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Examining China's science and technology statistics: a systematic perspective

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Abstract

Purpose – The purpose of this paper is to discuss the reliability of official Chinese government statistics in general, overview the evolution of China's S&T (science and technology) statistical system while highlighting the main sources of such statistics, point out some of the particular problems related to China's S&T statistics, and provide perspectives about how to best use and interpret these numbers.

Design/methodology/approach – Statistics of China's human resources in science and technology has been used to illustrate how such S&T statistics should be interpreted.

Findings – While the S&T data collection involving multiple government ministries causes problems, the interpretation of the data, including reconciling data from different sources and piecing information together, poses challenges to drawing an appropriate and overall picture of the development of S&T in China. In order to achieve a better understanding of China's S&T statistics, student researchers of Chinese science and technology have to comprehend the definitions, exhaust all the sources, and find and recognize discrepancies.

Originality/value – This paper represents the first effort to examine China's S&T statistical system, an important source of information regarding China's S&T development.

Keywords China, Science and technology, Data analysis, Statistics, S&T statistics, Labour

Paper type Research paper

Understanding and using Chinese statistics in Western research on contemporary China has presented many vexing challenges to scholars since the government of the People's Republic of China issued its first formal sets of "official" data in the 1950s. The bulk of the research for our recent book, *China's Emerging Technological Edge: Assessing the Role of High-end Talent*, compiled and interpreted primary statistics and related data from Chinese Government sources concerning China's science and technology (S&T) and education activities in general and human resources in science and technology (HRST) in particular (Simon and Cao, 2009). Our ostensible goal was to develop a comprehensive picture of the S&T human resource situation in China that perhaps is similar to the one used by Chinese policymakers and scholars. In relying heavily on these Chinese sources, we recognized from the start that there remains a huge reliability gap between China and developed countries, especially the USA and Europe, in collecting and reporting such statistics. A host of cautions was certainly warranted as we used these data, even after scrubbing and filtering for inconsistencies and associated explicit and implicit problems.

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These issues created a number of scholarly minefields as we sought to present an accurate picture of developments regarding China's high-end talent pool. Nonetheless, as scholars working on contemporary China, we also believed that it is just as important to acknowledge and appreciate the tremendous progress that China has made in developing a more uniform, coherent and systematic series of statistics concerning S&T activities and outcomes over the last two-plus decades. For example, the publication of an educational statistical yearbook dates back to 1984; in 1990, China started formal publication of an *S&T Statistical Yearbook* and a biannual set of S&T indicators. Without all three of these critical reports, scholars would not find it possible to study China's S&T and education system in any coherent manner; nor would we have been able to complete our book with any degree of confidence in the validity of the data – raw and in processed form.

Based on our experiences working with this data, this essay will be devoted to an in-depth discussion on how to deal with China's S&T and education statistics. As perhaps the first effort in this regard, it begins with an examination of the reliability of official Chinese Government statistics. Then, it provides an overview of the evolution of China's S&T statistical system while highlighting the main sources of such statistics. At the same time as we point out some of the particular problems related to China's S&T statistics, we also present our perspectives about how to best use and interpret these numbers by using HRST statistics as an illustrative case study.

Official Chinese statistics and their reliability

Quality aside, as noted, the reliability of Chinese official statistics has long been a topic of discussion and debate across Western academic circles. The lack of overall complexity regarding many facets of the Chinese economy during the 1950s and 1960s made it difficult to assess the reliability and comprehensiveness of Chinese data. Like many other developing countries, China suffered from an underdeveloped statistical system as its economy had not reached the level of sophistication of its counterparts in the West. Other than availability issues, statistical measures of economic activity, especially under the planned economy, presented few unique or special challenges. At the same time, it also was the case, as occurred during the Great Leap Forward, that there were countless incidences – largely politically induced – of falsification of statistics. This type of purposeful misreporting often was done to obscure problems that might result in job dismissal or political attack.

The post-Cultural Revolution period was characterized by a strong effort by the state to regain control over the operation of the economy and reinstitute a more reliable system for reporting data from the local to the central government. Still, many foreign scholars were mystified by the lack of reliable data. Problems related to the underdevelopment of the statistical system began to magnify as the economy started to grow while the quality of the prevailing data were quite poor in many cases. In the late 1990s, upward falsification of output statistics caught the attention of several Chinese and foreign scholars as well as Chinese Government leaders. For example, by analyzing the anomaly between increasing gross domestic product (GDP) and decreasing energy consumption between 1997 and 2000, economist Thomas Rawski suspected that real GDP growth in 1998 was not the official 7.8 percent but 5.7 percent or even less due to the "wind of falsification and embellishment" (Rawski, 2001, p. 350). More recent glitches in China's statistics went to the other extreme – instead

of overstating output to meet "official" growth targets, there has been underreporting of economic growth. The first national economic census conducted in 2004, for example, discovered that underreporting was most significant in such service sectors as transportation, storage, post and telecommunications; wholesale, retail and restaurant; and real-estate, where the emerging private economy had a larger share than thought. This resulted in a 16.8 percent upward revision of China's GDP for 2004 and correspondingly for the years between 1993 and 2004.

Nevertheless, most recently, Chinese origin, Princeton University-based economist Gregory Chow, who has had unimpeded access to different top Chinese leaders, optimistically commented that:

> Chinese official statistics are by and large reliable because of the assigned responsibility of the officials preparing them, of their being used in government decision making that is open to public scrutiny and in many published articles in referred journals.

But he also cautiously points out that "some data are not reliable" so that in using official data, one should "exercise caution to make sure that the data are reliable for the purpose at hand" (Chow, 2006, pp. 396-8). Quite clearly, the professionalism of the National Bureau of Statistics (NBS) has steadily improved. At the same time, because of the huge size of the task of collecting and processing statistical data and the unevenness of local statistical bureaus, a variety of critical problems remain.

To achieve a better understanding of Chinese S&T statistics, it is necessary to have an appreciation for the evolution, structure and operation of China's official statistical system as a whole. Upon the founding of the People's Republic, China set up a statistics division within the State Council, which evolved into the NBS in 1952. Statistics apparatuses also were established in various government ministries and at the regional levels; they were responsible for collecting data in sectors and regions under their jurisdictions and reporting the information back to the NBS in Beijing. Through conducting nation-wide and sector-wide surveys, statistical work became an integrated and important component of China's planned economy. On the occasion of the tenth anniversary of the founding of the People's Republic of China, in 1959, the NBS published *Ten Great Years*, a compendium of statistics covering achievements in infrastructure; industry; agriculture; transportation, post and communications; trade; employment; culture and education; people's living and so on. Even though there clearly had been serious exaggerations under the Great Leap Forward, which led to a host of propaganda driven, unrealistic economic growth data in this first statistics compilation in Chinese history, it did provide observers of the country's economy with a useful baseline and a rare opportunity to understand China from a quantitative perspective. Both Leo Orleans and Chu-yuan Cheng, the pioneers of the Western studies of China's post-1949 S&T manpower relied on this book extensively, benefiting as well as suffering from its strengths and weaknesses (Orleans, 1961; Cheng, 1965).

Generally speaking, China's statistical system was decimated during the Cultural Revolution. Statistics bureaus at the central and local levels were repealed between 1967 and 1969 and in 1969, the NBS was merged into the then State Planning Commission (SPC). Statistical data collected prior to the Cultural Revolution were destroyed and employees skilled in statistical analysis as well as mathematics and economics had to engage in irrelevant work, including raising pigs in the Chinese countryside.

Eventually, in 1970, some formal statistical work was restored, albeit on a limited and gradual basis. And, in 1974, the NBS was separated from the SPC.

Recognizing the need for more accurate statistical data to better manage the economy in the aftermath of the Cultural Revolution and especially after the initiation of the reform and open-door policy in the late 1970s, statistical work in China began to receive almost unprecedented attention from the central government. By 1978, the NBS was fully restored, which, gradually, but steadily, began to rebuild the integrity of the Chinese statistical system. In 1982, the NBS began publication of the *China Statistical Yearbook*. It also was during this time that China conducted its third population census (the previous two were carried out in 1953 and 1964, respectively). In December 1983, the third session of the Standing Committee of the Sixth National People's Congress (NPC) passed a Statistics Law, which was enacted on January 1, 1984, replacing the 1963 State Council Temporary Regulations on Statistical Work. The Statistics Law was revised in 1996 in accordance with a resolution passed by the 19th session of the Standing Committee of the Eighth NPC. The law requires that organizations and individuals under statistical investigation "provide truthful statistical data." In particular, it stipulates that altering statistical data without authorization, fabricating statistical data, or compelling or prompting statistics institutions or statisticians to tamper with or fabricate statistical data are violations subject to criticism and administrative sanctions or even criminal prosecution. This makes it less likely that those who collect and compile data actually falsify statistics under the pressure from the central or local government officials for political purposes – one of the common Western criticisms of China's official statistics. Changing statistical reports requires not only explicit direction from the Chinese leadership and cooperation from statistical bureaus or other agencies responsible for data collection and reporting, but also sufficient justification to survive the scrutiny by the international community of scholars and statistical professionals (Chow, 2006). Under the 2009 revised Statistics Law, government officials and institutional leaders who make purposeful changes or falsify statistics, ask statistical agencies to fake data or take revenge on staff who refuse to commit such acts will be punished and those fabricating data to gain honors, material rewards or promotions will receive legal punishment if convicted.

Nevertheless, it should be recognized that a two-track statistical work system caused considerable problems in data collection and reporting. On the one hand, a local statistics bureau receives professional guidance from the NBS and is responsible for collecting and reporting data to the NBS and fulfilling formal tasks as stipulated by the Statistics Law. On the other hand, the operating budgets of these local statistics bureaus are mainly provided by local governments, which also tend to carry more weight in appointing and promoting staff members. When a conflict between these two roles arises, local statistics personnel may feel pressures to submerge their professionalism to satisfy and even pander to local leaders' preferences. This explains why there have been numerous instances of exaggeration and underreporting regarding key statistical data. Interestingly, if data distortions during the Great Leap Forward period served a distinctly political purpose, the distortions of recent years more or less reflect the specific economic, but not necessarily the political interests of both local leaders and local statistics personnel (Zhao, 2006). The NBS has been working hard to ensure that these types of local distortions do not occur with any frequency; and indeed, over the last

decade or so in particular, the NBS has become a much more professionally sophisticated organization.

Bearing this context in mind, let us now move to a discussion on China's S&T statistics.

China's S&T statistics

Evolution[1]

The development of China's S&T statistics dates back to 1954 when the NBS surveyed the quantity, quality and distribution of engineering personnel. The survey targeted not only engineers at universities, research institutes and other organizations offering a college education, but also technicians and even workers who had been promoted into technical positions. In 1958, the then State Science Planning Commission, the precursor to the State Science and Technology Commission (SSTC), which became the Ministry of Science and Technology (MOST) in 1998 and the NBS conducted a survey of research institutes affiliated with the Chinese Academy of Sciences (CAS), government ministries, institutions of higher education and enterprises. In 1960, to put together a national S&T cadre development plan, another important survey was conducted, covering technical personnel across scientific research, engineering, agriculture, healthcare and teaching at non-military and non-national defense-related institutions and enterprises. This survey aimed at obtaining the numbers of technical cohorts by institution, professional title, field of study, industrial sector and ownership. In 1966, on the eve of the Cultural Revolution, the SSTC and the NBS initiated an investigation of organizations in the natural sciences to obtain the names, locations, numbers of employees (including research and technical personnel, supporting staff, professional management personnel and testing staff), areas of research and tasks. However, probably in view of the Cold War and China's sense of external threat – first from the USA and later from the former Soviet Union, a great deal of the statistical information collected during the above-mentioned surveys was never made public for national security reasons.

In 1978, at the onset of China's reform and door-opening, with the role of S&T and talent being given special emphasis, the NBS, the then SPC, the then SSTC and the Ministry of Civil Affairs jointly carried out a census of Chinese personnel in the natural science and technology fields at non-national defense state-owned enterprises and institutions. The scope of the census included personnel in production, scientific research and teaching in science, engineering, agriculture and medicine, with particular focus on anyone qualified as an S&T cadre, that is, having an S&T professional title, a graduate from a college or specialized vocational school (*zhongzhuan*) in an above-mentioned sector, or being promoted from workers or peasants. Information on political background and age of these S&T cohorts also was collected.

In 1985, the SSTC led and organized, along with the NBS and the State Education Commission, the predecessor of the Ministry of Education (MOE), a census of China's S&T system, therefore laying a preliminary foundation for the birth of China's formal S&T statistical system. In designing and developing a system of S&T statistical indicators for the census, these agencies consulted the definitions and classification standards used in the *Manual for Statistics on Scientific and Technological Activities*, a United Nations Educational, Scientific and Cultural Organization publication and then took China's special circumstances into consideration. The introduction of the manual

represented a first step toward making China's S&T statistics internationally comparable. The census also started an annual reporting system composed of three separate subsystems – government research institutes, institutions of higher education and large- and medium-sized industrial enterprises, from which to generate the nation's aggregate S&T statistics. The results of the census were published in the *Statistical Materials on Science and Technology*, the precursor of *China Statistical Yearbook on Science and Technology*, which started publication in 1990. Because the three subsystems did not follow the exact same definitions, statistically speaking, the aggregation did not necessarily reflect an accurate picture of China's S&T activities as a whole.

In 1988, the then SSTC studied and evaluated the international standards of S&T statistics and the Chinese situation again and subsequently revised China's S&T statistical indicators. A sampling survey on R&D inputs was conducted; for the first time information on Chinese R&D expenditures by large- and medium-sized industrial enterprises, research institutes and universities was collected. In 1990, the then SSTC conducted a survey of societal S&T inputs across 20 provinces and municipalities. By formulating clearer and more precise definitions of R&D activities, the survey data not only were internationally comparable, but also laid a solid foundation for a uniform annual S&T statistical reporting system, which started to operate in the following year. The further normalization of statistical indicators led to more comprehensive information about S&T activities in the People's Republic; the new data also highlighted the rather complex situation across China's S&T activities and became an important tool in S&T policy making, strategic management and operational decision making. Also in 1990, China released its R&D statistics – the scale and distribution of gross expenditure on R&D, known as GERD – as well as the R&D intensity, or GERD as a percentage of GDP. Between 1985 and 1995, the scope of S&T statistics remained focused on three main performers: research institutes; large- and medium-sized industrial enterprises; and institutions of higher education.

In recent years and especially since entering the twenty-first century, China has expanded and strengthened S&T activities in all facets of society. For example, high-technology enterprises and non-government enterprises that were once largely excluded in the statistical data collection process started to be included; in particular, enterprises in the sectors of agriculture, medicine and post and telecommunications also have been actively carrying out S&T activities since the early 1950s. Therefore, in 1995, the NBS expanded the scope of S&T statistics collection from large- and medium-sized industrial enterprises to state-owned small-sized industrial enterprises and enterprises in construction; transportation, storage, post and telecommunications; agriculture, forestry, husbandry and fishery; geological survey and hydraulics; medicine; and state-designated high-technology parks. Historical data were adjusted accordingly. This enlarged contingent of S&T activities is surveyed systematically every five years using increasingly sophisticated sampling techniques.

In 2000, approved by the State Council, the MOST, the NBS, the Ministry of Finance (MOF), the then SPC, the then State Economic and Trade Commission (SETC) (the SPC and SETC were merged into the National Development and Reform Commission (NDRC) in 2002), the MOE and the Commission of Science, Technology and Industry for National Defense (COSTIND)[2] jointly organized China's first comprehensive societal R&D resources census. The census included all enterprises and institutions within national

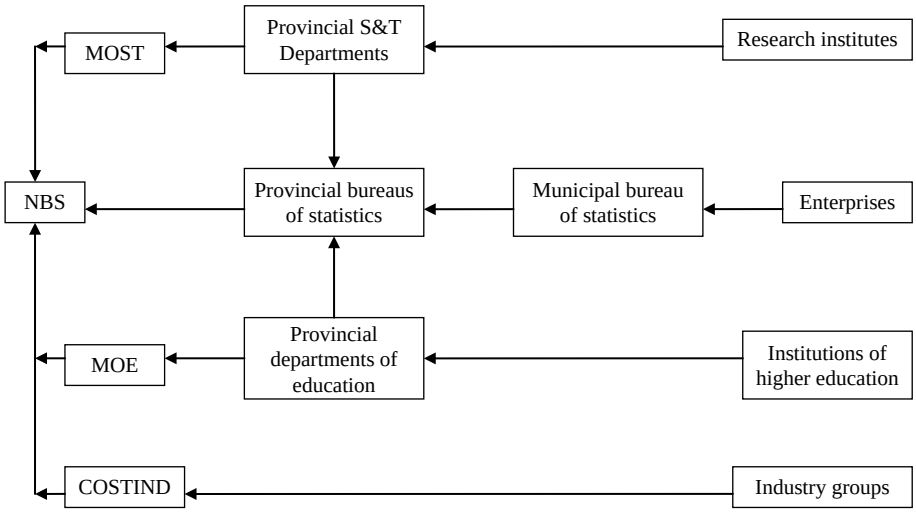
economic sectors having R&D activities; this effort had the same coverage as the country's GDP statistics collection and calculation efforts. The organizers issued the Regulation on S&T Input Statistics to unify overall statistical definitions, scope and technical standards used by the three major performers of the S&T activities. The indicators that the census used also became ever closer to existing accepted international standards, thus having better cross-national compatibility. The census is believed to provide highly accurate and rich information about China's R&D resources and their structures, including human resources devoted to R&D activities[3]. Finally, the national economic census conducted in 2004, mentioned above, collected information not only on scientific research as a service sector but also on S&T and R&D activities at enterprises, including foreign-invested enterprises (FIEs)[4].

The past two decades have seen not only various expanded and improved S&T-related statistical activities, but also a broadening of content among S&T statistics. In terms of inputs, for example, in 1990, the then SSTC and the MOF surveyed regional government's S&T funding to monitor its share in the nation's investment and the category of such investment. In 1996, surveys started to include national programs for S&T development, such as the State High-Tech Research and Development Program (863 Program), the State Key Basic Research and Development Program (973 Program), the State S&T Tackling Program (*gongguan*), projects under the Torch Program and Spark Program, S&T Achievement Spreading Program, among others. The culmination of these efforts was the annual internal publication of the *Annual Report on State Programs for Science and Technology Development*. This publication provides a thorough overview of the state of various Chinese S&T initiatives and contains a useful collection of current data.

In addition to systematic and comprehensive surveys and censuses, there have been specialized surveys on different topics, such as national high-technology zones, national S&T achievements, non-government S&T enterprises, technological markets, S&T international collaborations and exchanges, soft science research institutes, productivity promotion centers, S&T popularization and so on.

S&T statistics system[5]

Through a combination of censuses and rolling surveys, China's S&T statistical work is carried out by four major performers of S&T activities along four central line ministries (*tiao*, or *xitong*) to cover institutions and enterprises under their respective jurisdictions (Figure 1). In particular, the MOST and the S&T bureaus at provincial and lower levels are responsible for collecting and reporting data on the S&T activities of independent R&D institutes; the NBS and lower level statistics bureaus gather data on enterprises; the MOE, through its Department of Science and Technology and its provincial and regional bureaus of education, gathers data on regular institutions of higher education as their role in S&T and R&D activities have grown appreciably over the last several years; and the former COSTIND (now a bureau within the MIIT) collects and processes data on national defense research institutes and enterprises. The collection of data ranges from S&T personnel, S&T achievements, S&T programs and S&T organizations related to R&D activities. Within each *xitong*, a lower level agency in charge of S&T statistical work is responsible for reporting statistics to a higher level agency for review and appraisal until the data reach the top of the *xitong*. Also involved in the collection of S&T statistics are the MOF (S&T-related central



Notes: MOST – Ministry of Science and Technology; NBS – National Bureau of Statistics; MOE – Ministry of Education; COSTIND – Commission of Science, Technology and Industry for National Defense
Source: Liu (2006)

Figure 1.
China's S&T statistics system

government budget appropriations), the State Intellectual Property Office (SIPO, patent statistics) and the Institute of Scientific and Technical Information of China (ISTIC, S&T publication and citation statistics). The joint efforts of China's Government ministries and regional government agencies are designed to safeguard the overall quality of S&T statistics and avoid the type of distortions and problems that occurred during the Great Leap Forward and the Cultural Revolution.

While various ministries collect S&T statistics within their respective jurisdictions, the NBS, entrusted by the Statistics Law and through its Department of Population, Social and Science and Technology Statistics, organizes the nation's S&T statistical work, guides and coordinates concerned parties and cooperates closely with them to complete the work. It also serves as a gate-keeper and clearing house to assemble S&T indicators of all key performers and conduct the final examination, cleaning and approval. In addition, the Department of Industry and Transport Statistics of the NBS has specific responsibilities for collecting S&T data for the business sector as well as S&T-related industrial statistics.

The collection of education-related statistics also involves a multi-ministry, nationwide effort. The MOE, through its Department of Development and Planning, collects statistics on the basic situation, expenditure, enrollments and teaching, among others topics, at different levels of the education system and compiles and publishes an official statistical yearbook on education. The MOE also provides a set of aggregate data and related information to the NBS, which also produces data on the educational status of the general population from population censuses that are conducted every ten years and sampling surveys that are carried out in between population censuses; these include literacy rates, average years of education, enrollments and so on. One more

relevant education-related data source comes from vocational training provided by the Ministry of Labor and Social Security (MOLSS), now part of the Ministry of Human Resources and Social Security (MHRSS) after being merged with the Ministry of Personnel (MOP). The data from these respective ministries provide a complementary yet comprehensive picture of China's education and population quality.

Finally, after the December 2003 national talent conference, the Department of Organization of the Chinese Communist Party Central Committee, the MOP, the MOLSS, the Ministry of Agriculture and the NBS established China's talent resource statistical indicator system, which covers talent in five categories – professionals, party and administrative personnel, managers at state-owned enterprises, skilled personnel and agricultural personnel. A survey was conducted in late 2004 to come up with the total numbers of talent, but the results have not been released yet except for the mentioning of numbers in each of the five types of talent in a book published by the Chinese Academy of Personnel Science (2005)[6]. In mid-2010, the CCP Central Committee and China's State Council issued a Medium and Long-Term Plan for the Development of Talent (2010-2020), which outlines that various efforts to enhance the quality and quantity of high-end talent needed to support technological as well as economic development.

Major centers on S&T statistics

To analyze and process all the data collected, a series of centers for S&T statistics have been created by the Chinese Government. In 2003, the MOST approved the establishment of a Center for S&T Statistics and Analysis devoted specifically to the study of S&T statistics and indicators within the National Research Center for Science and Technology for Development, which recently was reorganized to become the China Academy of Science and Technology for Development (CASTED), an important think-tank under the MOST that carries out policy-related research. More precisely, the center is mandated to establish and maintain an S&T indicator database to support S&T policy decision making, train S&T statistical workers, carry out theoretical and methodological research on S&T statistics and participate in international exchange and collaboration related to S&T statistics. The center also is involved in the publication of the *China Statistical Yearbook on Science and Technology*, *China Science and Technology Indicators* and other key publications containing key S&T statistics.

The Center for S&T Statistics and Information at the Huazhong University of Science and Technology (HUST), located in Wuhan, Hubei Province, also plays an important role regarding the study of China's S&T statistics. Established in 1986, this center used to be part of the management school of MOST. In 2000, it was merged into HUST along with the management school. Now, as a formal part of the HUST management school, the center collects S&T statistics from public research institutes and maintains a web site on China's S&T statistics (www.sts.org.cn), which not only updates S&T statistics in a timely fashion, but provides analysis on various topics related to S&T carried out either at the center and elsewhere.

Major publications

Based on the data collection and statistical reporting activities described above, various government ministries, independently and working with the NBS, publish annual

statistical yearbooks (Table I). For example, the MOST and the NBS publish the *China Statistical Yearbook on Science and Technology* as well as the *China Statistical Yearbook on High Technology Industry*. The MOE publishes the *China Statistical Yearbook on Education* and the *China Statistical Yearbook on Education Expenditure*. S&T and related statistics also can be found in the *China Statistical Yearbook*, the *China Labor Statistical Yearbook* and the *China Population Statistical Yearbook*. All of these statistical yearbooks usually contain information for the current and previous years. Although the statistics in the *China Statistical Yearbook on Science and Technology* are obtained through surveys involving the NBS, the MOST, the MOE and the former COSTIND, as mentioned above, other government agencies, such as the MOF, the MHRSS, the Ministry of Commerce, the General Administration of Quality Supervision, Inspection and Quarantine, the SIPO, the CAS, the Chinese Academy of Engineering (CAE), the State Seismological Bureau, the State Metrological Bureau, the State Oceanic Administration, the State Bureau of Surveying and Mapping and the China Association for Science and Technology also contribute relevant data. This reflects huge progress in the country's overall statistics efforts as 20 years ago such cooperation and collaboration would have been difficult or fraught with problems of comparability and quality.

The MOST also publishes the *China Science and Technology Indicators*, known as the "Yellow Book" because of the color of its cover, biannually and issues two annual pocket-sized data books – *China Science and Technology Statistical Data* (from 1992 onward) and *China High Technology Industry Data* (from 2002 onward), which contain condensed information released prior to the publication of the full-blown *China Statistical Yearbook on Science and Technology* and the *China Statistical Yearbook on High Technology Industry*. At the same time, the MOST makes available an annual *Compilation of China Statistical Materials on Science and Technology*, which is something between a statistical yearbook and the pocket-sized data books; particularly, it contains a special section devoted to the results derived from monitoring S&T progress at national and regional levels. In the *China Educational Yearbook*, published by the MOE, there is a series of aggregate educational statistics, such as the number of college graduates and the number of advanced degrees awarded, as well as data on S&T and R&D activities occurring at Chinese universities.

Starting from 1998, the NBS, the MOST and the MOF jointly put out an annual statistical bulletin on national S&T expenditures, which summarizes information on R&D expenditures, sources of funds and expenditure for S&T activities and government appropriations for S&T. The bulletin usually is released in March on the occasion of the annual session of the NPC. Similarly, the MOE publishes an annual statistical bulletin regarding the utilization of education expenditures and an annual statistical bulletin of education enterprise development.

In addition, the MOST and various Chinese Government ministries publish and update various statistical data under their jurisdiction through their official web sites. Some of these sites contain English language as well as Chinese versions. It is usually the case that the Chinese language web sites are more current, while the English sites tend not be updated and revised as frequently.

Problems of China's S&T statistics

In the remaining two sections, we want to share our experience in identifying and dealing with problems in the use of China's S&T statistics by using HRST statistics

Table I.
Major publications on China's S&T and related statistics

Title	Author(s)	Coverage in the latest book	First publication	Publication cycle	Publisher
China Science and Technology Indicators (or *Yellow Book on Science and Technology*)	MOST	HRST R&D expenditure S&T activities in government research institutes, higher education and large- and medium-sized industrial enterprises Output of S&T activities Development of high-tech industry Public scientific literacy and attitudes toward S&T	1990	Biannual – Chinese in even year, English in odd year	Scientific and Technical Documents Publishing House
China Statistical Yearbook on Science and Technology (successors to *China Statistical Materials on Science and Technology* between 1986 and 1990)	NBS and MOST	Overview Independent research institutes Large- and medium-sized industrial enterprises and high-tech industry Institutions of higher education National programs for S&T development Results of S&T activities S&T services International comparison	1986	Annual	China Statistics Press
Compilation of China Statistical Materials on Science and Technology	MOST	Newest S&T statistics International comparison of major S&T and economic indicators Annual report on China's S&T statistics Results of monitoring S&T progress at the nation and regions Indicators and rankings of regional monitoring		Annual	MOST
China Statistical Yearbook on High Technology Industry	NBS, NDRC and MOST	Production and finance S&T activities Employment and technical personnel Investment in fixed assets Exports International comparison	2003	Annual	China Statistics Press

(*continued*)

Title	Author(s)	Coverage in the latest book	First publication	Publication cycle	Publisher
China Statistical Yearbook on Education (renamed *China Statistical Yearbook on Education Enterprise* between 1992 and 1997)	Department of Development & Planning, MOE	Development of educational enterprise: overview; education at various levels; geographical distributions of education Physical facilities: public expenditure; capital construction investment S&T activities: natural sciences and technology; social sciences	1984	Annual	People's Education Press
China Statistical Yearbook	NBS	Distributions of administrative areas and natural resources General survey National accounts Population Employment and wages Investment in fixed assets Energy Government finance Price indices People's livelihood General survey of cities Environment protection Agriculture Industry Construction Transport, post and telecommunications services Domestic trade Foreign trade and economic cooperation Tourism Financial intermediation Education, science and technology Cultural, sports and public health Other social activities Main social and economic indicators of Hong Kong and Macao International comparison	1982	Annual	China Statistics Press

(*continued*)

Table I.

Table I.

Title	Author(s)	Coverage in the latest book	First publication	Publication cycle	Publisher
China Labor Statistical Yearbook (successor to *China Labor and Wage Statistical Yearbook* between 1989 and 1990)	Department of Population and Employment Statistics, NBS and Department of Planning and Finance, MOLSS	General survey Employment and unemployment Employment and earnings in urban units, state-owned units, urban collective-owned units and other ownership units Employment in township and village enterprises Vocational training and skill appraisal Labor relations Labor and social security inspection Social security Trade union works Employment indicators of Hong Kong and Macao International comparison	1989	Annual	China Statistics Press
China Population Statistical Yearbook	Department of Population and Employment Statistics, NBS	National 1% population sample survey in 2005 Historical population statistics Household registration Family planning International comparison	1988	Annual	China Statistics Press

Notes: MOST – Ministry of Science and Technology; NBS – National Bureau of Statistics; NDRC – National Development and Research Commission; MOE – Ministry of Education; MOLSS – Ministry of Labor and Social Security
Source: Authors' research

as a case study. As part of the overall set of S&T statistics, HRST statistics are collected by the MOST, the MOE, the former COSTIND, along with the NBS and are presented in various statistical yearbooks. In addition, the MOP and its successor, MHRSS, is important for its role in monitoring and managing experts at the high end of the talent pool, such as members (*yuanshi*) of the CAS and the CAE, post-doctoral researchers, professionals and returnees with significant S&T credentials. While individuals falling into the first two categories are easy to count, the MHRSS does not necessarily know how accurate the number of professionals is and it may not know how large the fourth group – returnees with significant credentials – is as many of them have not bothered registering with government. The MHRSS and the Department of Organization of the CCP Central Committee, also along with the NBS, collect data on cadres and professionals based on the "party administers cadres" (*dang guan ganbu*) principle. However, the statistics collected by these two organizations are not available to the public. The various population censuses and sampling surveys by the NBS and labor market surveys overseen by the MHRSS also cover talent data. With the involvement of various government agencies, then, the first challenge is to reconcile data from different sources to get an overall integrated picture of China's talent situation. This is a major hurdle that researchers of the Chinese talent situation encounter and must overcome to provide any type of meaningful analysis.

Second, it is necessary to understand the differences between the definitions of HRST and general "talent" (*rencai*) in China. *Rencai* is an evolving but rather amorphous concept; in many ways it is a broad concept with the Chinese characteristics and seemingly not internationally comparable. Moreover, it is a concept with important policy implications. One of the problems with the *rencai* concept is that its definition is subject to change over time – from cadres to intellectuals to professionals in the Western sense. In its most recent context, *rencai* refers to anyone with certain "knowledge" and problem-solving capabilities, able to engage in creative work and contribute to the construction of China's political, spiritual and material civilization (General Office of the CCP Central Committee and General Office of the State Council, 2002). In other words, formal education is not a prerequisite for being classified as *rencai*. Indeed, Chinese talent is not confined to scientists and engineers and other professionals; it also includes party and public administration personnel; managers at enterprises; highly skilled workers; and agricultural personnel; therefore, the number is huge. Even within each of the categories, the statistics collected also have evolved. For example, although about one-quarter of the professionals now work for non-government economies, it was not until 1999 that the then MOP started to consider collecting data about this important category of personnel.

Third, ironically, China's statistics on HRST do not profile the characteristics of HRST in gender, age, educational attainment, discipline, geography, professional rank and employment sector, among others; this type of analysis by category is necessary for securing an in-depth picture of China's overall talent situation and its implications for S&T development. Conventional wisdom would suggest that such data are just simply unavailable, but that is very doubtful. For one thing, the population censuses and labor market surveys cover most, if not all, information, as we have found in *China Population Statistical Yearbook* and *China Labor and Social Security Yearbook*. The problem is that data in these statistical yearbooks are aggregate and not organized in such a way that allows researchers – Chinese as well as foreign – to easily draw useful

information about Chinese S&T talent for further analysis. If it is understandable that such information is not accessible to scholars from outside China for various reasons, at least China-based scholars should have better access to it. In reality, this too seems not to be the case, with some limited exceptions related to the research topics of strategic importance to the formulation of China's Medium and Long-Term Plan for the Development of Science and Technology (2006-2020). Nonetheless, even though the outcome of the research has not been made public, seven years after it was done, we have not found information beyond what was disclosed in various S&T and education statistical yearbooks in the publications of the researchers involved. Nor has the report on HRST done for OECD reviews of China's innovation policy (OECD, 2007). Because of this, we were forced to piece together a wide range of disparate information from different, often unrelated sources. Although to our great chagrin our efforts did not yield the full picture in its entirety in several instances, our analysis appears to be far more comprehensive and more integrated than what apparently has been done by our China-based colleagues[7]. This lack of a comprehensive, unified and cohesive view of the country's talent situation constrains efforts at policy making in many areas, especially with respect to innovation policy.

Fourth, to the extent that the lack of information as described above is real and perhaps even somewhat understandable because of the complexities involved in collecting and compiling such information, there also are cases where some key information appears to be missing. For our purposes, it would have been useful to have a breakdown for the educational fields and subfields of students in higher education. The reason that we were unable to do so and had to use the lumped-together information was not the unavailability of data. The *China Statistical Yearbook on Education*, for example, does publish annual data on admission, enrollment and graduation at undergraduate and graduate levels. It is interesting to note that the data are available concerning the number of students newly admitted, totally enrolled and graduated by fields of study (*yiji xueke*) such as science, engineering, agriculture, medicine and so on, but there are no further breakdowns by specialties (*erji xueke*) except in engineering. Given the specialty breakdown in engineering, it is not too far-fetched to assume that there must have been a similar breakdown in other fields of study but not made available to the public. Also, undergraduate enrollment data released in when the yearbook are broken down by length of study – two- to three-year short-cycle programs versus regular bachelor's degree programs – and by fields of study, which is quite valuable. What is puzzling, however, is that in presenting the undergraduate breakdown by specialties of engineering, the yearbook only indicates the total in the specialties without breakdown by length of program. That is to say, available information is on the levels of programs and specialties but not on their interface. Further evidence that the MOE possesses detailed information on Chinese university students is that the ministry, in May 2005, released a list of the so-called "hot" specialties which admitted more than 10,000 undergraduates at the bachelor's degree level in 2004, along with numbers of enrollment and graduation (admission, enrollment and graduation information for the year 2003 also was made available for comparison purposes) (Jiang, 2005). This gives us reason to suspect that similar information also maybe limited for public release. Although the planning economy mentality has been fading, the point holds that "the Chinese simply have not had the figures that Western analysts and visitors regard as indispensable for governing

a planned economy" (Orleans, 1980, p. 17)[8]. The question is how to reconcile the incomplete and some maybe problematic statistics for HRST on one hand and some superficially accurate statistics on the other.

Indeed, the problems discussed here created unique challenges in our study of China's S&T talent and by extension the study of Chinese science and technology in general. Ultimately, they probably also make it difficult, if not impossible, for the Chinese Government to formulate and implement a variety of critical policies because of the "shake, confusing and sometimes non-existent information" (de Jonquieres, 2005) and to evaluate the effectiveness and efficacy of these policies. For example, it is unclear how the decision to establish software colleges at some of the top Chinese universities in 2001 was made; in particular, how much of the effort relied upon accurate market information and how much simply was driven by the hype that China does not have enough software professionals to catch up with India. If the Japanese developed the "just in time" concept for their supply chain, the Chinese seem to have developed a "just in case" mentality regarding production of talent. Furthermore, it would be interesting to know whether these software schools are located in geographically appropriate spots, whether they have produced enough qualified software engineers to alleviate the claimed shortage, whether the software engineers who graduated from these schools have the right skill sets for their jobs and so on. Of course, more general questions are: what is the rationale behind the government's allocation of resources – financial, physical and human? How does the leadership know whether the country has too many mathematicians but may lack chemists or vice versa? What is the mechanism through which education effectively reacts to actual job market signals about the lack of talent in particular areas? What is the structure of the Chinese scientific workforce in terms of age, discipline, qualification and composition and is this structure appropriate for China's innovation push? What are the impacts of the demographic change on Chinese talent, S&T capability and international competitiveness? Without detailed direct or survey information on the labor market and wage system? Answers to many of these questions will remain more the purview of China's Government than is the case in the countries such as the USA. This is not to suggest that these are not challenging questions even in the context of advanced nations across OECD; but that recognized, it is definitely the case that China's policymakers have been challenged by the absence of a more reliable statistical base for capturing more than just the supply side of the talent equation. Nonetheless, one is left wondering what type of answers that Chinese leaders might get if they posed policy questions about China's comparative standing in the world with respect to the numbers of Chinese scientists and engineers in the country, where they are located and in which fields are the largest numbers.

Realizing the various problems involved in sorting through China's talent statistics and the importance of having a clear picture of the Chinese talent situation (our sense is that the leadership does not have such information), in late 2004, China's Government introduced a new talent and human resources statistical indicator system to replace the cadre statistical system that had been in place since the 1950s. According to the Department of Organization of the CCP Central Committee, the new system covers the entire society, reflecting the quantity, quality, distribution, structure, training, recruitment and utilization. The target of the system includes five types – party and administrative personnel, enterprise management personnel, professionals and institutional

management personnel, skilled personnel and agricultural personnel – as specified by the *Outline for Building-up of China's Talent Pool between 2002 and 2005*, with the latter two types being the new additions (General Office of the CCP Central Committee and General Office of the State Council, 2002). The new system is supposed to help the formulation of a new talent-building strategy and provide data support to policy research and macro-guidance. Based on that, a macro-human resources database is to be built. The new system, first implemented by the Department of Organization and the MHRSS, started to trial in late 2004 and was completed by May 2005. Unfortunately, we have not seen significant outcomes from this survey.

How to use China's S&T statistics

In this section, we provide our perspectives on the right strategy for using China's human resources statistics. This is based not only on our research on S&T talent in China, but more importantly, on our many years of experience working with China's S&T statistics in general.

Understanding Chinese definitions

While China has made tremendous progress in improving its HRST and S&T statistics and making them internationally comparable, some of its HRST statistics simply are a Chinese creation. For example, as mentioned, "talent" is one such broad definition of Chinese characteristics; so are terms such as "professionals," "S&T workers," and "S&T personnel" (Figure 2). Taking into consideration the evolution and reality of China's HRST statistics, we have to treat these Chinese "innovations" seriously. That is, it is vital to understand what is being said and defined in these categories, whether there have been changes over time and whether there are corresponding categories used internationally for comparison purposes. Otherwise, it is difficult, if not impossible, to study China's HRST situation and to exchange views with Chinese colleagues who use such localized definitions and statistics.

For example, "S&T personnel" are so defined that anyone who spends 10 percent of their time engaged in S&T activities in China is counted as such. This implies that overseas-based scientists, Chinese- or non-Chinese-origin, are S&T personnel in the

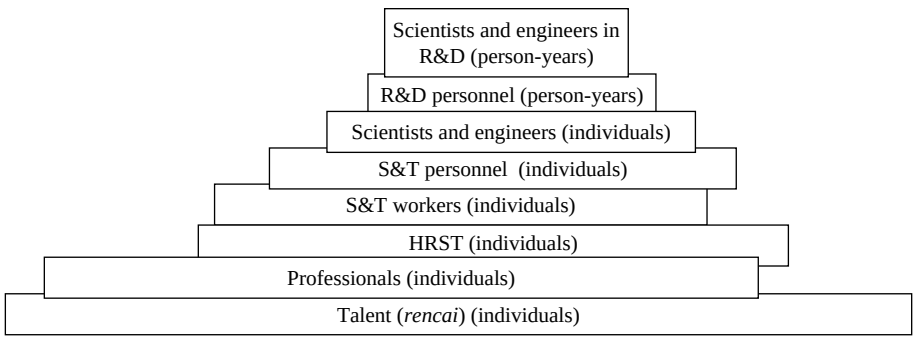


Figure 2.
Relations between various definitions of HRST

Note: The figure is for illustration of the relations and does not represent the exact quantitative relations

Source: Authors' research

context of China's S&T statistics if they are working for a Chinese institution of learning for a month or longer, either within or outside China. Of course, their R&D activities also should be counted in the full-time equivalent (FTE) measure. However, it is questionable as to whether all S&T statisticians treat them in this way. Also, ideally, it would be helpful to know how large this group really is. Related to this is how returnees are defined. Originally, students who study or conduct research overseas (*liuxuesheng*) referred to only those with an undergraduate education who have spent at least one year overseas pursuing an advanced degree or conducting research. But, at one time the threshold was lowered to include those going overseas for partial undergraduate education or even language studies and secondary education (MOST, 2003, p. 26). Then, how about those who, with an advanced degree, just go abroad for less than a year?

Exhausting all the sources

As statistics on China's HRST are collected and published by an assortment of Chinese Government agencies, it is necessary to exhaust many sources to find relevant data. The usual starting point is the *China Statistical Yearbook on Science and Technology*, which is most systematic and comprehensive, has been improved over the years and has added new sections almost every year. For example, the 2005 yearbook started to provide information on educational attainment of researchers at research institutes. While the *China Statistical Yearbook on Science and Technology* has information on the numbers of professionals employed in state-owned institutions and enterprises, it also is useful to consult or cross-check with the *China Population Statistical Yearbook* or the *China Labor Statistical Yearbook* for data on professionals.

It is well known that the statistics collected in the 2000 Census on Societal R&D Resources and the 2004 Economic Census are more accurate and reliable than most other similar data sources[9]. Although some of these data have been included in various statistical yearbooks, including S&T ones, the compiled data from both censuses have detailed information on human resources in general as well as S&T in particular and may be considered a valuable benchmark for previous and latter years.

In addition, we also paid special attention to research done by China-based scholars to secure new and deeper insights and data. For example, the *China Science and Technology Indicators* always devotes an entire chapter to HRST; in fact, this is the only Chinese publication that reveals a complete number for the particular statistics on HRST. The Chinese Academy of Personnel Science, a think-tank affiliated to the MOHRSS, discloses the total numbers of *rencai* in its *China Talent Report* (Chinese Academy of Personnel Science, 2005), which presumably will become a fully fledged series in the future. The report released the results of China's first talent survey – the total numbers of five-type talent but no further details. The Chinese Academy of Social Sciences, perhaps the most influential social science think-tanks in China, started to publish a *Report on the Development of Chinese Talent* as one of the so-called "Blue Book" series in 2004, which now has become an annual publication. Each year, the blue book on talent has a central analytic theme in addition to a general description of China's talent situation[10]. Of course, one should not overestimate the value of such publications as they are not necessarily peer reviewed and should exercise caution in using them as many of the data cited are not always current, are frequently inconsistent within the same book or between different books in the same series,

are careless in presentation and interpretation and are secondary without mentioning who collected the data from where, how, in which year and for what purposes.

One final source in dealing with China's S&T statistics is Chinese scholars at key research centers such as the CASTED and the HUST, mentioned above. Our study of China's talent benefited greatly from discussing and interacting with this small but very capable cadre of experts on China's S&T statistics. One of the highlights of our fieldwork in China was a unique meeting organized for us that brought together representatives from six or seven of the above-noted organizations. It was apparent that these groups, despite working on similar problems and issues, do not often get together to share data and experiences or collaborate across bureaucracies. The simple exercise of having these persons in the same room together for two to three hours opened up new insights about differences in definition, terminology and so on[11].

Finding and recognizing discrepancies

As indicated at the onset, China has made great efforts to normalize and minimize the differences on S&T statistics collected by different government ministries that, respectively, may have a different understanding of the appropriate definitions and scope of terms. But discrepancies often exist. Sometimes, publications, even those from the same government ministry, may convey the data in different ways and imply different meanings. Therefore, it is important to identify and recognize these discrepancies very early on in data collection and assessment efforts. Here, one specific example helps to illustrate the different ways numbers of postgraduates have been reported in the *China Statistical Yearbook on Education* and the *China Educational Yearbook*, both published by the MOE (Table II).

At first glance, there are two sets of numbers of graduates with significant differences at the master's degree level. It is only after a careful reading of the numbers and with help from Chinese experts on HRST that we figured out what caused the differences. First, the numbers represent two different reporting periods – calendar year versus academic year. Obviously, different time periods produce different numbers of graduates.

Second, in fact, the numbers report graduates differently: the numbers for the calendar year include only the graduates from regular institutions of learning who may or may not receive their degrees, whereas the numbers for the academic year are the exact numbers of advanced degrees awarded to graduates and also include those who have become qualified for advanced degrees through on-the-job (*zaizhi*) study. That is, the difference in the numbers reflects that between postgraduates and actual advanced degree holders. Because of the overlap between academic and calendar years, we cannot assume that the numbers of postgraduates always are greater than those of advanced degree holders, or vice versa, as some of the graduates will not be awarded advanced degrees, but *zaizhi* students included in the table have surely received their degrees.

Third, presumably and overall, it is easier to get a master's degree than a doctoral degree through *zaizhi* study, thus explaining the larger discrepancy between the two reporting methods at the master's degree level. However, students from military science are more likely to obtain their degrees – both master's and doctoral – through *zaizhi* study.

Fourth, we also should recognize the definitional differences between two reporting methods. For example, "professional" is a type of degree, but is not available in regular institutions of learning approved and certified by the MOE.

Year	Calendar 2002	2003	2004	2005	Academic 2001-2002	2002-2003	2003-2004	2004-2005
Master								
Philosophy	942	1,214	1,462	1,813	979	1,379	1,536	1,840
Economics	3,596	5,374	6,789	9,313	6,067	6,976	9,171	10,735
Law	4,476	6,714	10,075	12,912	5,065	7,170	10,216	11,782
Education	1,717	2,457	3,866	4,646	1,851	2,845	3,698	5,104
Literature	4,514	6,589	9,450	12,098	5,636	7,715	11,087	12,733
History	1,080	1,472	1,934	2,110	1,097	1,467	1,819	2,035
Science	7,058	9,515	13,022	16,570	7,037	9,782	12,627	15,938
Engineering	24,826	34,764	48,020	63,514	27,845	39,813	51,950	63,086
Agriculture	2,164	3,093	4,188	4,945	2,289	3,137	4,096	5,049
Medicine	6,511	9,382	12,428	15,114	9,571	12,347	15,653	18,432
Military science	28	26	46	92	1,151	1,553	2,624	3,089
Management	9,291	11,641	16,051	18,924	6,473	8,435	12,287	13,941
Professional					13,738	17,567	31,694	44,243
Total	66,203	92,241	127,331	162,051	88,799	120,186	168,458	208,007
Doctorate								
Philosophy	281	348	392	436	263	323	366	396
Economics	837	1,204	1,309	1,617	855	1,040	1,254	1,379
Law	663	770	1,022	1,191	615	683	906	1,038
Education	229	307	410	455	197	276	274	319
Literature	643	837	1,033	1,216	648	829	955	976
History	315	454	473	547	311	428	449	473
Science	2,808	3,705	4,518	5,458	2,813	3,580	4,213	5,083
Engineering	5,252	6,573	8,054	9,427	4,968	6,242	7,797	9,126
Agriculture	626	756	977	1,093	648	742	899	1,102
Medicine	2,166	2,825	3,700	4,291	2,444	3,073	3,714	4,401
Military science	5	6	13	22	91	98	161	228
Management	813	1,021	1,545	1,924	765	1,095	1,431	1,660
Professional					88	216	174	211
Total	14,638	18,806	23,446	27,677	14,706	18,625	22,593	26,392

Source: Department of Development and Planning under the Ministry of Education (comp.) (various years), Editorial Board of *China Educational Yearbook* (comp.)(various years)

Table II.
Postgraduates in academic and calendar years (persons)

Conclusion

Researchers of China's S&T enterprise face the constant challenges of dealing with the uneven quality and comparability of China's S&T statistics data. This essay represents a first effort to describe and discuss China's S&T statistical system by using HRST statistics as the case.

While significant achievements have been made in improving data collection and aligning China's S&T statistics with the international standards, serious problems still exist. Some are associated with the fluidity associated with the on-going reform of China's S&T system and China's statistical work in general, such as the involvement of multiple government ministries; others result from lack of full transparency or intentional reluctance to release the full array of available data and information. Given that China's S&T statistical system is a work in progress and analysts – foreign and Chinese – have to rely heavily on official Chinese statistics, critical questions need to be addressed to reconcile data from different sources, to piece information together

and to interpret the data. In order to better utilize and comprehend the essence of China's S&T statistics, we have to secure a better understanding of their definitions – some of which may have "Chinese characteristics," exhaust a multitude of sources and identify and recognize key discrepancies. This is not an easy task, nor pure science, but an important step toward drawing an appropriate and overall picture of the development of S&T in China.

Notes

1. This section is based on Liu (2006).
2. The COSTIND became a bureau within the newly founded Ministry of Industry and Information Technology (MIIT) in mid-2008. So are the cases of the MOP and the MOLSS, which merged to form a new MHRSS. But the discussion here still treats them as separate government agencies.
3. A second similar survey was conducted in 2010.
4. In fact, the 2000 R&D resources census also covered FIEs.
5. This section is based on Gao *et al.* (2006), Liu (2003) and Liu (2006).
6. The launch of this survey, however, does highlight the increasingly activist role of the CCP Central Committee, through its Department of Organization, in addressing China's evolving talent needs and requirements, especially at the highest level.
7. Nevertheless, it also is clear that China's specialists on S&T talent have done a remarkable job while working within the limits of the data and the policy constraints that they face on a regular basis.
8. "The Regulations of the People's Republic of China on Open Government Information" started to be in effect on May 1, 2008, which at least provides possibilities for China-based scholars to ask for detailed statistics concerning S&T and education.
9. It is expected that the 2010 census on R&D resources will unveil more accurate information on China's R&D activities, including that on talent, soon.
10. There are other series of publications that also contain useful S&T statistics, such as *Research Report on China's Development in Science and Technology* (Research Group on Development and Strategy of Science and Technology of China, 2000), *Annual Report of Regional Innovation Capability of China* (Research Group on Development and Strategy of Science and Technology of China, 2001) and *Report on Development of Science and Technology in China* (MOST, 2007).
11. The limited communication among them is less a reflection of speculation and more a consequence of bureaucratic compartmentation.

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