	1,402	2,920	6,939
1973	1,670	851	164	253	1,555	3,258	7,751
1974	1,854	933	176	273	1,715	3,584	8,525
PR[illegible]TIONS							
1975	2,055	960	195	307	1,917	3,997	9,411
1976	2,385	1,037	205	327	2,123	4,430	10,504
1977	2,660	1,118	219	353	2,352	4,692	11,395
1978	2,951	1,201	232	378	2,590	5,343	12,684
1979	3,245	1,289	243	402	2,863	5,844	11,884
1980	3,555	1,379	256	429	3,165	6,338	15,128
PERCENT CHANGE							
1960-65 . . .	77	106	73	74	61	52	63
1965-70 . . .	101	92	89	86	68	68	78
1970-75 . . .	71	56	61	63	59	59	61
1975-80 . . .	73	44	31	40	65	59	60

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Figure 8.2 TOTAL STI COMMUNICATION RESOURCE EXPENDITURES BY MEDIUM IN CONSTANT DOLLARS: 1960-1980



SOURCE: Table 8.1

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Table 8.3 ESTIMATED COSTS OF COMMUNICATION SCIENTIFIC AND TECHNICAL INFORMATION IN BOOKS, BY FUNCTION: 1960-1980

(Millions of Dollars)

Year	Composition & Recording	Reproduction & Distribution	Acquisition & Storage	Organization & Control	Identification & Access	Assimilation	Total
1960	14	66	23	23	117	328	571
1961	21	70	26	26	136	352	631
1962	26	74	29	29	148	382	688
1963	33	77	32	32	162	416	752
1964	40	86	36	36	175	444	817
1965	43	91	40	40	194	493	901
1966	50	104	45	45	215	545	1,004
1967	49	118	51	51	241	606	1,116
1968	54	123	61	61	268	663	1,235
1969	58	143	68	68	299	740	1,376
1970	74	151	75	75	330	814	1,519
1971	85	166	87	87	360	875	1,660
1972	92	180	94	94	385	932	1,777
1973	102	190	102	102	424	1,033	1,953
1974	117	200	109	109	466	1,143	2,144
PROJECTIONS							
1975	124	206	121	121	516	1,264	2,352
1976	138	216	127	127	564	1,398	2,570
1977	152	226	136	136	617	1,540	2,807
1978	166	237	144	144	669	1,679	3,039
1979	182	247	151	151	724	1,833	3,288
1980	199	257	159	159	779	1,985	3,538
PERCENT CHANGE							
1960-65 . . .	207	38	74	74	66	50	58
1965-70 . . .	72	66	88	88	70	65	69
1970-75 . . .	66	36	61	61	56	55	55
1975-80 . . .	60	25	31	31	51	57	50
1970-75 . . .	66	36	61	61	56	55	55
1975-80 . . .	60	25	31	31	51	57	50

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Table 8.4 ESTIMATED COSTS OF COMMUNICATING SCIENTIFIC AND TECHNICAL INFORMATION IN JOURNALS, BY FUNCTION: 1960-1980

(Millions of Dollars)

Year	Composition & Recording	Reproduction & Distribution	Acquisition & Storage	Organization & Control	Identification & Access	Assimilation	Total
1960	204	88	13	29	289	654	1,277
1961	263	113	15	34	332	704	1,461
1962	269	172	17	37	358	763	1,616
1963	316	189	19	40	392	832	1,788
1964	319	208	21	45	417	887	1,897
1965	357	227	23	51	461	986	2,105
1966	452	250	26	58	508	1,090	2,384
1967	559	294	30	64	565	1,212	2,724
1968	636	342	35	76	628	1,325	3,042
1969	707	400	40	86	697	1,480	3,410
1970	794	460	44	94	769	1,628	3,789
1971	890	512	50	109	834	1,750	4,145
1972	989	574	55	120	890	1,863	4,491
1973	1,143	651	59	126	989	2,066	5,034
1974	1,264	720	63	136	1,091	2,285	5,559
PROJECTIONS							
1975	1,400	741	70	154	1,221	2,528	6,114
1976	1,655	805	74	166	1,356	2,796	6,852
1977	1,855	873	79	179	1,507	3,079	7,572
1978	2,061	944	84	194	1,663	3,358	8,304
1979	2,285	1,019	87	206	1,845	3,666	9,108
1980	2,512	1,097	92	222	2,050	3,970	9,943
PERCENT CHANGE							
1960-65	75	158	77	76	60	51	72
1967-70	122	84	91	84	67	65	80
1970-75	76	61	59	64	59	55	61
1975-80	79	48	31	44	68	57	63

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

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Table 8.5 ESTIMATED COST OF COMMUNICATION SCIENTIFIC AND TECHNICAL INFORMATION IN TECHNICAL REPORTS, BY FUNCTION: 1960-1980

(millions of Dollars)

Year	Composition & Recording	Reproduction & Distribution	Acquisition & Storage	Organization & Control	Identification & Access	Assimilation	Total
1960	-	-	-	3	19	-	22
1961	-	-	-	4	22	-	26
1962	-	-	-	4	24	-	28
1963	-	1	-	4	27	-	32
1964	-	1	-	5	28	-	34
1965	19	2	-	5	31	-	57
1966	31	2	-	6	35	31	105
1967	36	4	-	6	39	50	135
1968	38	4	1	8	44	38	133
1969	53	5	1	9	49	58	175
1970	65	5	1	10	54	70	205
1971	78	6	1	11	59	84	239
1972	95	8	2	12	63	125	305
1973	107	12	2	13	71	159	364
1974	125	12	2	14	79	156	388
PROJECTIONS							
1975	145	13	2	16	90	205	471
1976	168	16	2	17	101	235	539
1977	192	19	2	19	114	273	619
1978	216	20	2	20	129	306	693
1979	243	22	2	22	147	345	781
1980	271	25	3	25	169	384	877
PERCENT CHANGE							
1960-65	-	-	-	67	63	-	159
1965-70	242	100	-	100	74	-	260
1970-75	123	160	100	60	67	193	130
1975-80	87	92	50	56	88	87	86

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

Table 3.6 ESTIMATED COST OF COMMUNICATING SCIENTIFIC AND TECHNICAL INFORMATION IN OTHER LITERATURE, BY FUNCTION: 1960-1980

(Millions of Dollars)

Year	Composition & Recording	Acquisition & Storage	Organization & Control	Identification & Access	Total
1960	119	-	3	19	141
1961	118	-	3	22	143
1962	129	-	4	24	157
1963	134	-	4	27	165
1964	144	-	5	28	177
1965	178	-	5	31	214
1966	178	-	6	35	219
1967	190	-	6	39	235
1968	211	1	8	44	264
1969	247	1	9	49	306
1970	269	1	10	54	334
1971	289	1	11	59	360
1972	288	2	12	63	365
1973	318	2	13	67	400
1974	338	2	14	79	433
PROJECTIONS					
1975	386	2	16	90	494
1976	423	2	17	101	543
1977	462	2	19	114	597
1978	497	2	20	129	648
19[illegible]	536	2	22	14[illegible]	707
1980	573	3	25	[illegible]	770
PERCENT CHANGE					
1960-65	50	-	67	63	52
1965-70	51	-	100	74	56
1970-75	43	100	60	67	48
1975-80	48	50	56	88	56

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

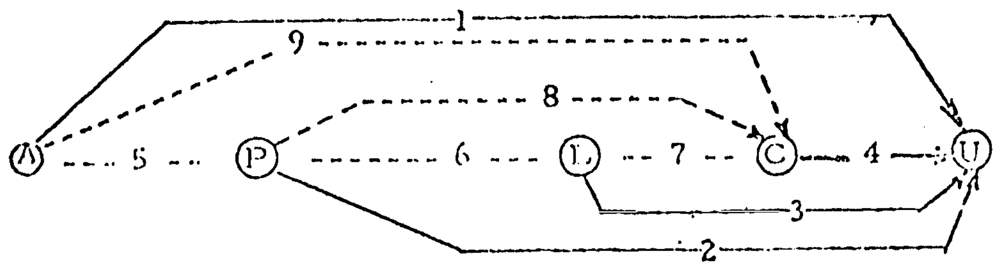

Figure 8.3 JOURNAL FLOW MODEL

In actuality, each of the channels one through nine represents a group of alternative paths leading up to use and assimilation of information contained in the journal literature. Table 8.7 describes and lists participants in these physical access channels. Each potential channels described varies according to frequency of use. This was verified by the Author Survey, which focused on the direct channels one through four.

It is possible to further subdivide the channels by method of identification. In other words, once a potential user identifies an article, there are then a variety of channels available for obtaining a copy of that article. It is reasonable to suppose, also, that there exists a relationship between how a user obtains an article and how the user identified the article. Theoretically, it should be possible to develop rough estimates of the costs associated with these various channels.

Consider the following methods of identification by which a user finds out about an article:

Table 8.8 METHODS OF IDENTIFICATION OF JOURNAL LITERATURE

1.	Discovered while reading own subscription
2.	Discovered while reading library subscription
3.	Discovered while reading colleague's or office subscription
4.	Received preprint from author
5.	Obtained preprint from colleague
6.	Received reprint from author
7.	Received reprint from colleague or co-worker
8.	Referred to article by colleague or co-worker
9.	Referred to in another article, book or report
10.	Found in search of printed indexes
11.	Found in output of computerized literature search
12.	Found in current awareness or SDI list

Table 8.7 PHYSICAL ACCESS CHANNELS FOR JOURNAL LITERATURE

Path	Participants		Alternative Descriptions
1	Author and User	(a)	User obtains reprint from author
		(b)	User obtains preprint from author
2	Publisher and User	(a)	User subscribes to journal
		(b)	User obtains reprint from publisher
3	Library and User	(a)	User reads library subscription issue
		(b)	User reads library microform edition
4	Colleague and User	(a)	User obtains reprint from colleague or office collection
		(b)	User obtains preprint from colleague or office collection
		(c)	User reads colleague or office subscription issue
5	Author and Publisher		Publisher accepts manuscript for publication
6	Publisher and Library	(a)	Library subscribes to journal
		(b)	Library purchases microform from publisher
7	Library and Colleague	(a)	Colleague obtains library subscription issue
		(b)	Colleague obtains library microform edition
8	Publisher and Colleague	(a)	Colleague or office subscribes to journal
		(b)	Colleague obtains reprint from publisher
9	Author and Colleague	(a)	Colleague obtains reprint from author
		(b)	Preprint from author

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Potentially, each of these identification techniques might be combined with each of the direct paths previously described, to result in 108 potential direct channels to the user. In actuality, some of these channels might be immediately rejected as infeasible, since, for example, identification methods one through seven may occur simultaneously with physical access. Note that 108 refers to the number of direct channels to the user; information flow to the colleague may also be described in the same manner. This results in a more complicated model, however, which is not described here.

With data from our Author Survey, we estimated: (1) which channels are actually employed by users in obtaining identification and access to the articles which they cite, and (2) the frequency with which these channels are used. Note that the description is limited to channels where articles are actually used; that is, in which the final node, the user, is reached. Use is restricted to citation use. Also, data is combined across different years with the assumption made that major shifts from channel to channel are not occurring.

Table 8.9 gives the frequency (in percent) for those channels which were identified by respondents to the Author Survey. Rows one through fourteen describe the methods of identification, and columns one through fourteen describe methods of physical access.

In Table 8.10 the most frequently employed individual channels are ranked. These channels account for 64 percent of article accesses. In other words, for articles which authors cite of which they are not co-authors, 64 percent are obtained via one of these seven top-ranked channels. Forty and eight tenths percent of these identified articles are obtained through a library's own copy of a journal. Also, this table again emphasizes the importance of individual subscriptions to scientists for identification of and access to articles which they cite, with this channel as the second most frequently used.

It is clear that the channels have widely different levels of cost associated with them. Another way of comparing the various channels is mean channel length, as shown on the right side of Table 8.10. Mean channel length was calculated by subtracting year of cited article from year of citing article and computing an average. Not surprisingly, channels which involve the library

Table 8.3
RELATIVE FREQUENCY OF IDENTIFICATION AND ACCESS CHANNELS

	1. User's Own Issue	2. Library Issue	3. Library Microform	4. Colleague/Office Copy	5. Office Microform	6. Publisher Reprint	7. Author Reprint	8. Reprint from Colleague	9. Preprint from Author	10. Preprint from Colleague	11. Colleague's Photocopy	12. No Access	13. Don't Remember	14. Other Sources, as Book	15. Total Percent
1. Discovered reading own copy	15.0	~	-	-	-	-	0.9	-	-	-	-	-	-	-	16.0
2. Discovered reading library copy	-	6.8	~	-	-	~	0.7	-	-	-	1.0	-	-	-	8.5
3. Discovered reading colleague's or office copy	-	~	-	1.0	-	-	-	-	-	-	-	-	-	-	1.0
4. Received preprint from author	0.1	~	-	-	-	0.1	0.5	-	5.1	0.1	-	-	-	-	5.9
5. Obtained preprint from colleague	~	0.1	-	0.1	-	-	-	-	0.3	1.0	-	-	-	-	1.6
6. Received reprint from author	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	0.6
7. Received reprint from colleague	-	0.4	-	0.1	-	-	1.2	4.0	-	-	-	-	-	-	5.6
8. Referred by colleague	1.9	7.7	0.4	0.5	-	0.1	2.1	1.2	0.2	0.2	0.7	~	0.1	-	15.2
9. Referred by other article, book, report	1.2	22.5	1.2	0.8	~	0.2	1.7	0.4	~	-	0.9	1.0	0.4	0.1	30.5
10. Found in search of printed indexes	0.2	8.1	0.5	-	-	0.2	1.3	-	-	-	0.1	-	-	-	10.4
11. Computerized literature search	0.6	0.3	-	-	-	-	-	-	-	-	-	-	-	-	0.9
12. Current awareness or SDI list	-	0.3	-	-	-	-	0.2	-	-	-	-	0.1	0.1	-	0.6
13. Don't remember	0.3	1.3	-	-	-	~	0.1	-	0.2	-	~	-	0.6	-	2.5
14. Other or No Response	0.6	0.1	-	-	-	-	-	-	-	-	-	-	-	-	0.7
15. Total percent	20.1	47.6	2.0	2.5	~	0.6	9.3	5.5	5.8	1.3	2.7	1.1	1.1	0.2	100.0

SOURCE: Market Facts, Center for Quantitative Sciences, Author Survey.
Key: - = No response received in this category
~ = Less than 0.1 percent of total

Table 8.10 MOST FREQUENTLY EMPLOYED CHANNELS FOR IDENTIFICATION AND ACCESS

Rank	Frequency (%)	Identification	Source of Access	Form of Access	Mean Path Length (Years)
1.	20.0	Referred to in other article, book or report	Library	Library copy of journal	15.0
2.	13.8	Discovered while reading own copy of journal in which article appeared	Publisher	User's own copy of the journal	4.6
3.	7.5	Found in a search of printed indexes or catalogs during the course of a literature search	Library	Library copy of journal	16.8
4.	7.1	Referred to article by a colleague or co-worker	Library	Library copy of journal	12.6
5.	6.2	Discovered while reading library copy	Library	Library copy of journal	12.5
6.	4.9	Received a preprint from author	Author	Preprint	4.1
7.	4.5	Received reprint from colleague or co-worker	Colleague	Reprint	8.0
	64.0				

SOURCE: Author Survey, Market Facts, Inc., Center for Quantitative Sciences.

have the longest mean channel length, while those involving the user's own subscription or reprints or preprints have the shortest.

8.3 Median Age of Scholarly Journal Articles Used

In the Journal Tracking Survey the published data of the original article and a cited article were both noted. From this we observed the age of cited articles up to twenty years. The data were also broken out by the source used to obtain the article including individual (i.e., user or colleague subscription), library, and other (i.e., reprints, preprints and so on). The data are presented in Table 8.11 by the cumulative proportion of article citations by age of cited articles. The median age for the journal citations is often referred to as the "half-life" of the literature since one-half of the citation uses occur before and one-half after that time. The half-life is as follows: for all articles, about 10.5 years; articles obtained through individual subscriptions, 3.7 years; articles accessed through libraries, about 11.8 years; and articles found by other means such as reprints, about 7.2 years. (Note that these median values are slightly lower than the mean path length values displayed in Table 8.10, evidence of a skewed distribution). The results are as one might expect. The age of copies obtained through one's own subscription (or that of a colleague) is about one-half of the age of copies obtained through libraries. Obviously, older articles are less likely to be held by an individual because the individual is too young to have subscribed to an old issue of a journal, or because files are just not maintained for long periods by most individuals.

By comparison, Houghton (61) refers to the half-life observed for references made in articles published in leading journals in several fields during the years 1953 to 1954. These figures are displayed in Table 8.12

8.4 Cost Effectiveness of Journal Channels

We have attempted to gain some insight into the cost-effectiveness of the journal channels mentioned above. As shown, we have been able to identify in some detail the activities which are performed in the use of each channel, as well as the corresponding volume of each activity. Combining this with associated costs, we have derived a figure of cost per use for each of the major channels. This figure is a reflection, then, of the total costs which go into

Table 8.11 CUMULATIVE PROPORTION OF ARTICLE CITATIONS BY AGE OF ARTICLES FROM ISI AND JOURNAL TRACKING SURVEY

Age in Years	Total ISI[1]	Journal Tracking Survey[2] Total	Individual	Library	Other
1	0.11	0.114	0.175	0.025	0.052
2	0.23	0.171	0.301	.054	0.118
3	0.33	0.221	0.425	0.097	0.175
4	0.41	0.265	0.521	0.149	0.262
5	0.48	0.305	0.610	0.202	0.324
6	0.55	0.342	0.671	0.247	0.409
7	0.60	0.379	0.726	0.292	0.482
8	0.65	0.414	0.771	0.332	0.556
9	0.69	0.449	0.820	0.383	0.591
10	0.72	0.484	0.846	0.431	0.610
11	0.75	0.519	0.880	0.483	0.638
12	0.78	0.552	0.904	0.523	0.667
13	0.80	0.585	0.935	0.562	0.688
14	-	0.616	0.969	0.591	0.709
15	-	0.644	0.969	0.622	0.742
16	-	0.669	0.973	0.649	0.768
17	-	0.689	0.976	0.687	0.790
18	-	0.709	0.976	0.718	0.804
19	-	0.730	0.979	0.760	0.816
20	-	0.750	0.979	0.800	0.820

SOURCE: [1] Institute for Scientific Information, Philadelphia, Pennsylvania.

[2] Journal Tracking Survey, Market Facts, Inc., Center for Quantitative Sciences.

Table 8.12 SELECTED HALF-LIFE VALUES OF THE JOURNAL LITERATURE FOR INDIVIDUAL DISCIPLINES

(Years)

Field	Half-Life
Chemical Engineering	4.8
Mechanical Engineering	5.2
Metallurgical Engineering	3.9
Mathematics	10.5
Physics	4.6
Chemistry	8.1
Geology	11.8
Physiology	7.2
Botany	10.0

SOURCE: Houghton, Bernard, Scientific Periodicals, Their Historical Development, Characteristics, and Control, 1975.

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the maintenance of a particular channel and the related volume of information use which occurs.

Gross estimates of figures for the cost per use are as follows:

Individual subscription	$6.80
Individual subscription (via colleague)	$9.00
Library subscription	$6.50
Reprint	$3.10
Reprint (via colleague)	$5.00

The average cost overall is about $5.95 per use.

The difference in costs are remarkably small in view of the total cost components which are included in each channel. Individual subscription costs are, of course, primarily direct and limited, whereas much more substantial figures go into the maintenance of a library journal system. This is balanced, in the cost per use figures, by the considerable use made of libraries.

The estimates above are based on cost estimates related to five channels and six sub-functions associated with these functions. These estimates are as follows:

Table 8.13 COST ESTIMATES OF COMMUNICATION BY FIVE CHANNELS AND SIX SUB-FUNCTIONS: 1974

	Channels				
Sub-Function	Individual Subscription	Colleague Subscription	Library Subscription	Reprints to Individual	Reprints to Colleague
Reproduction and Distribution	$5.56	$5.56	$2.48	$0.92	$0.92
Acquisition	1.27	1.27	0.31	0	0.09
Storage	1.27	1.27	0.33	0.09	0.09
Maintenance	0	0	2.26	0	0
Circulation	0	0	0.32	0	0
Accession	0	1.90	0.76	2.12	4.02
Total	$6.83	$9.00	$6.46	$3.13	$5.03

SOURCE: Market Facts, Inc., Center for Quantitative Sciences.

The procedure used to arrive at these average costs as described in Table 8.13 are described below.

From previous data, it has been shown that the number of scholarly journal articles published in 1974 was estimated to be 150,572 (Table 3.41). We assume that there are 690 readings per article (4) and that 24.8 percent (Table 8.9) of these go through the individual subscription channels (including colleague subscriptions). Thus, there are an estimated 25.8 million uses by this means. The total cost of individual subscriptions includes an estimated 7,144,000 subscriptions to individuals (Table 3.25) at a price of $20.08 (Table 3.26) which yields about $143.5 million estimated total cost. Thus, the estimated average cost to individual subscribers of reproduction and distribution is $5.56.

The cost of library subscriptions is computed in a similar manner. Here, about 4.57 million total library subscriptions for scholarly journals (Table 3.21) are estimated at $29.57 each (Table 3.21) for a total cost of about $135 million. About 52.4 percent (Table 8.9) of 690 readings of the 150,572 estimated articles occur in libraries. Thus, total usage in libraries is estimated to be 54.4 million and average cost of reproduction and distribution is $2.48. Reproduction and distribution cost for reprints is estimated from the cost model to be $0.036/page (Table 3.44). Since the average number of pages published per article is estimated to be 7.6, the total cost per reprint is $.274 plus $.13 for mailing to authors. This cost is divided by .51, since that is the proportion estimated to be sent to authors and not requested (Tables 3.28, 3.29). To the result ($.79), $.13 is added for mailing the request which yields a total cost of $.92 per use for reprint reproduction and distribution.

Acquisition, storage and maintenance costs in libraries are found by dividing $16.7 million (Table 4.11), $17.8 million (Table 4.13) and $123 million (Table 4.12) by 54.4 million library uses. The storage costs for individual subscriptions are found by assuming office rental at 12 journals per square foot at $5.50 or $0.46 per journal title. It is further assumed that the average life of a journal is ten years (slightly less than the average age of a citation) which yields an average total cost of about $4.60 per journal. This number is multiplied by 7.144 million individual subscriptions and divided by 25.9 million uses to yield $1.27 per use. The estimated cost of storing reprints incurred by users is 1/77th of the $1.27 since there are 77 articles per journal. Authors incur about twice this cost since they order two reprints for each one requested. The average between the two comes to about $0.09 per use. The average circulation cost in libraries is $0.32 (153).

Accession costs are based on the cost of photocopying. The photocopying cost for individuals is $0.25 times the number of pages per article (7.6). For colleague's subscriptions we assume that all copies are photocopies, thus the average cost is $.55. Reprints require typing and mailing of requests, look-up at the office of the author and so on that is estimated to take about one-half hour of secretarial time. This makes the cost 0.5 times $3.98 (Table 3.46) plus $.13 postage, plus $1.90 for photocopy if the copy comes from a colleague's reprint.

It should be emphasized that these costs reflect current patterns of provision and use of journals associated only with the citation of articles. Thus, we have assumed that the distribution of all article uses is similar to that of uses for citation. Further, in the total system each individual channel plays an important, and perhaps a unique, role. Any changes, for example, elimination of or even decreased volume through a given channel, would affect the total system. Thus, the total implications of any modification must be considered before action is taken: and conclusions drawn from the above data must be made with great caution.

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Annex Part III: The Design of Four Systems Configurations for Publishing Scientific and Technical Journals.

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APPENDIX I

METHODS USED IN THE JOURNAL TRACKING SURVEY AND THE AUTHOR SURVEY

I.1 Introduction

The Journal Tracking Survey measured such characteristics as subscription price, volume of pages, printed characters per page, articles, and issues contained in a sample of journals in nine fields of science over the time period 196 - 1974. The author survey utilized a sample of articles drawn from jour ls selected in the Journal Tracking Survey. Authors of these sampled articles were contacted to obtain information concerning publication costs, source of references, and access to references. Sampling for both surveys was closely related, and is described in a single section, I.2. Then the two sur s are described separately in I.3 and I.4.

I.2 Sampling

Sampling for the two related surveys was accomplished in several stages. In the st stage of sampling, journal titles in each of nine fields of science for the years 1972 and 1974 were selected. A second stage of sampling consisted of selecting three issues from all issues published by the selected journals during the year of interest. Subsequently three articles were chosen from each selected issue. From articles chosen a reference citation was selected from among all citations used by the author.

I.2.1 Selection of Sample Journals

In the primary stage of sampling, journal titles representative of each of nine fields of science were selected for each of the years 196 and 1974. The nine fields of science, as defined by the National Science Foundation, were:

- I. Physical Sciences (Astronomy, Chemistry, Physics, Other Physical Sciences)
- II. Mathematics
- III. Computer Science and Engineering
- IV. Environmental Sciences (Atmospheric Sciences, Geological Sciences, Biological Oceanography, Physical and Chemical Oceanography, Ecology, Other Environmental Sciences)
- V. Engineering (Aeronautical, Astronautical, Chemical, Civil, Electrical, Mechanical, Metallurgy and Materials, Other Engineering)
- VI. Life Sciences (Biological, Clinical Medical, Other Medical, Other Life Sciences)

Psychological Sciences)

VIII. Social Sciences (Anthropology, Economics, History, Linguistics, Political Science, Sociology, Law, Other Social Sciences)

IX. Other Sciences (Science and Technology [illegible] nt, Science Policy, Other Sciences not elsewhere classified)

Porportional sampling (i.e., where the ratio of journal titles among fields is the same for both sample and universe) was rejected in favor of a sample of equal size from each field of science. A minimum of 20 journal titles per field was decided upon, for a minimum projected sample size of 180 journals.* Survey results would then be weighted upward by the reciprocal of the number of observations and by the size of the sampling universe so that results could be compared across fields. (The use of such a weighting scheme was made necessary by the use of equal sample sizes with sampling frames of different sizes. For example, Field 6, Life Sciences had nearly 20 times as many journal titles in 1974 as Field 3, Computer Science).

In order to observe changes in the principle parameters over time, journal observations were made for each of the following years: 1962, 1964, 1966, 1968, 1970, 1972, and 1974. It was felt that these seven years, when observed for each journal title, would produce sufficient trend data for projecting into the future.

Due to the growth in the total number of U. S. journals published since 1962, an additional weighting factor was introduced in sampling and final analysis. In order to generate this weighting factor, three separate strata were defined for each of the nine fields of science.

Stratum 1: Journals which existed in 1962 and 1974

Stratum 2: Journals which existed in 1962 but not in 1974 (deaths)

Stratum 3: Journals which existed in 1974 but not in 1962 (births)

*Actually, each field of [illegible] D. C. area libraries.

After sampling, each journal title was assigned to one of these three strata, based on our observation of its "behavior" between 1962 and 1974. Observed characteristics were then weighted according to the actual number of journals known to exist in a particular stratum, field, and year.

Two sampling frames were necessary, one representing the nine fields of science in 1962, the other representing the nine fields of science in 1974. The Science Citation Index 1962 Annual Source Journals, published by the Institute for Scientific Information, was used as a basis for sampling 1962 journals.* Non-U.S. journals and known translation journals were excluded from this list prior to sampling; 93 U.S. journals remained following these exclusions. Because equal sample sizes were desired, remaining journal titles were grouped into the nine NSF fields of science prior to sampling. This subject classification was based on the 1962 subject categorization used by Science Citation Index, and resulted in some overlap among the NSF fields.

This overlapping was not removed prior to sampling. Due to the multidisciplinary nature of many scientific and engineering journals, it was felt that a potential occurrence in more than one field was justified, although this meant that each sample would not be truly statistically independent. (Even though potentially overlapping samples may give a truer image of the multidisciplinary nature of journal publishing, they result in some error when survey findings are weighted up to estimate values for all U. S. journals. Statistical techniques are available for correcting this error, but they were not used due to the small amount of overlap which actually occurred in sampling.**

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* We are grateful to Institute personnel for supplying us with information on the coverage of the annual source lists.

** Nine journal titles out of the 198 finally selected occurred in more than one field: IEEE Transactions on Audio and Electroacoustics (1 and 5); Journal of the Association of Official Analytical Chemists (1 and 6); SIAM Journal on Control (2 and 3); IEEE Transactions on Information Theory (2 and 9); Journal of the American Society for Information Science (3 and 7); Technometrics (3 and 9); Ecological Monographs (4 and 6); Bell System Technical Journal (5 and 9); IEEE Transactions on Education (5, 8, and 9).

A separate list was used as a basis for sam ng 1974 journals. This list was developed by Bernard M. Fry and associates at Indiana University for the NSF-sponsored "Study of the Economics and Interaction Between Publishers and Libraries in the Production, Acquisition, and Lending of Journals". The methodology for developing this list is described in Appendix IV. Three exclusions were made from this list, prior to sampling: (1) Journals not included in the nine NSF fields of science (e.g., Humanities, Fine Arts, etc.); (2) Journals known to be translation journals; (3) Known foreign publications. One thousand nine hundred and forty-five journals remained as a basis for 1974 sampling.

Initially, a sample of twenty journal titles was desired for each field for a minimum sample size of 180. In actuality, each field was over-sampled to insure that 1962-1974 issues for at least twenty journals would be located in Washington, D. C. area libraries. In addition, within each field more titles were selected from the 1974 list than from the 1962 list (approximate ratio: 13 to 7) to reflect the growth in the number of journals between 1962 and 1974.

Titles were sampled systematically from alphabetically arranged 1962 and 1974 lists. A sampling interval for each field and list was calculated by dividing the sample universe size by the desired sample size, and a random number table was used to generate a random start. During the course of the study, two journals (both in Field 8, Social Sciences) were replaced with journals randomly selected from the 1974 list when it was found that neither could be located in Washington, D. C. area libraries. The final sample titles for each field are listed in Appendix II. Appendix III shows journal distribution among publishers.

I.2.2 Selection of Sample Issues

The second stage of sampling involved the selection of issues within a particular publishing year for a given journal in a given field. Again, a fixed sample size was used. Field workers, after counting the number of issues published per year by the journal under observation,* used a random number table to select three issues for further observation. Workers were instructed to cycle through the random number table in order not to choose the same journal issues for each journal year.

*"Published per year" was defined as regularly published per year. Occasional extra or memorial issues were not counted.

I.2.3 Selection of Sample Articles

Within each issue an article was selected for observation. Again a random number table was used to select one article. Workers were required to select only from "research" articles, omitting letters to the editor, book reviews, abstracts, biographical articles, brief notices of research in progress, conference announcements, and the like.

I.2.4 Selection of Sample Cited Articles

A required input for the Author Survey was a sample of article authors, coupled with one randomly selected article which they had cited. Therefore, for each article sampled in the Journal Tracking Survey (the "citing article") a randomly chosen journal article from the article's bibliography was chosen (the "cited article"). Due to the particular requirements of the Author Survey (the generation of data relating to the identification of and access to cited articles) the following criteria were developed for input to the Author Survey mailing list:

1. The citing article must provide a sufficient U. S. address for the first author;
2. The citing article must be published no earlier than 1968;
3. None of the authors of the cited article must match any of the authors of the citing article.

During the course of the Journal Tracking Survey, it soon became apparent that its randomly selected articles would not generate sufficient numbers of articles to satisfy the above criteria. In order to develop the desired list of 2,000 U. S. authors for the Author Survey, an additional data collection effort was mounted, and nearly 2,000 extra author addresses and citations were collected from journals known to provide sufficient address data during the time period under consideration, 1968-1975. The non-random nature of the mailing list should be taken into account when reviewing the results of this study. In all, 2,123 author survey questionnaires were mailed out, and 943 were returned in time for tabulation by hand and by computer. If the 64 received after the cut-off date are included, a (surprisingly high) response rate of 48 percent was obtained.

I.3 Journal Tracking Survey

I.3.1 Introduction

The rationale behind performing the tracking survey was that the examination of a specific set of journals over the time period 1962-1974 would generate a longitudinal set of data large enough to provide a basis for estimating trends associated with this most basic commodity of scientific communication. Much of the data dealing with the graphic characteristics of journals would form a basis for estimating journal production costs. These costs would then be compared with subscription price, circulation, and other factors for an economic analysis. The volume of pages, articles, issues, and printed characters contained in these journals provided a basis for comparing information generation over time and among the various fields of science. Examination of changes in subscription prices would provide a basis for determining past and future trends in the effects of inflation. When combined with the volume of data available from other sources, a significant body of data has been provided for understanding the role of the journal in scientific communication.

I.3.2 Design of Tracking Survey Form

The tracking survey form was a compromise among several data collection objectives:

1. It needed to serve as an input to other efforts (specifically, cost model calculations, the Author Survey, and the general indicators study)
2. It covered several levels of data (specifically, journal issue, and article characteristics)
3. It had to be simple to facilitate training inexperienced field workers for field sampling and tedious measurement work.
4. It needed to generate input data which would require a minimum of computer manipulation to generate useable data in a format appropriate for further analysis.

A two-page form was originally designed to time workers as an aid to estimating how much time would be needed for data collection in the field. This form was then revised to further reflect data requirements of the Author Survey and the cost model calculations. The final revised tracking survey form is shown in Appendix V reduced from the original 8-1/2" x 14" eight-page booklet. The form consists of seven parts. At the top of the page, staff member name, date form was completed, source library, and library call number were recorded by the field workers. A unique form number was stamped on each tracking survey form, prior to use. This was used as a record tag during keypunching and computer analysis. Along the left side of the form is a ruler for measuring page size.

Part I, Journal Identification, consists of identification data which was carried through data collection and analysis. Three items in this section were used both for identification and sorting purposes: journal code (field of science and journal number) and year of journal being examined.

Part II, Subscription Information, identifies publisher, type of publisher, and distinguishes between subscription prices and membership prices. Because of wide variations in the way journals record price data, question #17, Subscription Prices, distinguishes among six separate categories.

Part III, Journal Description, covers basic descriptive data assumed to be constant over all issues published during a year, such as columns per page, lines per page, and characters per line. In addition, the number of articles per issue and pages of "notes" per issue were collected. The former number was used as a basis for our estimate of the number of articles published per year by the particular journal under consideration. The latter "pages of notes per issue" was designated to take into consideration such other information sources as brief communications, reports of work in progress, corrections, and other "current awareness" sources. Questions 29c and 29d were included to take into account the possible effect that use of bound library volumes would have on our estimate of advertising pages, since some binding processes remove covers and internal advertising.

Part IV, Article and Issue Information is identical to Parts V and VI. These pages cover data drawn from the sample of three articles and three issues which were sampled for each year a journal was observed between 1962 and 1974. Question #35 asks for the name of the first author listed. This was to be the author contacted fo the author survey. Question #39 is the author's current address as recorded in the journal, also for use in the author survey. Questions #40 - 43 dealt with grant and contract information, if this was supplied with the article. Question #44, "Date Article Received by Journal" was recorded when reported by the article. This was used in calculating publishing lags. Questions #46a covered number and pages of graphics in the sampled articles and in the n article, non-advertising portions of the sampled issue. Questions #50 and #51 refer to the reference/bibliography portion of the article; #51 is the journal article which was chosen as the "cited article" used in the author survey.

I.3.3 Tracking Survey Instructions and Training

To aid in data collection and training of field workers, an instruction manual was prepared to accompany the tracking survey form. This manual included the following:

> Journal Identification. General instructions; explanation of coding scheme for journal identification; single-digit month code; definition and description of volume and issue numbers.
>
> Subscription Information. Difference between a publishing organization and a sponsoring organization; definition of publisher codes, with examples of each; abbreviations of organizational names; description and examples of membership and subscription prices; distinctions among various categories of prices (individual, institutional, foreign); definitions of single copy prices and reprint prices.
>
> Journal Description. Definition of full page of text; method of counting columns per page, lines per page, characters per line, lines per inch; random number table and instructions for sampling three issues for the year under consideration; definitions of articles and notes for counting purposes; description of page size categories, paper types, journal formats, and journal types.

Article Information. General instructions and article sampling instructions; definitions and examples of codes for authors' institutional affiliations, with special discussion of hospitals; definition of a "funding source"; counting rules for funding sources; funding source codes; description and example of contract and grant numbers; detailed coding categories for federal agencies; rules for counting pages; definitions and/or actual examples of graphis, i.e., line drawings, graphs, tables, black and white half-tones and continuous tones, color photographs, math or chemical formulas; counting rules for reference/bibliography section, with examples of citations of journal articles and technical reports; definition of advertisements; sampling instructions for cited journal article selection.

Each field worker received an instruction booklet, and spent two to three days being "walked through" the instructions, using sample issues of journals from our office collection. During the early stages of data collection, numerous ambiguities and omissions were discovered in the instructions, and these were revised. After in-office training, workers visited assigned libraries, and were required to phone in progress reports every working day, during which time completed form numbers were recorded and questions answered. Workers were required to come into the office once per week to drop off completed forms and receive new assignments.

I.3.4 Data Collection

Because numerous subject fields were included in our journal samples, several different libraries were used as source libraries. These libraries were identified via local and national union catalogs. Toward the end of the survey, when some hard-to-find journal titles had not been located, and when some not-on-shelf journal volumes had still not been returned to the shelf, Washington area companies and special libraries were contacted by telephone, and most missing issues were located. The bulk of data collection was performed at three libraries: University of Maryland (McKeldin Library and Engineering Library) and Library of Congress. Journals were also located in the following libraries and offices: National Library of Medicine, Bethesda, Maryland; American University, Washington, D. C.; Computer Science Center, Chemistry Library, College of Library and Information Services, and Undergraduate Library, University of Maryland; Montgomery County Public Library, Davis Branch, Bethesda, Maryland; U. S. Energy Research and Development Administration, Washington, D. C.; Catholic University Library School, Washington, D. C.; U. S. National National Agricultural Library, Beltsville, Maryland; Johns Hopkins University, Baltimore, Maryland; U. S. National Bureau of Standards, Center of Computer Sciences and Technology, Gaithersburg, Maryland; Mitre Corporation, Washington, D. C.; General Electric, Washington, D. C.; Allison & Meyer, Professional Engineers, Rockville, Maryland; American Psychological Association, Washington, D. C.

Several problems surfaced repeatedly during data collection. It proved quite difficult to estimate completion rates for the tracking forms, since journals varied widely in length and complexity of graphic characteristics. Average hours performed varied widely from form to form, and also increased steadily as easy-to locate journals were completed first. Another unexpected delay in data collection was waiting time at closed-stack libraries.

When journals in the Physical Sciences field were completed and keypunched, a test run of a simple listing program was made, and numerous inconsistencies were discovered in the counting of pages of notes. Despite an attempt to clearly define "notes", wide variation in field workers' interpretation of this definition was found, and this counting was discontinued. Another difficulty which was brought to our attention during daily telephoned progress reports was in the counting of various graphics which were border-line to the examples illustrated in the instruction booklet. Coding decisions for these problems were made on ar ad hoc basis. We originally expected that data collection would be completed during the summer of 1975. Because of these delays, back-to-school season brought a large turnover in our original group of student and student-aged workers, and re-hiring and training, coupled with the above delays, extended tracking survey data collection through the beginning of November, 1975. A total of approximately 1,240 tracking forms were completed.

I.3.5 Data Processing for Tracking Survey

When the tracking survey form was designed and pretested, it had been hoped that it could be used as a direct form for keypunching without recourse to an intermediate coding form. Card and column numbers for keypunching were originally included, but were removed just prior to printing of the form when it was discovered that a major change in computer record characteristics might be necessary, due to the inclusion of certain alphabetic fields. (These fields, such as author address and publisher, were subsequently typed by hand). Keypunching was still done without an intermediate coding form.

Because no intermediate coding form was used as an input to keypunching, each tracking survey form was edited prior to keypunching. We edited each form when it was discovered in a trial data listing that keypunching of some decimal fields had been inconsistent, due to inconsistencies in reporting. This was remedied by the complete editing of forms and by explicit instructions to field workers to observe reporting requirements for decimal fields.

Data processing was accomplished in two phases: an initial listing of nearly-raw data in five separate printouts, and a final computation in which average characteristics were computed. (Average journal characteristics were also calculated by hand, using the same computational formulas).

The initial listing was in five parts:

Part 1:	Number of authors per article, author affiliations, publishing lags
Part 2:	Article characteristics (number and pages of graphics, article length, articles per issue)
Part 3:	Prices (individual, institutional, and foreign
Part 4:	Issue characteristics (graphics, advertising pages)
Part 5:	Funding source codes, grant and contract numbers, and number of items in author's bibliography

Because of the large amount of data to be included in these printouts, we decided to print only the average of article and issue characteristics which were observed three times in a given journal in a single year. All data was sorted by field of science, and within field of science, by journal and year published. Development of these printouts simplified later programming of average characteristic computations, since they required a considerable amount of work in field specification due to the great length of the individual records. The five individual printouts also proved invaluable in error checking and as a source for hand computation of characteristics when machine calculations would have been too time consuming or expensive to program or debug completely.

Programming for the five printouts and the average characteristic computations was done in COBOL. The latter job served as a direct input to cost model calculations. In order to differentiate between "large journals" and "small journals", it was decided that 1,500 article pages published per year would be the cut-off point for large and small. Therefore, the program performed an initial scan of each journal observation in 1974 (or earlier, if no 1974 observation was available), calculated how many article pages were published each year (pages per article times articles per issue times issues per year), and identified journals as large or small on this basis. Journal characteristics for "large" and "small" journals were then used in cost model calculations. The two classes were subsequently recombined for other analyses.

I.3.6 Computations

The following notation is used in the computational formulas for Journal Tracking Survey data. Computations were identical, whether done by hand or machine.

k	denotes sampling stratum 1, 2, or 3. K denotes the total number of strata used, i.e., 3.
N_k	denotes the number of journals in the universe for stratum k for each field and year.
m_k	denotes the total number of journals in the sample for stratum k in a given year and field of science for which observations were obtained.
i	denotes the particular journal observation under consideration for stratum k in a given year and field of science. (Range: $0 \leq m_k \leq 26$. Twenty-six is the maximum number of journals in a sample of a given field).
n_i	denotes the total number of articles (or issues) observed in journal observation i.
j	denotes the particular article (or issue) in journal observation i.
ISS_i	denotes the number of issues per year published for journal observation i.
ART/ISS_i	denotes the number of articles published per issue for journal observation i.
$TOTPAG_{ij}$	denotes the number of pages in article j for each journal observation i.
X_{ij}	the variable under consideration.

The following levels of data were collected in the journal tracking study:

- article characteristics (e.g., pages per article)
- issue characteristics (e.g., pages of advertising per issue, articles per issue)
- page characteristics (e.g., lines of text per page)
- journal characteristics (e.g., individual journal subscription price)

Average per article characteristics were calculated as follows:

$$\left[\sum_{k=1}^{K} \frac{M_k}{m_k} \sum_{i=1}^{m_k} (ISS_i)\,(ART/ISS_i) \left(\frac{\sum_{j=1}^{n_i} X_{ij}}{n_i}\right)\right] \div \left[\sum_{k=1}^{K} \frac{M_k}{m_k} \sum_{i=1}^{m_k} (ISS_i)\,(ART/ISS_i)\right]$$

The variable X_{ij} was simply replaced with observed values from the journal tracking survey suc as total pages, number of formula inserts, number of lines of math or chemical formulas, number of graphics, pages of graphics, etc

$$\left[\sum_{k=1}^{K} \frac{M_k}{m_k} \sum_{i=1}^{m_k} (ISS_i) \left(\sum_{j=1}^{n_i} X_{ij}\right)\right] \div \left[\sum_{k=1}^{K} \frac{M_k}{m_k} \sum_{i=1}^{m_k} (ISS_i)\right]$$

Here, the variable X_{ij} was replaced with observed values from the journal tracking survey such as pages of advertising per issue, pages per issue not devoted to advertising or articles, number of graphics in non-article, non-advertising portions of the issue, and pages of graphics in non-article, non-advertising portions of the issue.

[illegible] were calculated in a similar manner, for [illegible] of [illegible], with the [illegible] of the variables "LIN/PG$_i$" [illegible] "CHAR/LIN$_i$" [illegible] per page and [illegible] per line of text for [illegible] D):

$$\frac{\displaystyle\sum_{k=1}^{K} \frac{M_k}{m_k} \sum_{i=1}^{m_k} (ISS_i)(ART/ISS_i) \frac{\sum_{j=1}^{n_i} TOTPAG_{ij}}{n_i} (LIN/PG_i)(CHAR/LIN_i)}{\displaystyle\left[\sum_{k=1}^{K} \frac{M_k}{m_k} \sum_{i=1}^{m_k} (ISS_i)(ART/ISS_i) \frac{\sum_{j=1}^{n_i} TOTPAG_{ij}}{n_i}\right]}$$

Average per journal characteristics for each field and year were calculated as follows:

$$\left[\sum_{k=1}^{K} M_k \sum_{i=1}^{m_k} X_{ij}\right] \div \left[\sum_{k=1}^{K} M_k m_k\right]$$

[illegible] subscription prices, [illegible] per year were calculated [illegible], [illegible] X_{ij} [illegible] data from the tracking [illegible].

[illegible] receipt of a manuscript by a [illegible] characteristic. Therefore [illegible] the difference between receipt [illegible]

Average characters per page (formula three), once it was calculated, served as a basis for calculating characters per article (by multiplying it by pages per article) and characters per journal per year (by multiplying characters per article by articles per issue and issues per year). In some analyses, it was thought that characters as a unit of measurement would be more indicative of "information content" or "information productivity" than a simple measurement of pages and articles. This is nece arily a simplifying assumption, because of differences in technical vocabularies, word length, and so on. It also does not take into account other journal sources of information such as book reviews, letters to the editor, brief communications, and advertisements, which also communicate information and consume time and money in physical preparation and printing. Strictly speaking, these should also be included in estimates of total pages published and total characters, but the practical problems of accurate counting and weighting are considerable.

I.3.7 Estimation of Weighting Factors

Because equal sample sizes were sought for each field of science, simple averages of journal, article, and issue characteristics were insufficient for analysis if comparisons of, say, the number of articles per issue were to be made across fields. Since the number of journals (or articles) published in each field of science differed (an initial assumption borne out by fact), weighted averages were calculated for use in our final analyses. If each of the nine fields of science is considered to be a sampling stratum, then the probability that a particular journal would be sampled was different from stratum to stratum. Also, within the journal population of each field of science there are potentially several separate groups of journals. Some journals are born, die, merge with other journals, change names, split into two or three separate parts, shift to publishing on microforms, increase or decrease their frequency of publication, and so on. We wanted the major categories of these examples of journ "behavior" to be reflected in the final weighting scheme, so three main strata we developed to reflect the numbers of journals in each field which existed in 1962 and 1974 (stratum 1), those which existed in 1962 but not 1974 (stratum 2), and those which existed in 1974 but not 1962 (stratum 3). (Since a journal may be started at any month during the year, stratum 3 journals may have begun some time during 1962, so a 1962 stratum 3 weighting value was calculated). A journal which changed its name, publisher, or numbering sequence was not affected by these above definitions.

A set of weighting factors was developed to reflect the proportional sizes of these various groups. These weighting factors are shown in Table I.1. Strictly speaking, the weighting factors were the ratio of the table values and the number of observations made in a given field, year, and stratum, or M_k/m_k, where M_k equals the table value and m_k equals the sample size. In actual calculations, m_k was considered to be the number of observations obtained, and assumed to be equal to the sample size in that field for that year and stratum. In order to maintain the characteristics of a probability sample, it is important that the sample size and the number of observations are equal or as nearly equal as possible. While 95% of the planned data collection was completed (a 100% "response rate" was impossible due to continued problems in locating a few isolated journal volumes), some variation did occur in the number of observations of given data items.

For example, a key data item in the analysis of trends in journal publication is subscription price. The existence of different types of subscriptions prices complicates data collection. Therefore, accommodation must be made for individual, institutional, and foreign subscription prices, and for society published journals, member and non-member subscription prices. Not all journals (when examined in the library) provide this information for every category. Also, some journals change their price reporting policy from year to year. For example, many sampled journals did not begin printing different (and usually higher) institutional subscription prices until the middle or late 1960's, and for some journals institutional prices were not reported at all. Instead of treating these as "missing values", we assumed that individual and institutional prices were identical for those years, and substituted the former. Therefore, for a sample of 20 journals from stratum 3 and a given field of science observed in 1968, there was no guarantee that all 20 would provide an actual institutional subscription price. Only a few other data elements, such as publishing lags, exhibited the above characteristics so these values were calculated by hand instead of by computer.

To develop weights for stratum 3, journal growth rates for individual fields of science were estimated by observing the number and year of journal starts between 1962 and 1974 in our sampled journals which were chosen from the

Table I.1 WEIGHTING FACTORS USED IN CALCULATING AVERAGE JOURNAL, ARTICLE, AND ISSUE CHARACTERISTICS (M_k)

Field of Science	Stratum[1]	1962	1964	1966	1968	1970	1972	1974
1. Physical Sciences	1	44	44	44	44	44	44	44
	2	1	1	1	1	3	1	2
	3	1	14	27	43	55	69	79
2. Mathematics & Statistics	1	32	32	32	32	32	32	32
	2	--	--	--	--	--	--	--
	3	2	4	7	10	12	14	16
3. Computer Sciences	1	12	12	12	12	12	12	12
	2	--	--	--	--	--	--	--
	3	4	6	7	9	10	11	12
4. Environmental Sciences	1	30	30	30	30	30	30	30
	2	1	1	1	2	4	2	2
	3	29	29	29	28	26	28	28
5. Engineering	1	188	188	188	188	188	188	188
	2	--	--	--	--	--	--	--
	3	63	63	62	61	46	39	37
6. Life Sciences	1	506	506	506	506	506	506	506
	2	--	--	--	--	--	--	--
	3	60	60	60	60	60	60	60
7. Psychology	1	55	55	55	55	55	55	55
	2	--	--	--	--	--	--	--
	3	0	7	14	23	31	38	44
8. Social Sciences	1	455	455	455	455	455	455	455
	2	--	--	--	--	--	--	--
	3	51	82	113	153	176	200	224
9. Other Sciences	1	39	39	39	39	39	39	39
	2	--	--	--	--	--	--	--
	3	7	8	9	10	10	10	11

[1] Stratum 1 Existed in 1962 and 1974
Stratum 2 Existed in 1962 but not 1974
Stratum 3 Existed in 1974 but not 1962

[2] "--" denotes no sample journal in this field in this stratum.

Indiana University list. This was done prior to actual data collection when journal locations were identified; at this time the "start" year for sampled journals was also recorded.

To estimate the rate at which journals are discontinued by publishers (journal "deaths") it was necessary to sample a different set of 1962 journals and track them forward. Our original sample, as noted previously, was composed of journals selected from the 1962 ISI list and the Indiana University list for 1973/74 journal titles. The latter list necessarily reflected still existing journals. We suspected that the ISI list underestimated journal deaths because of the way this list was generated in 1962. To get a better estimate of journal "deaths", a more comprehensive 1962 journal list was used, the 1962 Ulrich's (142) First, journals which did not fall into the nine NSF fields of science were excluded. Next, the number of U. S. published journals were counted by field. We noted that the relative proportions among fields were different from the proportion: .. the table of weights used in computation. This is due to the increased co. .age of scholarly journals which the Fry/Indiana University list provided, the more restricted coverage of the 1962 ISI list, and the changes in the number of journals published in each field since 1962.

Next, twenty journals in each field were randomly selected from the 1962 Ulrich's, and then tracked forward through successive issues of Ulrich's and New Serial Titles (114) to determine the death rate. Name changes were noted so that deaths would not be overestimated. "Superceded" journals were counted as still existing continuations. A journal published in the U. S. in 1962 but later listed as published in another country was counted as still existing. The results are shown in the following table. (We caution that these results only approximate true rates, due to the small sample sizes used). Note that two Engineering journals which ceased publication in 1960 were carried in the 1962 Ulrich's. Also, there were nine "don't knows", where it was impossible to determine the exact date when the journals ceased publication. We assumed that these were deaths, although they may be due to changes in coverage of the lists we examined.

Despite these efforts, our sample included only two journals which we classified as stratum 2 journals: Plastics World and Aerospace Management.

Table I. 2 RESULT OF ANALYSIS TO DETERMINE DEATH RATES

Field of Science	1962 Ulrich's Total	Sample Size	Still Existing	Deaths	Year of Death
1. Physical Sciences	130	20	19	1	1962
2. Mathematics & Statistics	66	20	19	1	Don't Know
3. Computer Science	19	19	14	5	1964, 1968 1965, Don't Know (2)
4. Environmental Science	152	20	18	2	1969 1961
5. Engineering	474	20	15	5	1960(2) 1970, 1962(?) Don't Know
6. Life Sciences	761	19	17	2	1968 Don't Know
7. Psychology	67	20	20	0	--
8. Social Sciences	1,183	20	18	2	Don't Know (2)
9. Other Sciences	95	20	17	3	1970 (2) Don't Know (2

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(In actuality, *Aerospace Management* was begun after 1962 and ceased publication prior to 1974). Therefore, we feel that our sample over-represents stratum 1 and stratum 3 journals, and under-represents "deaths". For this reason, stratum 3 weighting factors were adjusted slightly downward so that journal growth would not be overestimated.

It was brought to our attention during the project that especially high death rates may be associated with trade journals and engineering publications. Trade journals were included in our sample because of their scientific and technical information value. However, some specific fields which emphasize technical, engineering, and trade information, and which may be especially sensitive to research and development funding, such as the aerospace and electronics communities, may be underrepresented because they were not adequately covered in the source lists used for our sampling.

The preceding described the methods used to develop weighting factors which reflected the growth in the total number of journals published in 1962. These were used for M_k in the computational formulas. Because of the different sampling levels, individual article characteristics, for example, had to be weighted up to annual values in order to calculate averages. In formula one, (ISS_i) X (ART/ISS_i) represents the total number of articles published in a given year by journal i, estimated by multiplying issues per year times articles per issue. In formula two, (ISS_i) is the number of issues regularly published by journal i during the year under consideration. In formula three, $(CHAR/LIN_i)$ times $(LIN/PG_i$ estimates the characters per page for journal i, and this is then weighted by pages per article, articles per issue, issues per year, and M_k/m_k for each observation, and then summed, prior to division.

I.4 The Author Survey

I.4.1 Introduction

The Author Survey was conducted during the summer of 1975. It was designed as a simple, low-cost method of obtaining data in two areas: authors' experiences with their own published articles, and their identification of and access to the articles which they cite. From the beginning, a major design criterion was the use of a short questionnaire format which would simplify response, hopefully resulting in a high response rate. Results were to be used to estimate values for all authors of scientific and technical articles.

I.4.2 Design of Author Questionnaire

One objective in the design of the Author Survey questionnaire was to minimize respondent effort, since a mail questionnaire was to be used without mail or telephone follow-up. The number of questions was kept to a minimum. No demographic characteristics were requested. In order to minimize the bulk of the questionnaire, we decided to use a regular business envelope for mailing. This included two items: a cover letter with the full text of questions printed on the back, and a post-paid return postcard which included abbreviated forms of the questions.

Two separate surveys were originally planned. We needed to collect data on the production and dissemination of information from the author's viewpoint; we also needed data on the use of this information. The authors of articles sampled in the journal tracking survey would be contacted for information regarding article revision, page changes, reprint purchases, and reprint distribution. Then, through Science Citation Index, users of these articles would be identified by noting authors who cited the original articles. These users would then be contacted about how they identified and obtained access to the articles which they cited. In this way, we would obtain information about several different stages of the information transfer cycle. Information on the number of revisions made would be input to the journal cost model. Page charges would give an indication of one source of journal income. Reprint distribution would identify the author's own role in dissemination of his or her own article. On the other end, citing authors' identification and access methods would describe the major step from the generation to the assimilation of information. Addresses for this latter group of authors would be identified via directories of scientific organizations, biographical listings, and other sources, such as examination of the citing authors' own articles.

There were practical problems associated with doing two separate surveys. First, identifying enough cited articles from the articles sampled in the tracking survey would be difficult. Second, locating current addresses (or any addresses) for these citing articles would require examination of more sources. Considering this, we decided to combine the two surveys into one. Authors were asked questions about their own article and about an article which they had cited. Therefore, only one form was needed, with two separate sets of questions.

Data requirements for part one of the questionnaire were straightforward:

- number of times the article was returned to the author for revision
- amount paid in page charges
- number of reprints obtained from publisher
- whether or not reprints were paid for
- number of reprint requests received

The questions dealing with the cited article were more complex. We wanted to develop a model of article "flow" which included both method of identification and method of access. Points to be considered were whether or not the author was doing a literature search, method of identification used, method of access used, and whether or not the article was photocopied.

The first point was simple, assuming familiarity with the term "literature search".

The second point, method of identification, included a combination of "direct" and "indirect" identification methods. Direct identification means that the author was looking for information on the selected topic. Indirect identification means that the author "chanced upon" the cited article. We realized that in some cases, identification and access occur simultaneously, for example, when an author receives a reprint without requesting it.

The third and fourth points, access method and photocopying, at first caused some problems in developing a flow model. Photocopying itself might be thought of as an access method. However, we were most interested in the author's initial access method, and considered that photocopying is a secondary method used after the author first obtains physical possession of an article in a journal, reprint, or preprint form. Still, photocopying was retained in both the question on copying and access, since a photocopy can serve as both primary and secondary access.

Also, "copying" was expanded to include both photocopying and the generation of hard-copy from microform.

I.4.3 Pretesting

Pretesting was done in July and August of 1975. The initial questionnaire version is shown in Appendix VI. Twenty-three were mailed out, and thirteen were returned to CQS plus one marked "deceased". The questionnaire was printed on the back of the cover letter. Instead of a printed postcard, pretest authors received a copy of the postcard photocopies on an 8-1/2 x 11" sheet, on the front of which was copied the address for the Center for Quantitative Sciences in Rockville. We asked them to fill out the answers, fold over, staple, and return the sheet.

Several multiple responses were received to single questions. Based on this, respondent comments, and further discussion, the list of response categories was expanded as shown in the revised questionnaire, Appendix VII. The cover letter was also revised slightly, and postcards were printed with the Chicago Market Facts post office box number as a mail drop. This was done so that return postage would be paid only for respondents.

We were somewhat surprised by the response rate, even for such a small pretest, and felt that this was due to the nature of the audience, the questionnaire topic, and the method of questionnaire preparation.

The authors contacted are not simply a generalized audience. They are a select group of people who have taken the time to perform timeconsuming research and/or prepare articles for journals, many of which are professionally reviewed. We assumed that the author's feeling of pride in their own work would carry over to being asked about their activities surrounding it Also, even though the questionnaire was copied, each one had article citations individually typed, and each one was signed by hand. This added a note of personalization.

I.4.4 Data Collection

The following operations were involved in mailout from CQS: typing of author's article and cited article citation on cover letter; typing of author name and address on envelope insertion (by hand) of coding numbers on response card; folding, insertion, sealing, and stamping of envelopes. A total of 2,123 questionnaires were mailed out during September of 1975.

Survey monitoring consisted of re-addressing questionnaires which were returned with forwarding addresses and responding to telephone queries of authors regarding the survey. The cover letters included a long-distance collect number, but only two long-distance calls were received. Fewer than ten calls were received from authors located in the Washington, D. C. metropolitan area. All questions dealt with the purpose of the survey rather than with questionnaire ambiguities.

I.4.5 Interpretation of Survey Results

Several considerations should be kept in mind when analyzing the results of the Author Survey.

As mentioned in the section on sampling, authors were selected only from journals which were included in the journal tracking survey. Therefore, the representativeness of respondents was limited initially by the representativeness of the sampling process which generated the sample list of journal titles.

The majority of authors were selected on the basis of the journal's inclusion of a useable address. This practice varies considerably from journal to journal; many journals consistently do not print author addresses, even though we found that the exchange of reprints among scientists accounts for a considerable amount of the total of article accesses.

Although authors who publish in scientific and technical journals are predominantly college or university-based, it was our impression that the proportion of university addresses to non-university addresses was higher than the actual proportion of university authors to non-university authors. Therefore, we feel that our responses were biased somewhat towards university-based authors. Because place of employment was not a consideration in selection or analysis, however, we have no data to support this.

Cited journal articles were chosen which were not authored or co-authored by any of the authors listed for the source article. This restriction was made because we were interested in the more "formal" methods of article distribution. It is likely that inclusion of self-authored or co-authored articles would result in a bias towards "internal" article transfer such as professor to graduate student. It is also likely that self-citations are made to articles which are already in the author's own collection since authors generally maintain copies of their own articles for future reference or for distribution via reprint channels.

Only "first authors" were contacted, i.e., only those whose names were listed first. In some fields, it is the common practice to list graduate students' names first before professors' names. We considered limiting our survey only to single-article authors, but this was infeasible due to the large number of co-authored articles. We do not know what effect this had on responses or response rate.

For many authors who responded, a problem of recall was possible. Authors were contacted by mail in the summer of 1975, and some were asked about articles which they had cited in their 1968 articles, a minimum span of seven years. Since the questionnaire was in two parts, part one asking about the author's article, and part two asking about the cited article, we expected much more non-response to part two than to part one, especially for older source articles. This was not the case; practically all respondents answered both parts of the questionnaire.

Because we did not intend to analyze data by field of science for the Author Survey, an exact count was not kept of outgoing questionnaires by field. Also, the number of outgoing questionnaires by year of source article was not recorded, since authors had not been randomly sampled. It is interesting to examine the number of responses by field and year, however.

An attempt was made to collect equal numbers of author addresses for recent articles as well as for older articles. We expected a much lower response rate for older articles. Although we do not at this time have an exact count of numbers of outgoing questionnaires by year of source article, we were somewhat surprised by the large number of older responses, a credit to the cooperation of respondents and to the diligence of the postal service and past employers in forwarding questionnaires. Exact numbers of responses, by field and year, are shown in Table I.3.

Two thousand one hundred and twenty-three author questionnaires were mailed out, and 943 useable responses were received in time for analysis, a 44.4% response rate. Sixty-four were returned too late for analysis, resulting in a total response rate of 47.4%. One hundred ninety-one were returned as undeliverable prior to the cut-off data, and 34 after. If undeliverables (due to no forwarding addresses or incomplete addresses) are subtracted from the total mail-out, a prior to cut-off date response rate of 48.8% was obtained, and a post cut-off response of 53.1 percent.

We considered these response rates to be very high, especially since no mail or telephone follow-ups were used. We felt that our initial objective of performing a low-cost, simplified author survey had been attained. Still, there always exists in a survey of this type the problem of non-response. No rigorous analysis of non-response has been performed thus far, nor has a separate survey of non-respondents been conducted.

Numerous hypotheses might be developed regarding the unaccounted-for 891 questionnaires. What percent were neither forwarded nor returned to us? How many secondary authors received the questionnaires and felt they could not answer the questions? How many authors had died? How many questionnaires were received by institutions while the author was away on summer vacation, only to be forgotten in the bottom of a mail pile? How many authors refused to respond either because they could not remember as far back as 1968 or because they felt the questionnaire was an invasion of privacy? (We felt the privacy issue was

Table 1.3 RESPONSES TO AUTHOR SURVEY

Field of Science	Year of Published Article							
	1968	1969	1970	1971	1972	1973	1974	1975
1. Physical Sciences	12	13	15	16	25	13	25	17
2. Mathematics & Statistics	12	3	12	4	11	11	21	5
3. Computer Sciences	6	17	5	16	12	23	4	27
4. Environmental Sciences	16	9	20	19	22	8	17	11
5. Engineering	12	4	6	9	21	9	15	12
6. Life Sciences	7	22	16	28	13	35	16	30
7. Psychology	22	13	27	16	21	23	34	11
8. Social Sciences	0	2	2	5	3	11	6	6
9. Other Sciences	2	3	0	6	3	6	5	8
Total	89	92	103	119	131	139	143	127

minimized because of the non-inclusion of demographic questions and because of the promise of confidentiality. Still, one author did telephone us to voice concern that the survey's objective was really the evaluation of him or his program).

Because of these above considerations, the reader should view the author survey results with some care. We feel that the major conclusions -- the relative use of various sources of access, for example -- are valid, and have no reason to believe that non-respondents behave differently from respondents vis-a-vis these conclusions. Keeping all the above in mind, we feel that the particular theoretical and methodological techniques used in this survey merit further application.

I.4.6 Data Reduction and Analysis

Response cards were addressed to the Market Facts, Chicago facility for editing and keypunching. Most cards required little editing since response format was straightforward. A few with problems -- e.g., multiple responses, seemingly contradictory responses -- were mailed to CQS in Rockville, where a short set of coding instructions was developed. These were then returned to Chicago for keypunching. Specifications for machine tabulating (sorting instructions, column headings, cross-tabulations) were developed and these, along with coding formats, were programmed in Chicago.

Two major tasks were required for proper analysis: year of cited article and weighting factors needed to be inserted into the computer record prior to tabulation.

Year of cited article was needed so that the time between cited article publication and use of that article could be measured. These had been collected but had not originally been included in the response card record format. Supplementary coding sheets were prepared, and for each outgoing questionnaire (excluding those which were returned as undeliverable) year of cited article was inserted as a two-digit number. (Cited article dates prior to 1900 were coded as "99").

Two weighting factors, similar to those discussed for the Tracking Survey in Section I.3.7, had to be calculated. These factors represented the proportional numbers of articles cited in all the journals and articles represented by our sample, for each field of science, year, and stratum under consideration, divided by numbers of responses. The "article weight" was generated by multiplying (articles per issue) times (issues per year) times (journals published per year) for each field of science (1-9), year (1968-1975), and stratum (1, 2, 3). This was then divided by the number of author responses in that field, year and stratum. The "citation weight" was generated by multiplying (articles per issue) times (issues per year) times (journals published per year) times (articles cited per article) for each field, year and stratum. This was also divided by the number of responses in that field, year, and stratum.

Note that these weights are similar to those described in Section I.3.7, except for the sequence of operations. Journal Tracking Survey weights also were calculated by dividing by the number of "responses" (i.e., the number of journal observations, m_k), except that this step was accomplished as an integral part of computer calculation. (Table I.1, strictly speaking, depicts only a multiplicative element which was combined with factors such as issues, pages, characters per page, etc., prior to division to generate the final weighting factor).

Because the tabulated results from the journal tracking survey were not yet available for the development of weights in the author survey, Tracking Survey forms were examined manually (prior to keypunching). Articles cited per article, articles per issue, and issues per year were recorded on data sheets from each tracking survey form used as a source for the article survey. These were subdivided by year, field of science, and stratum, and the average items cited per article and average articles published per journal were calculated for each of these categories. The latter average was then multiplied times our estimate of the number of journals per year published in each field and stratum, to generate a table of the total number of articles published per year, field, and stratum. These figures were then multiplied times the average number of articles cited per article to generate a table of the total number of items cited per year.

The stratum number for each author questionnaire (equal to the stratum number for the journal in which the author's article appeared) was inserted on the supplementary coding sheet containing the date of the cited article. These date elements were added to the individual keypunched records, and responses were counted by year, field, and stratum. Each of the values in the two preceding tables (total articles published per year and total articles cited per year) was then divided by responses for each field, year, and stratum to generate the final weighting factors. These weighting factors are displayed in Tables I.4 and I.5.

Note that the estimate of articles per issue and issue per year, used in calculating average articles published per journal per year, were drawn only from journals used as sources for the author survey, resulting in small sample sizes for individual field, year, and stratum cell values. These values were somewhat different from the final values calculated from tracking survey data, and may be the source of some error in author survey responses. Also, another minor source of error was the count of the number of articles cited per article. Although the survey considered identification and access of articles which were not self-citations, the count used in generating the citation weights was made of all articles cited by the contacted authors. Assuming that the proportion of self-citations to non-self-citations is similar across fields, this should not significantly affect the calculation of response percentages for the author survey data.

Initial tabulation of data was by computer, with various sorts and cross-tabulations by year of author's article, year of citing author, individual questions, and so on. Calculation of individual path frequencies and percents (i.e., percent and frequency of each combination of identification method and access method) was done by hand, directly from response cards. No analysis by individual field of science was performed because of the small individual field sample size for each year.

Table I.4 AUTHOR SURVEY ARTICLE WEIGHTS (x20)

Field of Science	Stratum	Year 1968	1969	1970	1971	1972	1973	1974	1975
1. Physical Sciences	1	132	117	123	95	111	140	71	101
	3	348	395	107	--	80	403	157	278
2. Mathematics & Statistics	1	30	346	45	93	35	64	20	64
	3	57	31	17	--	--	16	42	--
3. Computer Science	1	18	6	15	7	15	6	24	6
	3	14	6	--	.	6	5	59	4
4. Environmental Science	1	26	48	19	30	20	65	28	56
	3	49	57	25	11	30	42	25	20
5. Engineering	1	175	517	338	267	145	286	159	199
	3	--	--	--	--	37	--	--	--
6. Life Sciences	1	853	294	436	306	592	311	604	362
	3	--	--	--	118	527	64	490	102
7. Psychology	1	25	60	38	58	54	32	28	80
	3	56	49	20	32	18	44	28	110
8. Social Science	1	--	371	348	243	243	819	152	152
	3	--	--	--	56	--	17	--	--
9. Other Sciences	1	94	70	--	40	79	39	47	29
	3	--	--	--	--	--	--	--	--

Note: "--" = No response received.

Table I.5 AUTHOR SURVEY CITATION WEIGHTS (x100)

Field of Science	Stratum	Year 1968	1969	1970	1971	1972	1973	1974	1975
1. Physical Sciences	1	140	124	130	100	118	149	75	107
	3	321	365	99	--	74	372	145	257
2. Mathematics & Statistics	1	19	217	28	58	22	40	13	40
	3	32	17	9	--	--	9	23	--
3. Computer Science	1	10	3	8	4	8	3	14	3
	3	11	5	--	4	5	4	47	3
4. Environmental Sciences	1	36	66	27	42	28	90	39	78
	3	264	311	137	61	165	228	137	109
5. Engineering	1	135	398	260	206	112	220	122	153
	3	--	--	--	--	--	--	--	--
6. Life Sciences	1	1,062	367	543	381	737	387	752	451
	3	--	--	--	86	--	47	357	74
7. Psychology	1	41	101	64	97	89	53	47	134
	3	45	39	16	27	14	35	22	88
8. Social Science	1	--	175	165	115	115	387	72	72
	3	--	--	--	13	--	4	--	--
9. Other Sciences	1	73	55	--	31	62	30	36	23
	3	--	--	--	--	--	--	--	--

Note: "--" = no response received.

APPENDIX II

SAMPLE JOURNAL TITLES

Field 1 -- Physical Sciences

Journal Code		Title
1	01	Adhesives Age
1	02	Analytical Chemistry
1	03	Applied Optics
1	04	Astronomical Society of the Pacific Publications
1	05	Cereal Chemistry
1	06	Comments on Solid State Physics
1	07	Critical Reviews in Solid State Sciences
1	08	High Temperature*
1	09	International Journal of Theoretical Physics
1	10	IEEE Transactions on Audio & Electroacoustics
1	11	Journal of the Association of Official Analytical Chemists
1	12	Journal of Chemical Documentation
1	13	Journal of Crystal and Molecular Structure
1	14	Journal of Magnetic Resonance
1	15	Journal of Medicinal Chemistry
1	16	Journal of Physics and Chemistry of Solids
1	17	Journal of Plasma Physics
1	18	Letters in Heat & Mass Transfer**
1	19	Nuclear Technology
1	20	Particles and Nuclei Series
1	21	Physical Review Letters
1	23	Plastics World
1	24	Rocks and Minerals
1	25	Spectroscopy Letters

* High Temperature, a translation of a Russian journal, was used only for calculation of average physical characteristics.

** Another translation from Russian, dropped from survey.

Field 2 -- Mathematics and Statistics

Journal Code		Title
2	02	American Mathematical Society Proceedings
2	03	American Statistician
2	04	Applicable Analysis
2	05	Communications in Algebra
2	06	Duke Mathematical Journal
2	07	Illinois Journal of Mathematics
2	08	International Journal of Computer Mathematics
2	09	Journal of Differential Equations
2	10	Journal of Mathematical Analysis and Applications
2	11	Journal of Recreational Mathematics
2	12	Mathematical Systems Theory
2	13	Mathematics Teacher
2	14	Pacific Journal of Mathematics
2	15	Quarterly Journal of Mathematics
2	16	Society for Industrial and Applied Mathematics
2	17	SIAM Review
2	18	Studies in Applied Mathematics
2	19	American Journal of Mathematics
2	20	Annals of Mathematical Statistics
2	21	Bulletin of Mathematical Biophysics
2	22	Communications in Pure and Applied Mathematics
2	23	IEEE Transactions on Information Theory
2	24	Journal of Mathematical Physics

Field 3 -- Computer Science and Engineering

Journal Code		Title
3	01	ACM Communications
3	02	Automation
3	03	Computer
3	04	Computer Graphics and Image Processing
3	05	Computers and Automation
3	06	Computers and the Humanities
3	07	Computing Reviews
3	08	Data Management
3	09	EDP Performance Review
3	10	Honeywell Computer Journal
3	11	IBM Journal of Research and Development
3	12	International Journal of Computer and Information Science
3	13	Journal of Computer and System Sciences
3	14	Journal of Educational Data Processing
3	15	Operating Systems Review
(3	16)	SIAM Journal on Control
3	17	SIGCUE Bulletin
3	18	Simulation Councils Proceedings
3	19	Journal of the American Society for Information Science
3	20	Bulletin of the Medical Library Association
3	21	Information and Control
3	22	IEEE Transactions on Automatic Control
3	24	Journal of the Association for Computing Machinery

Field 4 -- Environmental Sciences

Journal Code		Title
4	01	Aerospace Management
4	02	American Meteorological Society Bulletin
4	03	Bulletin of Marine Science
4	04	Coastal Zone Management Journal
4	05	Earth Science
4	06	Fieldiana Geology
4	07	Geographical Analysis
4	08	Geophysics
4	09	Journal of Applied Meteorology
4	10	Journal of Geology
4	11	Journal of Marine Research
4	12	Journal of the Atmospheric Sciences
4	13	Marine Biology
4	14	NLGI Spokesman
4	15	Ocean Industry
4	16	Professional Geographer
4	17	Radio Science
4	18	Bulletin of the Seismological Society of America
4	19	American Journal of Science
4	20	American Mineralogist
4	22	Ecological Monographs
4	23	Ecology
4	24	Journal of Atmospheric and Terrestrial Physics
4	25	Journal of Geophysical Research

Field 5 -- Engineering

Journal Code		Title
5	01	AFS Cast Metals Research Journal
5	02	American Institute of Steel Construction Engineering Journal
5	03	American Society of Civil Engineers, Soil Mechanics & Foundations
5	04	Bell System Technical Journal
5	05	Civil Engineering
5	06	Die Casting Engineer
5	07	High Speed Ground Transportation Journal
5	08	IEEE Transactions on Circuit Theory
5	09	IEEE Transactions on Instrumentation and Measurement
5	10	ISA Transactions
5	11	Journal of Applied Mechanics
5	12	ASME Journal of Fluids Engineering
5	13	Lubrication Engineering
5	14	Metal Science and Heat Treatment
5	15	Modern Metals
5	16	Plating
5	17	Review of Scientific Instruments
5	18	Southern Pulp and Paper Manufacturer
5	19	Astrophysical Journal
5	20	Industrial and Engineering Chemistry Process Design & Development
5	22	IEEE Transactions on Education
5	23	Journal of Molecular Spectroscopy
5	24	Nuclear Science and Engineering
5	25	Stain Technology

Field 6 -- Life Sciences

Journal Code		Title
6	01	Agricultural Engineering
6	02	American Journal of Digestive Diseases
6	03	American Midland Naturalist
6	05	Biotechnology and Bioengineering
6	06	Citrus & Vegetable Magazine
6	07	Delaware Medical Journal
6	08	Evaluation
6	09	Group Practice
6	10	International Pathology
6	11	Journal of Dental Education
6	12	Journal of Nervous and Mental Diseases
6	13	Journal of Surgical Oncology
6	14	Medical Marketing and Media
6	15	North Carolina Medical Journal
6	16	Pharmacy in History
6	17	Rhode Island Medical Journal
6	18	Theoretical Population Biology
6	19	American Heart Journal
6	20	Analytical Biochemistry
6	21	Bulletin of Experimental Biology and Medicine
(6	22)	Ecological Monographs
6	24	Journal of the National Cancer Institute
6	25	New York State Journal of Medicine

Field 7 -- Psychology

Journal Code		Title
7	01	American Journal of Psychology
7	02	Behavioral Biology
7	03	Clinical Psyc.iologist
7	04	Developmental Psychology
7	05	Genetic Psychology Monographs
7	06	International Journal of Symbology
7	07	Journal of Applied Psychology
7	08	Journal of Contemporary Psychology
7	09	Journal of Experimental Child Psychology
7	10	Journal of Humanistic Psychology
7	11	Journal of Personality
7	12	Journal of School Psychology
7	13	Journal of Transpersonal Psychology
7	14	New Outlook for the Blind
7	15	Perceptual and Motor Skills
7	16	Psychological Issues
7	17	Psychology in the Schools
7	18	School Psychology Digest
7	20	Behavioral Science
(7	21)	Genetic Psychology Monographs
7	22	Journal of Comparative and Physiological Psychology and Supplement
7	23	Journal of the Experimental Anal of Behavior
7	25	Psychiatry

Field 8 -- Social Sciences

Journal Code		Title
8	01	American Journal of Criminal Law
8	02	Arkansas Law Review
8	03	Chronicles of Oklahoma
8	04	Criminology
8	05	Extrapolation
8	06	Growth and Change
8	07	Illinois School Research
8	08	Journal of Collective Negotiations in the Public Sector
8	09	Journal of Mississippi History
8	10	Foundational Studies
8	11	Missouri Historical Society Bulletin
8	12	Northwest Anthropological Research Notes
8	13	Pakistan Perspective
8	15	Smith College Studies in Social Work
8	16	Stanford Law Review
8	17	Social Service Review
8	18	Yale Law Journal
(8	19)	IEEE Transactions on Education
8	20	American Journal of Pharmaceutical Education

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Field 9 -- Other Sciences

Journal Code		Title
9	01	American Laboratory
9	02	Annals of the New York Academy of Sciences
9	03	Drexel Library Quarterly
9	04	Energy Systems and Policy
9	05	Georgia Academy of Science Bulletin
9	06	Industrial Research
9	07	Iowa State Journal of Research
9	08	Kansas University Science Bulletin
9	09	Library Journal
9	10	Library Trends
9	11	Michigan Academician
9	12	National Academy of Sciences Proceedings
9	13	Northwest Science
9	14	PNLA Quarterly
9	15	Science
9	16	Scientific American
9	17	Technical Communication
9	18	Texas Journal of Science
(9	19)	Journal of the American Society for Information Science
9	20	American Scientist
(9	21)	Bell System Technical Journal
(9	22)	IEEE Transactions on Education
(9	23)	IEEE Transactions on Information Theory
(9	25)	Science
(9	26)	Technometrics

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APPENDIX III

DISTRIBUTION OF SAMPLE JOURNAL TITLES AMONG PUBLISHER TYPES

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Sample journal titles were distributed among publisher types as follows. The first row is the number of publishers in the sample which publish one sampled journal, the second row is the number of publishers which publish two sampled journals, and so on.

	Publisher Type			
	Society	Commercial	Educational Institutions	Other
One Journal	54	30	20	5
Two Journals	5	5	0	0
3-4 Journals	3	2	3	0
5-6 Journals	2	1	0	0
7-11 Journals	1	1	0	0
No. Publishers	65	39	23	5
No. Journals	103	53	30	5
No. Publishers Covered in Sample = 152				

The publisher categories used were defined as follows:

1. Society or Association - scientific and professional societies in the U. S.

2. Commercial - commercial publishers or for-profit companies which publish a journal.

3. Educational Institutions - university presses or college or university departments or divisions.

4. Other - government, private individuals, and others.

APPENDIX IV

METHODOLOGY FOR DEVELOPMENT
OF PUBLISHER/JOURNAL POPULATION

Supplied by Bernard M. Fry, Principal Investigator, Economics and Interaction of the Publisher-Library Relationship in the Production and Use of Scholarly and Research Journals. National Science Foundation, Office of Science Information Services, Grant No. GN-41398.

IV.1 Definition of Scholarly/Research Journal in Context of Study

Since the fields of human endeavor are so vast and all-inclusive, in one sense periodicals of all kinds and all descriptions may possibly be used for research or scholarly purposes. Additionally, the economic impact of declining budgets and rising periodicals costs on libraries and publishers involves more types of periodicals than those narrowly defined as primary scholarly research journals. As a result, for the purposes of this study the definition of journals to be included was developed by exclusion of certain categories of periodicals believed to be inappropriate either because the category would not ordinarily contain communications useful for scholarly purposes or would have no economic impact, e.g., nos. 13-17 below. These exclusions are as follows:

1. newsletters
2. house organs
3. general, mass audience magazines
4. popular culture magazines
5. periodicals intended for a juvenile audience
6. little magazines
7. preprints
8. patents
9. secondary periodicals or services
10. periodicals intended for a local audience
11. trade journals
12. periodicals not indexed by an indexing and/or abstracting services*
13. processed periodicals
14. tabloids
15. free periodicals
16. government publications
17. controlled circulation periodicals

---

*Exceptions were made in those subject areas which are inadequately covered by indexing and/or abstracting services and for periodicals which began publication after 1970.

Because of the difference in production costs and rates of inflation, periodicals produced by countries other than the United States were not included. Translations of foreign language journals were excluded because of the unique costs involved in production of these journals.

IV.2 Identification of Publisher/Journal Population

No existing publication or service adequately identifies periodical publishers or their publications in all subject areas and for all types of publishers. However, it was felt that Current Contents, published by the Institute for Scientific Information, served the purpose of generating a core list of periodicals in the subject areas which it covers, namely: Behavioral and Social Sciences, Life Sciences, Physics and Chemistry, Agriculture and Biology, Clinical Sciences, and Engineering. Only those publishers with United States addresses were chosen. Some of the periodicals which were listed by Current Contents were eliminated on the basis of the above exclusions list. The number of periodicals chosen from Current Contents totalled 1,866, published by 1,143 publishers.

In order to augment the list of publishers drawn from Current Contents in those subject areas not covered, or covered inadequately, Ulrich's International Periodical Directory, 15 ed., was used to identify the remaining periodicals and their publishers, again eliminating on the basis of the exclusions. In accord with the decision to omit categories which would not ordinarily contain communications useful for scholarly purposes, some of Ulrich's subject areas in addition to those on the exclusion list were not considered to be appropriate. These were:

- Adventure and Romance
- Bibliographies
- Clubs
- College and Alumni
- Gifts and Toys
- Hobbies
- Meetings and Congresses
- Pets
- Sports and Games
- Travel and Tourism
- Women's Interests

Various publications were used to verify the completeness of the periodical list. These included the Encyclopedia of Associations, National Trade and Professional Associations of the United States, Scientific and Technical Societies of the United States, Research Centers Directory, Publishers Trade List Annual, Publishers' Weekly, Directory of the Association of University Presses, and numerous published discipline studies of periodicals. When the identity of the publisher was in doubt, the current issue of the periodical was examined.

IV.3 Size of Publisher/Periodical Population

Selected through the techniques enumerated in the previous sections, the population of the periodicals chosen totaled 2,563. These periodicals were produced by 1,702 publishers. The publishers were subdivided into four categories: Commercial (for profit), Society, University Press, and other not-for-profit publishers. The following table shows the breakdown of the publisher/periodical population by type of publisher.

Type of Publisher	Number of Publishers	Number of Periodicals Published
Commercial	284	683
Society	777	1101
University Press	40	129
Other not-for-profit	601	650
Total	1702	2563

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APPENDIX V

TRACKING SURVEY FORMS

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V.1 REVISED TRACKING SURVEY FORM

Staff member________________________ Form #__________ (1-4)

Date__________ Library__________ Call no. __________

TRACKING SURVEY
JOURNAL INFORMATION

I. Journal Identification (to be filled out prior to library visit)

1. Full Journal Title ____
____

2. Abbreviation ____( ).

3. Journal Code: a. Field of Science______( ) b. Journal #________( )

4. Year of journal being examined: ________( )

5. Last event prior to 1975 (circle all applicable events)

   a. Type of last event: Name change 1 Split 2 Combination 3 ( )
   Start 4 Terminate 5 Other 6

   b. Date of event: Month _____ ( ) Year _____ ( ) Volume ________ ( ) Issue ________ ( )

6. Original source list for this title (circle one)
   1962 ISI... 1 1962 Other... 2 1974 ISI... 3 Indiana... 4 ( )

7. Final sampling status of this title (circle one)
   1962 and 1974 1 1962 only 2 1974 only 3 ( )

II. Subscription Information (See Instructions for definitions)

8. Name of publishing organization ____
____( )

9. Code of publishing organization (circle one)
   Society or Association 1 ( )
   Commercial or Business 2
   Educational Institution 3
   Other 4 (specify) ____________________

10. Is this journal sponsored by a professional society or association?
    Yes 1 No 2 (go to #16) Don't Know 3 (go to #16) ( )

11. Is sponsoring society or association same as publishing organization?
    Yes 1 (go to #13) No 2 (go to #12) Don't Know 3 (go to #13) ( )

12. What is the name of the society? ____
____( )

13. Are membership dues given for this society or association?
    Yes 1 No 2 (Go to #16) ( )

14. Do the membership dues include a subscription to this journal?
    Yes 1 No 2 (Go to #16) Don't Know 3 (Go to #15) ( )

15. Membership Dues:
    a. Individual (U.S.) $______.___ ( )
    b. Institutional/Corporate $______.___ ( )
    c. Foreign $______.___ ( )

16. Is a subscription price for this journal given? ( )
    Yes 1 No 2 (Go to #18)

17. Subscription Prices for this journal:

		Member	Non-Member
a.	Individual (U.S.)	$_______ ( )	$_______ ( )
b.	Institutional/Corporate	$_______ ( )	$_______ ( )
c.	Foreign (non-U.S.)	$_______ ( )	$_______ ( )

18. Is single copy price of a journal issue given?

Yes 1 No 2 (Go to #20) ( )

19. Single copy price of journal issue: $_______ ( )

20. Is the price of article reprints given?

Yes 1 No 2 (Go to #22) ( )

21. Single reprint price $_______ ( )

22. Number of issues regularly published per year: _______ ( )

(biweekly = 26, Monthly = 12, Bimonthly = 06, Quarterly = 04. Write "99" if this is an "irregular" publication in which the number of issues varies from year to year.)

III. Journal Description

23. Columns per page of text (circle one) 1 2 3 4 ( )

24. Number of lines per full page of text (without footnotes) _______ ( )

25. Number of characters per full line of text (across all columns) on one page _______ ( )

26. Number of lines per inch of text _______ ( )

27. Choose three issues at random from the volume you are examining (see instructions for how to choose issues). (a) Write down the issue number and the number of research articles for each of these three issues. (b) Add up the total number of research articles. (c) Divide this number by 3.

a. First issue # _______ No. of articles _______ Notes _______
Second issue # _______ No. of articles _______ _______
Third issue # _______ No. of articles _______ _______

b. Total number of articles in these issues _______ _______

c. Divide Total (b) by 3 _______ ( ) _______ ( )

28. What is the page size of the journal? (Circle category which best approximates page size. If none of the printed dimensions comes within a half inch of the actual size, circle "5" and write in your measurement. Ignore cover size.)

6x9...1 7x10...2 8x11...3 9x12...4 Other...5 _______ ( )

29a. What type of paper is this journal published on?

Glossy 1 Non-glossy 2 Don't Know 3 ( )

29b. Journal format being examined

Bound 1 Microform 2 Loose Issues 3 ( ).

29c. Have front and/or back covers been removed?

Yes 1 No 2

29d. Has any or all advertising been removed?

Yes 1 No 2 Don't Know 3

29e. Type of Journal

Research/academic 1

Trade/news journal 2

Other 3

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TRACKING SURVEY ARTICLE INFORMATION

IV. Article and Issue Information (If answer does not have a go to, continue with next question)

30. Abbreviation ____________________

31. Article Number (circle) 1 2 3 ( )

32. Article Date:

a. Month ________( ) b. Issue Number ________( )
c. Volume ________( ) d. Page ________( ) e. Year ________( )

33. Title of Article: ____________________

____

____________________( )

34. What is the total number of authors? ____________________( )

35. Print name of first author (last name, first name, middle initial)

____________________( )

36. Print first author's title (Professor, Director of Research, etc.)

____________________( )

37. Institutional affiliation or place of business of all authors:

Affiliation codes of all authors (circle all applicable at the time article was written)

Federal government (U.S.)	1	
State or local government (U.S.)	2	
Educational Institution (U.S.)	3	
Other non-profit institution (U.S.)	4	( )
Industrial/commercial institution (U.S.)	5	
Foreign	6	
Other (specify) ____________________		
____________________	7	
No affiliations given	8	

38. Is first author's (current) address given?

Yes 1 No 2 (Go to #40) ( )

39. First author's current address:

Department or division: ____________________( )

Institution or place of business: ____________________

____________________( )

Street Address: ____________________( )

City, State, Zip Code, Country: ____________________

____________________( )

40. Is a funding source identified by name for the research reported in this article?

Yes 1 No 2 (Go to #42) ( )

41. a. How many funding sources are identified? 1 2 3 4 5 or more ( )

b. Circle the funding source code for each funding source, using the following code: 1=Federal government, 2=state or local government, 3=industrial/commercial organization, 4=educational institutions, 5=other non-profit institutions, 6=other or unknown.

First funding source	1	2	3	4	5	6	( )
Second funding source	1	2	3	4	5	6	( )
Third funding source	1	2	3	4	5	6	( )
Fourth funding source	1	2	3	4	5	6	( )

42. Is a contract or grant number (e.g., NCT 21-025-006) identified for the research reported in this article?

Yes 1 No 2 (Go to #44) . ( )

43. Write the contract or grant numbers which are mentioned, and code the federal funding source by referring to the federal agencies list in the instructions. If the funding agency is not federal, use the code number 99, and write in the name of the agency on the dotted line.

no. ______________( ) Code ______( )__________________

no. ______________( ) Code ______( )__________________

no. ______________( ) Code ______( )__________________

44. Date article received by journal: Month ________( ) Year ________( )

45. Total number of pages in article ______________( )

46. Graphics in this article and in non-article portions of this issue (excluding advertising). See instructions for definitions.

	Graphics in this Article		Graphics in this Issue	
	no. of graphics	no. of pages	no. of graphics	no. of pages
a. Line Drawings	______( )	___.__( )	______( )	___.__( )
b. Tables	______( )	___.__( )	____	___.__( )
c. B/W half tones	______( )	___.__( )	______( )	___.__( )
d. B/W continuous tone	______( )	___.__( )	______( )	___.__( )
e. Color photographs	______( )	___.__( )	______( )	___.__( )

47. Total number of pages of small type in this article (footnotes, notes, labels for graphics, references at end of article, etc.) ___.__( )

48. Total number of math or chemical formula inserts in this article: ______( )

49. Total number of lines of math or chemical formulas in this article: ______( )

50. Number of items in references/bibliography section of article:

a. Total number of items: ______( )
b. Journal articles: ______( )
c. Technical reports: ______( )

51. Sample journal article from article's bibliography:

a. Author(s)______________________________( )
b. Article title ______________________________
______________________________( )
c. Journal name ______________________________( )
d. Volume_____( )Issue_____( ) Page_____( )Year_____( )

52. Pages of advertising in this issue (including front and back cover)

a. Black and white advertising ___.__( )
b. Color advertising ___.__( )
c. Total pages of advertising (a + b) ___.__( )

53. Number of pages in this issue not devoted to advertising or articles:

______( )

TRACKING SURVEY ARTICLE INFORMATION

V. Article and Issue Information (If answer does not have a go to, continue with next question)

54. Abbreviation ____________________

55. Article Number (circle) 1 2 3 ( )

56. Article Date:

a. Month ________( ) b. Issue Number ________( )
c. Volume ________( ) d. Page ______( ) e. Year _____( )

57. Title of Article: ____________________

____

____________________( )

58. What is the total number of authors? ____________( )

59. Print name of first author (last name, first name, middle initial)

____________________( )

60. Print first author's title (Professor, Director of Research, etc.)

____________________( )

61. Institutional affiliation or place of business of all authors:

a. Affiliation codes of all authors (circle all applicable at the time article was written)

Federal government (U. S.)	1
State or local government (U. S.)	2
Educational Institution (U. S.)	3
Other non-profit institution (U. S.)	4
Industrial/commercial institution (U. S.)	5
Foreign	6
Other (specify) ____________	7
No affiliations given	8

( )

62. Is first author's (current) address given?

Yes 1 No 2 (Go to #64) ( )

63. First author's current address:

Department or division: ____________________( )

Institution or place of business: ____________________

____________________( )

Street Address: ____________________( )

City, State, Zip Code, Country: ____________________

____________________( )

64. Is a funding source identified by name for the research reported in this article?

Yes 1 No 2 (Go to #66) ( )

65. a. How many funding sources are identified? 1 2 3 4 5 or more ( )

b. Circle the funding source code for each funding source, using the following code: 1=Federal government, 2=state or local government, 3=industrial/commercial organization, 4=educational institutions, 5=other non-profit institutions, 6=other or unknown.

First funding source	1	2	3	4	5	6	( )
Second funding source	1	2	3	4	5	6	( )
Third funding source	1	2	3	4	5	6	( )
Fourth funding source	1	2	3	4	5	6	( )

66. Is a contract or grant number (e.g., NGT 21-025-006) identified for the research reported in this article?

Yes 1 No 2 (Go to #68) ( )

67. Write the contract or grant numbers which are mentioned, and code the federal funding source by referring to the federal agencies list in the instructions. If the funding agency is not federal, use the code number 99, and write in the name of the agency on the dotted line.

no. ________( ) Code ______( )__________________

no. ________( ) Code ______( )__________________

no. ________( ) Code ______( )__________________

68. Date article received by journal: Month ________( ) Year ________( )

69. Total number of pages in article ______________( )

70. Graphics in this article and in non-article portions of this issue (excluding advertising). See instructions for definitions.

	Graphics in this Article		Graphics in this Issue	
	no. of graphics	no. of pages	no. of graphics	no. of pages
a. Line Drawings	______( )	______( )	______( )	______( )
b. Tables	______( )	______( )	______( )	______( )
c. B/W half tones	______( )	______( )	______( )	______( )
d. B/W continuous tone	______( )	______( )	______( )	______( )
e. Color photographs	______( )	______( )	______( )	______( )

71. Total number of pages of small type in this article (footnotes, notes, labels for graphics, references at end of article, etc.) ______( )

72. Total number of math or chemical formula inserts in this article: ______( )

73. Total number of lines of math or chemical formulas in this article: ______( )

74. Number of items in references/bibliography section of article:

a. Total number of items: ______( )
b. Journal articles: ______( )
c. Technical reports: ______( )

75. Sample journal article from article's bibliography:

a. Author(s)______________________________( )

b. Article title ______________________________

______________________________( )

c. Journal name ______________________________( )

d. Volume_____( )Issue_____( )Page _____( )Year_____( )

76. Pages of advertising in this issue (including front and back cover)

a. Black and white advertising ______( )

b. Color advertising ______( )

c. Total pages of advertising (a + b) ______( )

77. Number of pages in this issue not devoted to advertising or articles:

______( )

TRACKING SURVEY ARTICLE INFORMATION

VI. Article and Issue Information (If answer does not have a go to, continue with next question)

78. Abbreviation______________________________ (   )

79. Article Number (circle) 1 2 3 (   )

80. Article Date:

a. Month ________( ) b. Issue Number ________( )

c. Volume ________( ) d. Page ______( ) e. Year ______( )

81. Title of Article: ______________________________

______________________________( )

______________________________( )

82. What is the total number of authors? ______________( )

83. Print name of first author (last name, first name, middle initial)

______________________________( )

84. Print first author's title (Professor, Director of Research, etc.)

______________________________( )

85. Institutional affiliation or place of business of all authors:

a. Affiliation codes of all authors (circle all applicable at the time article was written)

Federal government (U.S.)	1	
State or local government (U.S.)	2	
Educational Institution (U.S.)	3	
Other non-profit institution (U.S.)	4	( )
Industrial/commercial institution (U.S.)	5	
Foreign	6	
Other (specify) ______________	7	
No affiliations given	8	

86. Is first author's (current) address given?

Yes 1 No 2 (Go to #88) (   )

87. First author's current address:

Department or division: ______________________( )

Institution or place of business: ______________

______________________________( )

Street Address: ______________________( )

City, State, Zip Code, Country: ______________

______________________________( )

88. Is a funding source identified by name for the research reported in this article?

Yes 1 No 2 (Go to #90) (   )

89. a. How many funding sources are identified? 1 2 3 4 5 or more (   )

b. Circle the funding source code for each funding source, using the following code: 1=Federal government, 2=state or local government, 3=industrial/commercial organization, 4=educational institutions, 5=other non-profit institutions, 6=other or unknown.

First funding source	1	2	3	4	5	6	( )
Second funding source	1	2	3	4	5	6	( )
Third funding source	1	2	3	4	5	6	( )
Fourth funding source	1	2	3	4	5	6	( )

90. Is a contract or grant number (e.g., NGT 21-025-006) identified for the research reported in this article?

Yes 1 No 2 (Go to #92) ( )

91. Write the contract or grant numbers which are mentioned, and code the federal funding source by referring to the federal agencies list in the instructions. If the funding agency is not federal, use the code number 99, and write in the name of the agency on the dotted line.

no. ________( ) Code ______( )------------------

no. ________( ) Code ______( )------------------

no. ________( ) Code ______( )------------------

92. Date article received by journal: Month ________( ) Year ________( )

93. Total number of pages in article ________________( )

94. Graphics in this article and in non-article portions of this issue (excluding advertising). See instructions for definitions.

	Graphics in this Article		Graphics in this Issue	
	no. of graphics	no. of pages	no. of graphics	no. of pages
a. Line Drawings	______( )	______( )	______( )	______( )
b. Tables	______( )	______( )	______( )	______( )
c. B/W half tones	______( )	______( )	______( )	______( )
d. B/W continuous tone	______( )	______( )	______( )	______( )
e. Color photographs	______( )	______( )	______( )	______( )

95. Total number of pages of small type in this article (footnotes, notes, labels for graphics, references at end of article, etc.) ______( )

96. Total number of math or chemical formula inserts in this article: ______( )

97. Total number of lines of math or chemical formulas in this article: ______( )

98. Number of items in references/bibliography section of article:

a. Total number of items: ______( )
b. Journal articles: ______( )
c. Technical reports: ______( )

99. Sample journal article from article's bibliography:

a. Author(s)________________________________( )

b. Article title ________________________________

____( )

c. Journal name ________________________________( )

d. Volume_____( )Issue_____( )Page _____( )Year_____( )

100. Pages of advertising in this issue (including front and back cover)

a. Black and white advertising ______( )

b. Color advertising ______( )

c. Total pages of advertising (a + b) ______( )

101. Number of pages in this issue not devoted to advertising or articles: ______( )

TRACKING SURVEY FORM ASSIGNMENTS

Journal Code(s) [ ][ ][ ] [ ][ ][ ] [ ][ ][ ]

Full Journal Title ______________________________

Alternate Title ______________________________

To Be Done	Form Number	Library and Call Number
62		
64		
66		
68		
70		
72		
74		

APPENDIX VI

AUTHOR SURVEY PRETEST FORMS

VI.1	COVER LETTER
VI.2	QUESTIONNAIRE
VI.3	RESPONSE CARD

MARKET FACTS, INC., 4410 Executive Boulevard, Rockville, Maryland 20852 (301) 881-6766
CENTER FOR QUANTITATIVE SCIENCES

Dear Colleague:

The Center for Quantitative Sciences of Market Facts, Inc., is investigating journal publishing practices and use between 1962 and 1974. This is part of a larger effort to study the economic aspects of scientific and technical information transfer. Your name was obtained from a sample of journal articles published during that period. In order to estimate trends in journal publishing costs, we observed a number of physical characteristics of your journal article, such as length, number of graphs, formulas, and other illustrations. In order to obtain additional information relevant to scientific communication, we would appreciate a few moments of your time to help us with the supplementary questions printed on the back of this letter.

There are two groups of questions. The first applies to the article which you wrote:

The second group of questions refers to an article which you cited in your article:

Please check your answers on the enclosed post-paid postcard. Of course, individual responses will remain confidential. If you have any questions, please call Dennis McDonald collect at (301) 881-6766.

Thank you for your cooperation.

Sincerely,

Donald W. King
Director

[illegible] answers on the [illegible]. All [illegible] are [illegible]. If you [illegible], contact, [illegible].

[illegible]

1. How [illegible] was your article [illegible], if [illegible]? *(Insert appropriate number [illegible], zero if [illegible])*

2. [illegible] you or your [illegible] paid [illegible] to support journal publication? *(Insert number, [illegible] if none)*

3. How many reprints of your article have you [illegible] published? *(Insert number, zero if none)*

4. Of these reprints, for how many did you pay? *(Insert number, zero if none)*

5. How many reprint requests have you received for this article? *(Insert number, zero if none)*

[illegible]

6. When you first became aware of this article, were you *(circle appropriate response on card)*
   1. Doing a literature search for information on the article's topic or a related topic
   2. Not doing a literature search for information on the article's topic or a related topic
   3. Don't remember

7. To be more specific about the manner in which you first became aware of this article, circle the appropriate response on the card for the way in which you first found out about it: *(Circle response on card)*
   1. Discovered while reading *my own copy* of the journal issue in which it appeared.
   2. Discovered while reading a *library's* copy of the journal issue in which it appeared.
   3. Discovered while reading a *colleague's* or *office* copy of the journal issue in which the article appeared
   4. I was *referred* to this article by a *colleague*.
   5. I was referred to it by a list of *references in another publication*.
   6. I received a preprint of this article prior to its being published.
   7. Found in a search of *printed indexes* or catalogs during the course of a literature search.
   8. Found in the course of a *computerized* literature search of an automated retrieval system.
   9. Found in a current awareness list, or a selective dissemination of information list *(SDI)*.
   10. Don't remember.
   11. Other *(please describe on card)*

8. How did you obtain physical access to this article so that you could actually read it? *(Circle response on card)*
   1. My own subscription to the journal in which it appeared.
   2. A library's copy (bound volume or loose issue)
   3. A library's microfilm (microfiche) viewer.
   4. An office microfilm (microfiche) viewer.
   5. A preprint prior to article's being published.
   6. A reprint obtained from the author.
   7. A reprint obtained from the journal.
   8. A [illegible] or office copy of the journal.
   9. I didn't have physical access to this article, or I was able to read only an [illegible] summary.
   10. Don't remember.
   11. Other ________________

9. [illegible] did you [illegible] obtain a copy [illegible]? *(Circle response on card)*
   1. [illegible]
   2. [illegible]
   3. [illegible]
   4. [illegible]
   5. [illegible]

[illegible]

[illegible]

1. Number of [illegible] returned to you for [illegible] .... ____ (11)
2. Page [illegible] .... ____ ([illegible]-15)
3. Number of [illegible] you obtained .... ____ (16-19)
4. How many reprints you [illegible] .... ____ (20-2[illegible])
5. How many [illegible] received .... ____ (24-2[illegible])

[illegible]

6. When you first became aware of this article: 1 2 3 (28)
7. Way in which you first found out about the article:

   1 2 3 4 5 6 7 8 9 10 11 ____________ (29)

8. How you obtained physical access to the article:

   1 2 3 4 5 6 7 8 9 10 11 ____________ (30)

9. Did you make or obtain a copy of this article?

   1 2 3 4 5 ____________ (31)

APPENDIX VII

REVISED AUTHOR SURVEY FORMS

VII.1 COVER LETTER

VII.2 QUESTIONNAIRE

VII.3 RESPONSE CARD

MARKET FACTS, INC.. 1110 Executive Boulevard, Rockville, Maryland 20852 (301) 881-6766

CENTER FOR QUANTITATIVE SCIENCES

Dear Colleague:

The Center for Quantitative Sciences is studying journal publishing practices and use between 1962 and 1974. This is part of a larger effort entitled "Statistical Indicators of Communication of Scientific and Technical Information."

Your name was obtained from a sample of journal articles published during that period. In order to estimate trends in journal publishing, we observed a number of characteristics of your journal article, such as scientific field of publication, extent of citation to and from the article, content of the article and so on.

In order to obtain additional information relevant to scientific communication, we would appreciate a few moments of your time to help us with the supplementary questions printed on the back of this letter. We have purposely kept the amount of information to a bare minimum which can be incorporated as parameters in a mathematical model.

There are two groups of questions. The first applies to the article which you wrote:

The second group of questions refers to an article which you cited in your article:

Please check your answers on the enclosed post-paid postcard. Of course, individual responses will remain confidential. If you have any questions, please call Dennis McDonald collect at (301) 881-6766.

If you would like a reference to our final report, please so indicate on the card. Thank you for your cooperation.

Sincerely,

Donald W. King
Director

NOTE Check your answers on the enclosed, post-paid return postcard. All responses are confidential. If you have any questions, call Dennis McDonald, collect, 301-881-6766.

ABOUT YOUR ARTICLE

1. How many times was your article returned to you for revisions, if at all? *(Insert appropriate number on card, zero if none)*

2. How much did you or your employer pay in page charges or special fees to support journal publication? *(Insert number, zero if none)*

3. How many reprints of your article have you obtained from the publisher? *(Insert number, zero if none)*

4. Of these reprints, for how many did you pay? *(Insert number, zero if none)*

5. How many reprint requests have *you* received for this article? *(Insert number, zero if none)*

ABOUT THE ARTICLE WHICH YOU CITED

6. When you *first became aware* of this article, were you *(circle appropriate response on card)*

   1. Doing a literature search for information on the article's topic or a related topic
   2. Not doing a literature search for information on the article's topic or a related topic
   3. Don't remember

7. To be more specific about the *manner* in which you first became aware of this article, circle the appropriate response on the card for the way in which you first found out about it: *(Circle response on card)*

   1. Discovered while reading *my own copy* of the journal issue in which it appeared.
   2. Discovered while reading a *library copy* of the journal issue in which it appeared.
   3. Discovered while reading a *colleague's or office* copy of the journal issue.
   4. I received a *preprint* of this article from the *author*, prior to its being published.
   5. I obtained a *preprint* of this article from a colleague or co-worker.
   6. I received a *reprint* of this article without having requested it.
   7. I received a *reprint* of this article from a *colleague or co-worker*.
   8. I was *referred to this article* by a *colleague or co-worker*.
   9. I found it referred to in another *article, book, or report*.
   10. Found in a search of *printed indexes or catalogs* during the course of a literature search.
   11. Found in the output of a *computerized literature search* of an automated retrieval system.
   12. Found in a *current awareness* list, or a *selective dissemination of information* list (SDI).
   13. Don't remember.
   14. Other *(please describe on card)*

8. How did you obtain *physical access* to this article so that you could actually read it? *(Circle response on card)*

   1. My *own issue* of this journal.
   2. A *library's issue* of this journal *(loose issue or bound volume)*.
   3. A library's *microfilm/microfiche issue* of this journal.
   4. a *colleague's or office copy* of this journal.
   5. An office *microfilm/microfiche* copy of this journal.
   6. A *reprint* of this article obtained from the journal publisher.
   7. A *reprint* of this article obtained from the *author*.
   8. A *reprint* of this article obtained from a *colleague or office collection*.
   9. A *preprint* of this article obtained from the *author*.
   10. A *preprint* of this article obtained from a *colleague or office collection*.
   11. A *photocopy (or Xerox copy)* obtained from a *colleague or office collection*.
   12. I didn't have physical access to this article or I was able to read only an abstract or summary.
   13. Don't remember.
   14. Other *(please describe on card)*.

9. At any time did you make a copy of this article for yourself? *(circle response on card)*

   1. No copy obtained.
   2. Photocopy (*Xerox copy*) made.
   3. Copy made from microfilm reader-printer.
   4. Other (*please describe on card*).

NUMBERS IN BRACKETS ON RESPONSE CARD ARE AIDS TO KEYPUNCHING.

Front

FIRST CLASS
PERMIT 32150
CHICAGO, ILL.

MARKET FACTS, INC.

P.O. BOX 6613

CHICAGO, ILLINOIS 60680

Check here to receive reference
to final report: ☐

Back

ALL RESPONSES ARE CONFIDENTIAL 1 9 2 1 9 4 5 ☐☐☐ ☐☐ ☐

ABOUT YOUR ARTICLE

1. Number of times returned to you for revision....______ (11)
2. Page charges or special fees (to nearest $).....______ (12-15)
3. Number of reprints you obtained.................______ (16-19)
4. How many reprints you paid for..................______ (20-23)
5. How many reprint requests you've received.......______ (24-27)

ABOUT THE ARTICLE WHICH YOU CITED

6. When you first became aware of this article: 1 2 3 (28)
7. Way in which you first found out about the article:

   1 2 3 4 5 6 7 8 9 10 11 12 13 14 ______ (29)

8. How you obtained physical access to the article:

   1 2 3 4 5 6 7 8 9 10 11 12 13 14 ______ (30)

9. Did you make or obtain a copy of this article?

   1 2 3 4 5 6 7 8 ______ (31)

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APPENDIX VIII

RESEARCH DOCUMENT TRACKING EXPERIMENT

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VIII.1 Report Literature

This experiment attempted to track the report literature generated from research projects registered with the Smithsonian Science Information Exchange (SSIE).

A sample of approximately 50 research projects in each of the nine NSF fields of science in each of the four fiscal years 1966, 1968, 1970 and 1972 was drawn from the SSIE historical files. These projects were then used to search the NTIS file for reports generated as a result of the research. The data obtained and the problems encountered are discussed below.

VIII.2 SSIE System

The basic record in the SSIE System is a single page Notice of Research Project (NRP), which contains essential information about individual projects. Following is a list of the essential data elements which can be found on the NRP.

- Supporting organization
- Grant or contract number
- Performing organization name and address
- Name, department and specialty of the principal investigator
- Names of co-investigators
- Project title
- Period covered by the NRP
- Funding level
- In most cases, a 200-word technical description of the project

VIII.3 Sample Selection From SSIE

A two-stage sampling procedure was necessary to obtain data on the approximately 1800 projects (50 contracts in nine fields for four years from SSIE).

In the first stage, SSIE ran searches of the FY 1966, 1968, 1970 and 1972 files. For each year, four searches were run, by combining two or three NSF fields of science in each search. The resulting listing contained approximately 1,000 research contracts for each search. The listing identified the scientific field of each entry. The combination of fields were selected so that there would be a minimum of chance of picking up two documents indexed under both fields.

From these listings, approximately 50 items were randomly selected per field. For those contract numbers to be included in the sample (1811), an effort to obtain a copy of the SSIE's NRP for each contract number was made.

VIII.3.1 Problems Encountered

The first problem encountered was that in searching SSIE's files some of the NRPs could not be found and others that were found were not legible; a total of 139 NRPs fell into this category. Removing these 139 contracts from the sample meant an eight percent reduction in our sample size (the original sample included 1811, the revised sample included 1672).

The second problem encountered was that for the 1672 NRPs that were located in SSIE files not all of the essential information was included; e.g., there were missing contract numbers, project titles, funding, time period covered, etc. According to the SSIE pamphlet entitled Research Information Services, this essential information "is recorded as it is provided by supporting organizations" (131). Since this data is provided on a voluntary basis and SSIE does not verify each data element, errors in data and omissions of data were found to exist.

With respect to this portion of the study, the most essential information needed was the contract number. The NRP does not have a place on the form entitled "Contract Number". There is a block entitled "Agency Number" which was supposed to be used as the contract number block; however, most often this block did contain some sort of agency number rather than a contract number.

If SSIE had verified this one data element alone (contract number), the task of tracing a project from SSIE to NTIS would have been much easier and the data obtained much more reliable.

VIII.4 NTIS Search

The data from the 16[illegible] NRPs was then recorded on coding forms, keypunched, and a master printout made to facilitate the search of the NTIS files.

VIII.4.1 Contract Number Search

It was clear that the most efficient and accurate search would be by contract number, as opposed to an author or subject search. By searching by contract number, we felt we could obtain the total number of reports generated by each contract and the dates these reports were received by NTIS. However, due to the following problems this procedure did not provide the results expected.

VIII.4.1.1 Project Exclusions From Sample

Approximately 58 percent of the sample projects had to be excluded from the contract number search for one of the following reasons.

1. No contract number was given for project on NRP. If contract number was given, it was not reliable, i.e., number was missing a suffix, prefix or was other than a true contract number (approximately 43 percent of total sample).

2. Both NTIS and the Agriculture Department felt that contracts that were non-Federal or Agricultural would be unlikely to appear in the NTIS listings; therefore, these were excluded from sample (approximately 15 percent of total sample).

As a result of these contract number problems the sample was reduced from 1672 to 708 projects. These 708 contract numbers represented numbers thought to be accurate and complete. However, another stipulation upon searching the NTIS files was that contract numbers had to have all spaces, hyphens, etc., in the correct place, or NTIS could not make a match. Therefore, the contract numbers were searched for manually by Market Facts personnel, in an effort to look up each contract number in a variety of formats (with or without dashes, suffixes, etc.). Of the 708 contract numbers, 21 percent (150) produced related report information. Though this number seems low, it is higher than could have been expected from an NTIS automated search, because of the matching problem.

Therefore, of our representative sample of 1672 projects, only nine percent of this sample produced reports located in NTIS holdings. A more detailed analysis and the results of the contract number search appears in a later portion of this section.

VIII.4.2 Author Search

Having obtained such a low response to the contract number search (mainly due to excluding 58 percent of sample) a search by principal investigator and other co-investigators was undertaken* in order to see if better results could be obtained. This task required Market Facts personnel to manually search through each volume of the Government Reports Index (GRI), Personal Author Index (56) for the years 1966 through 1974 inclusive, by individual author/co-authors.

VIII.4.2.1 Problems Encountered

From the initiation of this task, it was known that it would be difficult to match the titles of projects given on the SSIEs NRPs to report titles referenced on the GRI. The first difficulty was that the Personal Author Index of the GRI did not relate report titles to contract numbers; therefore, there was no reliable way to verify GRI titles with the sample project titles on the NRP. Secondly, the NRP project titles were most often general in scope, which made it difficult to match titles. Thirdly, since contract numbers were not available in the author index, and since authors tend to work in the same or related scientific areas, it was impossible to

---

*Hereafter referred to as author search.

know if a report appearing in the 1974 GRI which had a similar title to the project on the 1966 or any year NRP, was in fact a result of that NRP project or another project not in a sample on which the author had participated. Fourth, since the length of the contract and funding were often omitted from the NRP, it was also impossible to know if a report written three, five, or even eight years after the project was initiated could realistically pertain to that project.

Therefore, the results of this search, which are presented shortly, are most likely an overestimate of the true probability of locating a project in NTIS, due to the problems just mentioned.

VIII.5 NTIS Search

VIII.5.1 Contract Number Search - Results

VIII.5.1.1 Number of Contract Numbers Found

A search by contract number of the NTIS holdings was the first search to be run. Certain contracts were excluded in the search (58 percent of sample) for the reasons cited earlier. The remaining 42 percent (708 contracts) were included in the search with the following results.

Table VIII.1 presents, by scientific field, the percent of projects searched for and percent of projects found in NTIS. Of the 708 contracts searched for in NTIS holdings, 150 contracts were found or 21 percent of those projects searched for were found. These 150 contracts constitute only nine percent of the total contracts in the sample (1667).

Fields 1, 2, and 3 (Physical Sciences, Mathematics and Computer Sciences respectively) contained the greatest percent of projects which had contract numbers which could be searched for: from 55 percent to 60 percent of these projects had full, legible, Federal, non-Agriculture contract numbers. Fields 6 and 8 (Life Science and Social Science) had the lowest percent of projects with appropriate contract number data (24% and 29%).

Table VIII.1: CONTRACT NUMBER SEARCH: PERCENT OF CONTRACTS FOUND, BY FIELD OF SCIENCE

Field of Science	Total Number of Contracts in Sample	Total Number of Contracts included in Search	Contracts included as Percent of Total (%)	Total Number of Contracts Found	Contract Found as Percent of Total Sample (%)	Contracts Found as Percent of Contracts included in Search (%)
Physical Sciences	188	112	60	29	15	25
Mathematics	196	112	57	32	16	29
Computer Sciences	195	107	55	27	14	25
Environmental Sciences	184	72	39	20	11	28
Engineering	185	75	41	14	8	19
Life Sciences	187	45	24	6	3	13
Psychology	193	67	35	4	2	6
Social Sciences	200	58	29	9	5	16
Other Sciences	144	60	42	9	6	15
Mean	186	79	42	17	9	21

SOURCE: Document Tracking Study, Market Facts, Inc., Center for Quantitative Sciences.

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Fields 1, 2, 3 and 4 (Field 4 being Environmental Sciences) produced the best results with respect to contract numbers found: from 25 percent to 29 percent of these contracts were found. Field 7 (Psychology) produced the weakest response: only six percent of these contract numbers were found that were searched for. Fields 5, 6, 8 and 9 had percents ranging from 13 percent to 19 percent for contracts found. The overall average of contracts found was 21 percent.

VIII.5.1.2 Number of Reports Found

During the Contract Number Search, it was discovered that three contracts (affecting four projects in Field 1 and one project in Field 5) generated between 1,100 to 2,900 reports each. A query to NTIS concerning these large numbers of reports and meager funding allocation per contract resulted in NTIS forwarding to our office a list of contract numbers which were to be considered as general use contracts, and should be deleted from the sample. Therefore, since these three contracts appeared on the NTIS List, they were deleted from our tabulations concerning "Numbers of Reports Found" in order to arrive at a more accurate and meaningful analysis.

Table VIII.2 contains the results of the Reports Found analysis. The mean number of reports found per field was 282.3 (Range: 68-757), with an average of 18.4 (Range: 7.5-35.8) reports found per contract. Fields 2 and 3 had the largest overall number of reports found (757 and 619 respectively). However, Field 6 and 9, with only 215 and 232 reports found, had the highest number of reports found per project found (35.8 and 25.8 respectively) with Field 2 and 3 following, having had 23.6 and 22.9 reports found per project found.

The range for the number of reports found per contract number is included in Table VIII.3.

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Table VIII.2: NTIS CONTRACT NUMBER SEARCH: NUMBER OF REPORTS FOUND

Field of Science	Total Number of Contracts in Sample	Number of Contracts Found	Number of Reports Found	Number of Reports per Contract Found
Physical Sciences	184	25	187	7.5
Mathematics	196	32	757	23.6
Computer Sciences	195	27	619	22.9
Environmental Sciences .	184	20	260	13.0
Engineering	184	13	121	9.3
Life Sciences	187	6	215	35.8
Psychology	193	4	82	20.5
Social Sciences	200	9	68	7.6
Other Sciences	144	9	232	25.8
Total	1,667	145	2,541	-
Mean per field	185.2	16.1	282.3	18.4
Median	187	13	215	20.5

SOURCE: Document Tracking Study, Market Facts, Inc., Center for Quantitative Sciences.

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Table VIII.3: RANGE FOR NUMBER OF REPORTS FOUND PER CONTRACT NUMBER

Field Number

	1	2	3	4	5	6	7	8	9
Range	1-46	1-277	1-277	1-185	1-36	1-112	1-74	1-55	1-135

VIII.5.1.3 Number of Reports Found By Year

The contract number search by year produced the total number of reports that were generated subsequent to the year the contract was awarded. Therefore, total numbers of reports for 1966 projects include all those reports generated during 1966 through 1974; 1968 projects include reports generated 1968 through 1974; and so on. An expectation was that 1966 projects would yield the greatest number of reports and also the greatest ratio of reports per project; 1968 would yield the next greatest totals, etc. However, due to the following factors this expectation was not fulfilled.

a. There has been a strong tendency in recent years for the U.S. Government to require the registering of documents at NTIS in recent years. Thus, greater numbers of reports and projects could be expected to appear in later years.

b. Also, more contractors are submitting project reports to NTIS voluntarily in recent years.

c. As previously stated, because of the illegibility or lack of contract numbers on certain projects or the probability that a certain group (agriculture) of contract numbers were not usually included in NTIS holdings, certain projects could not even be included in the search (about 58 percent of projects were excluded). An assumption was made that the remaining 42 percent of the contract numbers were valid and complete, since it was difficult to ascertain whether a contract number was, in fact, complete and accurate. Contract numbers that were obviously missing prefixes or suffixes were deleted if prefixes could not be added. Some partial contract numbers may have been searched for since we were not aware of the fact that they were incomplete.

Table VIII.4 presents the results of the search by year. Column 1 presents the number of projects in the sample; Column 2, the number of projects searched; Column 3, the number of projects found; Column 4, the number of reports found; Column 5, the percent of projects found (Column 3 ÷ Column 1); Column 6, the number of reports found per project found (Column 4 ÷ Column 3).

The average number of reports found per year was 610.5, the range by year was 234 (for 1966 contracts) to 1254 (for 1968 contracts). The average number of reports found per project was 16.3; ranging from 7.3 (for 1966 and 1970 projects) to 28.5 (for 1968 projects). However, as can be seen below on Table VIII.5, the individual range per field for the four sample years varied even more.

Table VIII.5: RANGE FOR NUMBER OF REPORTS FOUND PER YEAR

Year of Contract Award	Range of Number of Reports Found Per Contract Number (Project)
1966	1 - 67
1968	1 - 277
1970	1 - 74
1972	1 - 185

As can be seen from the range data, on an individual contract number basis, as many as 277 reports were found associated with one contract number; this finding was not rare and, therefore, these numbers of reports cannot be discarded as unusual or as non-representative of the number of reports that are generated as a result of a contract award. As was to be expected, the mode was one (1) for the number of reports found for each contract number.

From the Contract Number Search, it was not possible to identify the time lapse from initiation of contract to appearance of first report in NTIS, since this data was not recorded in the NTIS Contract Number Listing as such. The NTIS Contract File consisted of contract numbers with the number of reports listed after the appropriate contract numbers. The time lapse information is contained in the Author Search section of this Chapter.

Table VIII.4: CONTRACT NUMBER SEARCH: REPORTS FOUND, BY YEAR OF PROJECT

Year	1 Total Number of Projects in Sample	2 Number of Projects Searched	3 Number of Projects Found	4 Number of Reports Found	5 Percentage of Projects Found to Number in Sample (%)	6 Number of Reports Found Per Project Found
1966	408	162	32	234	7.8	7.3
1968	398	190	44	1,254	11.0	28.5
1970	427	178	40	292	9.4	7.3
1972	434	178	34	662	7.8	19.5
Total	1,667	708	150	2,442	-	-
Mean Per Year . . .	416.8	177.0	37.5	610.5	9.0	16.3
Median Per Year . .	417.5	178.0	37.0	477.0	8.6	13.4

SOURCE: Document Tracking Study, Market Facts, Inc., Center for Quantitative Sciences.

It was apparent from the Contract Number Search/Year Data (Table VIII-4) that it can be expected that nine percent of contracts awarded will have documentation appearing in NTIS. This percent is on the lower side of the spectrum in that it takes into account the circumstances that prevailed on our sample of data, i.e., illegible or no contract numbers to search for, which automatically eliminated projects from search process.

A more optimistic outlook is that 21.2 percent of the projects were found out of those contract numbers that could be included in the search (42 percent of the total sample was included in search). Therefore, it should be expected that approximately 21 percent of Feder l contracts initiated (excluding agriculture) will generate reports appearing in NTIS.

VIII.5.2 Author Search - Results

As discussed previously, an author search was conducted by a manual search of the GRI for the years 1966 through 1974 inclusive. Following are the results of that search.

Of the 1667 sample projects, 431 were located by the author search, or 26 percent of the sample. These 431 projects produced 928 reports or 2.2 reports per project. Table VIII.6 includes the number of reports per project for each field.

Table VIII.6: NUMBER OF REPORTS PER PROJECT

	Field									
	1	2	3	4	5	6	7	8	9	Mean
Reports/ Project	2.6	2.2	2.6	1.9	2.0	2.1	1.9	1.6	1.6	2.2

VIII.5.2.1 Field Analysis

By the nine fields, there was an average of 103.1 reports found per field, the range being 42 - 194. Again, fields 1, 2 and 3 produced the greatest numbers of reports: 166, 153 and 194 respectively. Fields 7, 8 and 9 had the lowest numbers of reports: 42, 50 and 46 respectively.

Table VIII.7 relates the sample years with the total number of reports subsequent to the year the project was initiated.

Table VIII.7: TOTAL NUMBER OF REPORTS FOUND AFTER CONTRACT INITIATED

Year Project Initiated	Total Number of Reports From Year Project Initiated Through 1974
1966	242
1968	285
1970	194
1972	207

From Table VIII.7, it is apparent that the ~~l number of reports is slightly greater for the earlier years than for ~~ter years. This was to be expected since a project initiated in 1966 had eight years in which to produce related reports, while a project in 1972 only had a two-year time span; thus the total number of reports are lower for a 1972 project than a 1966 project. The reduction in the reports from year-to-year is not as great as anticipated; however, this can probably be explained by the increase in NTIS coverage in recent years. Also, the Federal Government is requesting that more government contracts submit reports to NTIS.

VIII.5.2.2 Time Lapse

An analysis of the time lapse from initiation of contract/grant to appearance of first report in NTIS was attempted. This analysis did produce one meaningful result -- the number of projects and reports in a three-year span after initiation of contract increased significantly for each of the sample years. See Table VIII.8.

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Table VIII.8: PROJECTS FOUND WITHIN THREE YEARS AFTER INITIATION OF CONTRACT

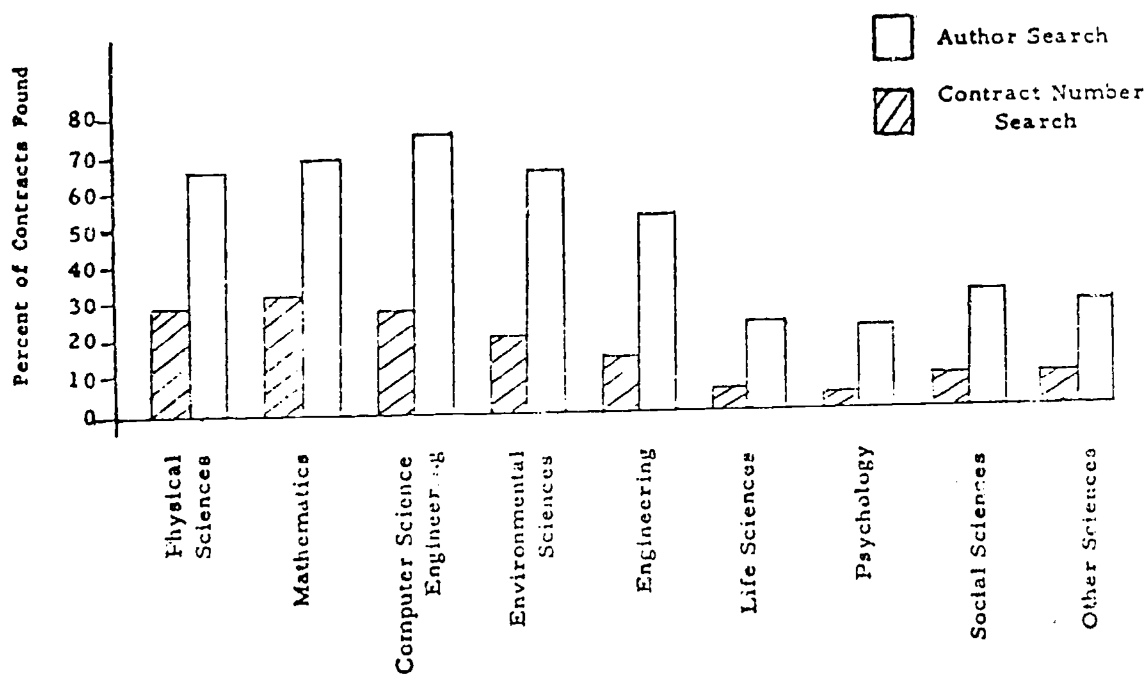
Year Project Iniated	Total Number of Projects Found From Initiation of Project Through Year Span	Total Number of Projects in Sample
1966	40	408
1968	73	398
1970	83	427
1972	116	434
	312	1667

This increase from year to year may be explained by one or both of the following reasons: (1) NTIS has been expanding its coverage to include additional agencies each year; (2) the Federal Government is encouraging that contractors submit reports to NTIS, thereby increasing coverage in NTIS. Thus, it can be expected that a project from a more current year will have a better chance of being located than an earlier project.

VIII.6 Comparison of Results From Contract Number Search and Author Search

From Figure VIII.1, it can be seen that more contracts were found by the Author Search than by the Contract Search. This can be explained by two factors. The Contract Search only included 42 percent of the sample while the Author Search included close to 100 percent of the sample. Therefore, the Contract Number Search should be considered as a low estimate. Furthermore, contracts were considered as found under the Author Search if the title in the GRI closely resembled the title on the NRP. However, often the NRP title was too general to allow exclusion of a specific GRI title that referred to the same subject. For this reason the author search numbers could be considered as a high estimate. On the other hand, a corporate author or agency search was not conducted since it was known that additional problems would arise: such as whether corporate authors were those listed as such on NRP, or whether the report came out issued under a subcontractor or the funding agency. Such a search would have provided additional contracts found which were referenced by corporate/agency author and not by personal author. Thus, the author search could also be considered a low estimate since this additional corporate search could not be conducted.

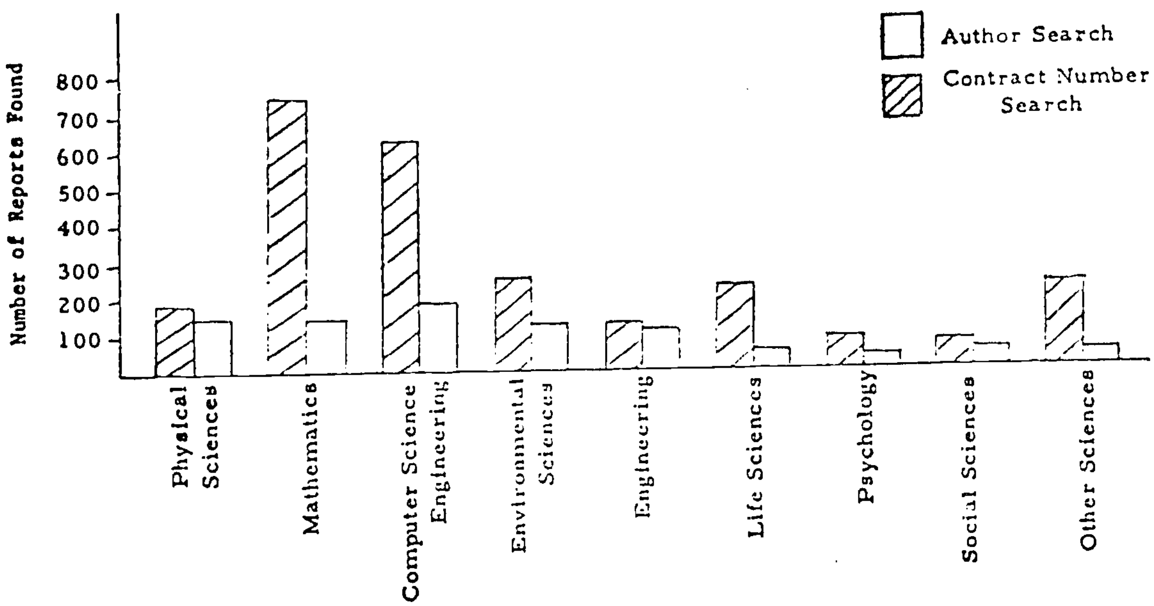
Figure VIII.1 PERCENT OF CONTRACTS FOUND IN NTIS BY AUTHOR AND BY CONTRACT NUMBER SEARCH



I.6.1 Number of Reports Found

The total number of reports found by Author and Contract Search for 1 field are presented in Figure VIII.2. The con-ract number search is idered to present the most reliable data, since this search included all rts pertaining to a specific contract. The author search only tracked down these reports which include those authors listed on the NRP, thus excluding reports that came out under a corporate author or an author not listed on NRP.

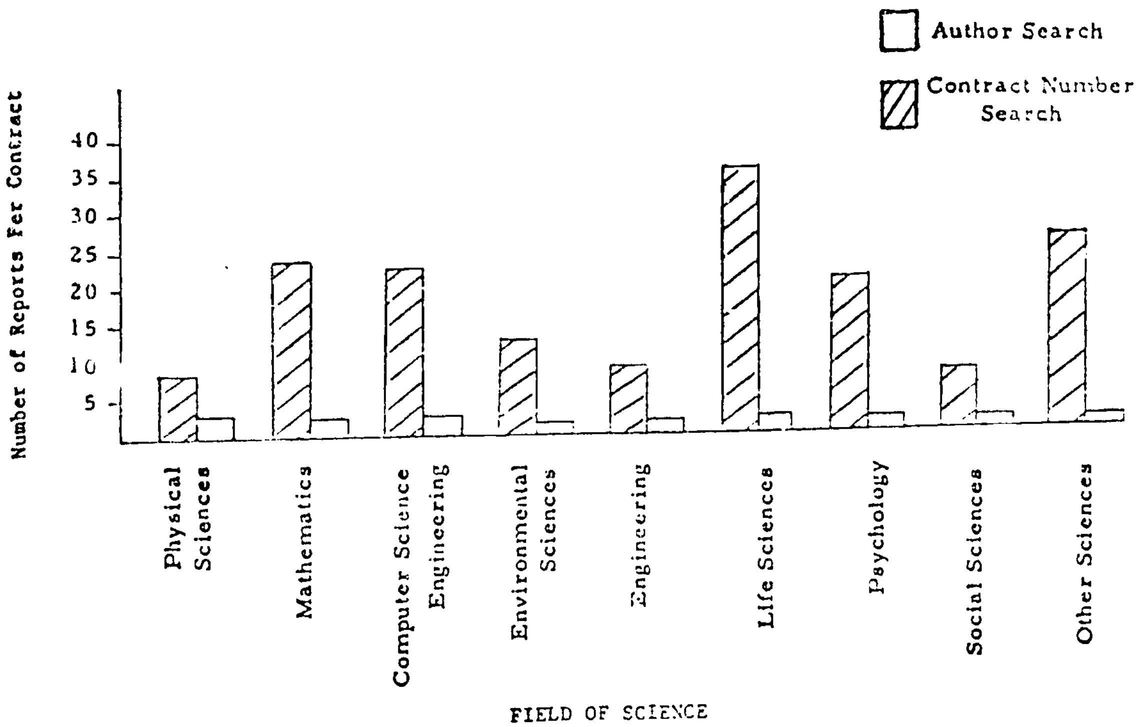
Figure NUMBER OF REPORTS FOUND IN NTIS BY AUTHOR AND CONTRACT SEARCH



VIII.6.2 <u>Number of Reports Per Contract</u>

Figure VIII.3 shows the comparison of number of reports per contract for the author and contract number search. Again, the contract number data was considered to be the most reliable for the same reasons stated earlier.

Figure VIII.3 NUMBER OF REPORTS FOUND IN NTIS PER CONTRACT NUMBER BY AUTHOR AND CONTRACT SEARCH



VIII.6.3 Individual Field

From Figures VIII.1, VIII.2 and VIII.3 it is evident that fields 1, 2 and 3 had the highest number of contracts found by either search; the highest total number of reports found; and the highest number of reports per contract found.

Therefore, it is concluded that work performed relating to a project pertaining to one of these three fields (Physical Sciences Mathematics or Computer Sciences) has a greater chance of resulting in a report format after being submitted to NTIS than work done in the other fields.

VIII.7 Conclusion

It was found that due to increased NTIS coverage and the Government's requesting contractor to submit reports to NTIS, reports from contracts let in most recent years have a better chance of being located in the NTIS holdings.

VIII.8 Recommendations

One strong defect in the SSIE's process became evident immediately and hindered obtaining accurate results through this phase of the study. This flaw is that SSIE does not require agencies or corporations to submit complete and accurate information pertinent to contracts to be recorded on the NRP. SSIE does not require this presently because information is provided to them on a voluntary basis by supporting organizations. It is, therefore, difficult to set requirements for something done voluntarily. It is recommended that SSIE establish a follow-up campaign which specifically involves verifying that the contract number is accurate and complete; this includes verifying that dashes and spaces are in the correct place since NTIS cannot search contract numbers unless the contract number appears exactly in the form they receive it. By verifying this one essential piece of information the results obtained from searching NTIS files would increase significantly.

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