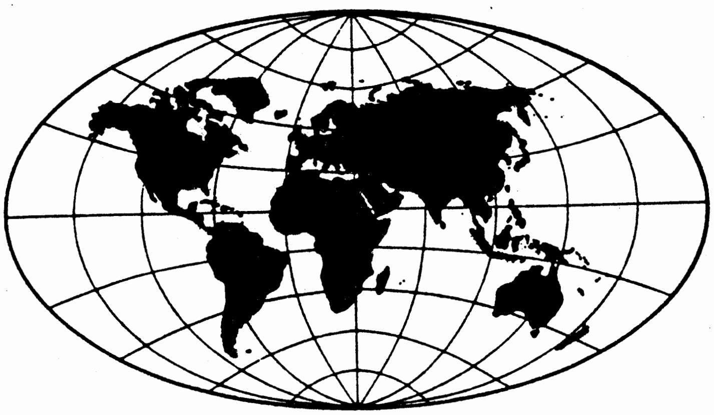
SCIENTISTS AND ENGINEERS IN CHINA: 1990 AND 1995

by

David Zaslow



International Programs Center
Population Division
U.S. Census Bureau
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EXECUTIVE SUMMARY

"Scientists and Engineers" (S/E) in China[1] are distributed fairly evenly across working age groups, although the greatest concentration of S/E in China are in their mid- to late twenties. This even spread indicates that China's S/E workforce includes individuals whose skills are based both on recently completed formal education and a wide range of on-the-job skills. The S/E cohort that came of age during the Great Leap Forward (1958-1960) and the Cultural Revolution (1966-1976) are proportionately smaller because schools closed and intellectuals were persecuted. S/E generally are male, overwhelmingly engaged in manufacturing (most notably in the production of machinery and equipment), and are distributed among a wide range of educational levels.[2] These characteristics may reflect the influence of the Soviet research system, after which China's research system was patterned.

Scientists and engineers are hampered by minimal resources for research and development (R&D). China devotes only about one-half of one percent of its gross domestic product (GDP) to R&D. Many research facilities lack adequate equipment, and technical staff are short on funding for intellectual exchange with foreign specialists. To compensate, many Chinese researchers look abroad to fund research, while others leave China for study and spend their subsequent careers as expatriates. R&D funding levels are planned to increase, with official plans calling for R&D to receive 1.5 percent of GDP by the end of the Ninth Five Year Plan (1996- 2000). However, data through the first half of 1997 indicate little progress towards meeting this goal (Plafker, 1997, p. 5). On the bright side, technical personnel such as scientists and engineers no longer face the prospect of their careers being curtailed by the political elite's antagonism towards "experts," as was the case from the "Great Leap Forward" through the ascension of Deng Xiaoping (1958 to 1978). Moreover, the fact that China has been able to generate impressive economic growth and expansion, albeit not at the technological frontier in many instances, may suggest that China will continue to become an increasingly important economic power without having to expend substantially larger sums for research and development.

[1]Data in this report refer to non-academic scientists and engineers. Data for technicians are reported in the appendix tables as the 1995 industrial census did not disaggregate occupations, as did the 1990 population census, but the report focuses on scientists and engineers.

[2]Data for industrial scientists, engineers and technicians are available only for those in independent accounting units. These are enterprises that have independent administrative status, independent accounting with responsibility for profits and losses and an independent bank account, and authority to enter into contracts with other units (Rana and Hamid, 1996, p. 218).

PREFACE

The International Programs Center conducts economic and demographic studies, some of which are issued as Staff Papers. A complete list is included at the end of this report. The use of data not generated by the U.S. Bureau of the Census precludes performing the same statistical reviews the Bureau of the Census does on its own data.

We are grateful to Andrea Miles and Denise Spivey of the International Programs Center for secretarial support. Any shortcomings in this report are the responsibility of the author.

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INTRODUCTION

This report presents statistics on scientists, engineers, and technicians in China based upon the 1990 population census and the 1995 industrial census. Scientists and engineers (S/E) are a small share of China's economically active population compared with other countries studied thus far in the Census Bureau's S/E series. In 1990, China had approximately six S/E per 1,000 members of its economically active population. While this proportion is at the low end of the most advanced countries in this series, it is comparable to the levels found in the economies of South Korea, the Philippines, and Taiwan (Figure 1).[3]

Chinese officials have expressed dissatisfaction with the scope of China's scientific and engineering efforts. This may be due to several factors. First, there are far fewer educational opportunities than in the West, although steps are being taken to improve scientific and engineering training. Equally important, limited support for research and development (R&D) discourages young Chinese from entering the scientist and engineer fields at the outset and impairs the efforts of those who do engage in R&D. Nevertheless, the level of S/E is surprisingly high, considering the substantial share of the employed population engaged in agriculture (48 percent in 1996) (State Statistical Bureau, 1997, p. 98).

Appendix tables provide detailed information upon which the graphic presentation is based. Users wishing to compare data in this report with those of other countries should consult the list of IPC/CIR Staff Papers in the back of this report. The most recently published report of this series is "Scientists and Engineers in the Philippines: 1990."

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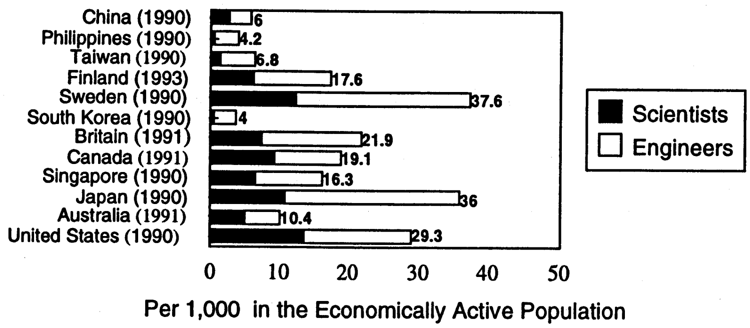
[3]Generally, this refers to the entire working age population, although definitions may vary across countries.

Figure 1. Scientists and Engineers per 1,000 Members of the Economically Active Population*



Source: Table CH-1(90); Tabulation, 1993, p. 40; Zaslow, 1998a, p. 2.

China's scientists and engineers have faced numerous obstacles.

The science and engineering professions have not attracted more Chinese due to the limited financial support for their work, insufficient higher educational opportunities, as well as the hostility directed at the highly educated. Through much of the post-1949 period, particularly between the mid-1950s and the late 1970s, there was considerable distrust of intellectualism (Miller, 1992, pp. 41, 49; Suttmeier, 1980, p. 35).[4] By the late 1970s, processes to expand the scientist and engineer workforce and to employ existing resources better took hold as official hostility towards the educated elite abated.[5] Universities reopened, permitting new scientists and engineers to be trained, and foreign contacts again were encouraged. The leadership adopted financial incentives to improve the allocation of S/E (Orleans, 1984, p. 63). More recently, college graduates who agreed to work in remote areas or in designated work units have had their college tuition reduced or waived ("Tuition," 1995, p. 15; "Students," 1997, p. 21).[6] Currently there is a media campaign underway to upgrade the image of S/E. Chinese science leaders believe that the general public is insufficiently aware of the role of technology in daily life, and have launched a publicity program to inspire young Chinese to become scientists and technicians, and thereby reduce the country's shortages in these occupations ("Song Jian," 1996, p. 1).

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[4]Scientists reportedly were ostracized less than other "intellectuals" until the beginning of the Cultural Revolution, at which point all "intellectuals" became suspect, regardless of their potential importance to technological development (Suttmeier, 1980, p. 36).

[5]Despite these notable improvements, not all constraints on technical personnel were lifted immediately after the Cultural Revolution ended. All technical personnel were still required to spend work time on non-work related (political) matters. Mistrust of, and antagonism towards workers engaged in intellectual, rather than manual labor continued. Many supervisors of scientists reportedly felt threatened by more highly educated scientists, creating institutional roadblocks to their professional growth (Orleans, 1983, pp. 5-7). Yet politics' role at least was decreasing, as in 1977 and 1978, professional personnel were promised that they would be required to spend no more than one-sixth of their work time in political meetings, a decline from demands during the Great Leap Forward and the Cultural Revolution (Suttmeier, 1980, p. 41). More recently, while political meetings continue to be held in government organizations (which comprise most of the urban work force) and can be mandatory, this practice is less common than in the 1970s.

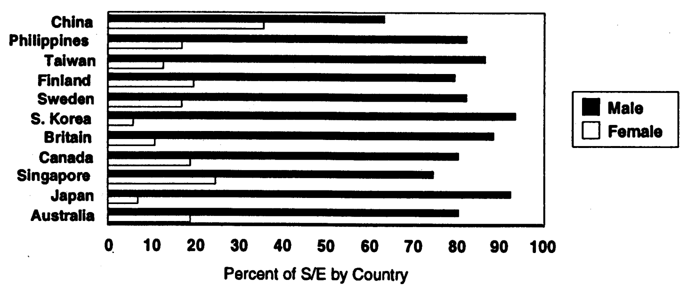
[6]This practice is changing. Many Chinese higher educational institutions now charge tuition (with all to charge tuition by 2000).

Males occupy most scientist and engineer positions.

Sixty-four percent of scientists and engineers are male, the smallest share of any country in this series (Table CH-1(90); Figure 2). This exceeds males' share of Chinese working and non-working adults, and the economically active population (defined as the employed population), of which males comprised 51 and 55 percent, respectively, in 1990 (Tabulation, 1993, pp. 13, 46, 50; and International Data Base). In each country in this series, males are a higher proportion of S/E than either the economically active population or the labor force (Zaslow, 1998a, p. 3).

Male predominance among science and engineering occupations may decline in the future, as educational opportunities for women improve, albeit slowly. Females' share of students in higher education rose from 30 to 36 percent between 1985 and 1997 (State Statistical Bureau, 1986, p. 103; State Statistical Bureau, 1997, p. 79). This has contributed to China's having the most even gender breakdown among scientists and engineers among the countries in this series.

Figure 2. Scientists and Engineers by Sex



Source: Table CHIN-1(90); see Bibliography for other reports in this series.

Scientists and engineers are concentrated among a few employment categories.

Within the employment category "Scientists and Engineers,"[7] the five leading categories (in sequential order) are statisticians, mechanical engineers, civil engineers, economic planners, and chemical engineers (Figure 3). These fields comprise 85 percent of all S/E (Table CHIN-1(90)). Males account for 62 percent of the 3,308,136 S/E in these fields. Males also dominate among geological and mining engineers. Among females, statisticians are most numerous, comprising 57 percent of female S/E (Figure 4).

The distribution of male S/E across occupations is more concentrated than the female.[8] As with many countries in this series, females are concentrated among the science rather than engineering occupation fields. However, China is the only country in this series for which females outnumber males among the scientist occupations, accounting for 54 percent of scientists. Overall, males account for 46 percent of scientists but 80 percent of engineers (Table CHIN-1(90)).

China, similar to other countries in this series, does not publish as detailed an occupational schedule as the United States. Nevertheless, other sources shed light on personnel in several key industries.[9] China has over 40,000 scientists, engineers and technicians engaged in space research and operations (Zhi, 1996, p. 1). Between 1970 (when China entered the space race) and mid-1996, China reportedly launched 47 rockets (Zhi, 1996, p. 1), although judging by the reported events, this may exclude military-related missions. In addition, China has a growing nuclear power program, employing at least 5,000, and perhaps far more scientists, engineers and technicians ("Daya Bay," 1998, p. 9).[10]

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[7]See Table CHIN-1(90) for a list of occupations that constitute the category "scientists and engineers."

[8]The standard deviation of the occupational categories' distribution for males is 8.0 percent, compared to 13.6 percent for females.

[9]The occupations noted in this paragraph are listed in an extremely detailed occupation schedule, such as the United States' "Dictionary of Occupational Titles" (U.S. Department of Labor, 1991). For China, they are assumed to be included in the more general occupational title used in the appendix tables of this report. The lack of detailed occupational schedules for many countries in this series is not surprising, as the United States published its first Standard Occupational Classification (SOC) in 1977 (Weinberg, 1997, p. 1).

[10]Another source reports there to be more than 300,000 employees in China's nuclear power program (Suttmeier and Evans, 1996, p. 16), with many presumably being scientists, engineers, or technicians.

Figure 3. Scientists and Engineers by Specialty and Sex: 1990

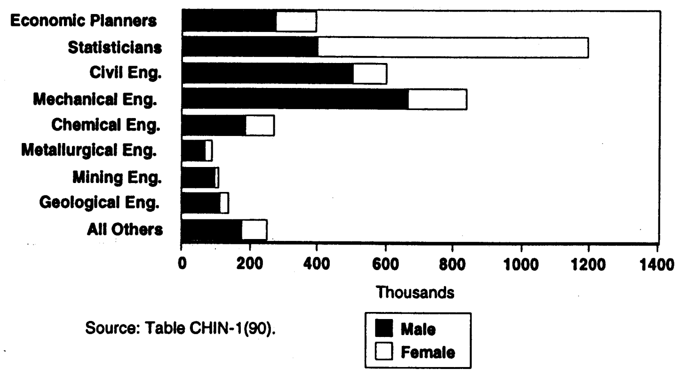
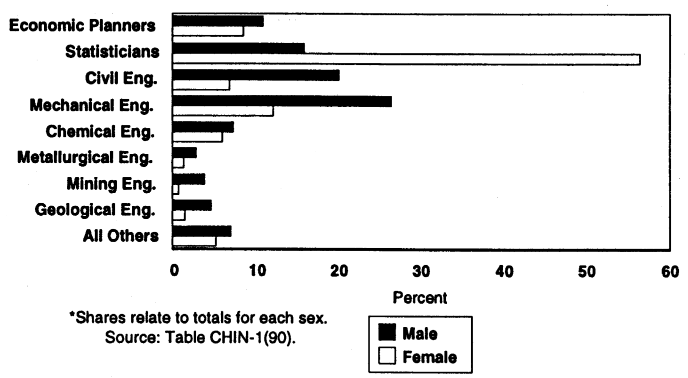


Figure 4. Distribution of Scientists and Engineers by Specialty and Sex: 1990*



Female scientists and engineers generally are younger than their male colleagues.

Across age groups, the largest share of S/E for both males and females is the 25-29 year old cohort. When separated by gender, a slightly higher share of female S/E are found among the youngest ages (15 percent) than for males (13 percent) (Table CHIN-1(90)). Fifty-seven percent of female S/E are under-35, compared to 47 percent of males. Few S/E are at the oldest working ages, with retirement ages of 60 for men and 55 for females (Figure 5). Fifty-one percent of scientists and engineers were below age 35, compared with 58 percent of the economically active population (Table CHIN-1(90); International Data Base). This is far less than the share of S/E in the under 35 age group for Taiwan.[11] Measured by 5-year age cohorts, the S/E population and the economically active population are skewed nearly equally (.34 and .33, respectively), although the economically active population's age structure is peaked far more than that of S/E.[12] The fact that the scientist and engineer population is skewed so similarly to that of the economically active population may suggest that China is not expanding its scientific and engineering work force faster than its overall work force.

The cost/efficiency implications of the scientist and engineer work force's age structure are mixed. Younger workers are paid less than older workers, while benefitting from education in the latest technological developments. However, they may lack the specific job-related skills acquired on the job by more experienced workers.

Scientists and engineers age structure seems relatively unaffected by the most severe periods of political animosity towards scientists and engineers. Among those reaching age 18 during the Cultural Revolution (1966-1976) (those in ages 32 to 42 in 1990) and the Great Leap Forward (those aged 48-50 in 1990), there is only a gradual decline in each age cohort's share of total S/E. However, there is an increase in the age 50-54 cohort's share of total S/E (Figure 6).[13] Such an increase so late in the age scale is unusual for the countries in this series. Considering the upheaval in the country's educational system during the Cultural Revolution (educational opportunities declined precipitously, with much of the remaining education system being devoted to political education) (Tang, 1994, p. 392), a sharper decline might have been expected.[14]

When political normalcy returned, attempts were made to compensate for the lack of educational opportunities during the years of turmoil and to encourage undertrained S/E to meet

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[11]In Taiwan, 63 percent of S/E are below age 35, compared to 49 percent of the employed labor force (Zaslow, 1998b, p. 6).

[12]The measure of kurtosis (relative peakedness or flatness of a distribution, compared to a normal, bell-shaped distribution) of the economically active population, by 5-year age cohort is 3.45, compared to .68 for S/E.

[13]In Taiwan, by contrast, each 5-year age cohort's share of total S/E declines after age 30 (Zaslow, 1998b, p. 7).

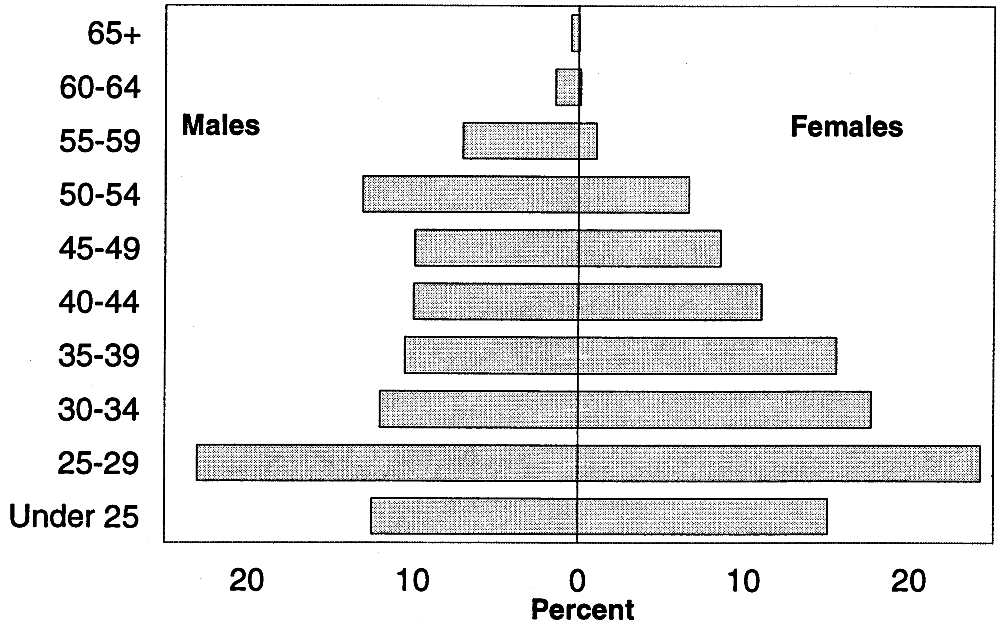
[14]One source did report that the age structure of scientific authors is bimodal, concentrated among those under age 40 and over age 60 (Chen, 1998, p. 1). Although this does not directly address the 50-54 age group, it suggests that older technical workers' job titles are consistent with their duties.

the higher academic standards of the 1980s. Scientists and engineers who never attended college were given that opportunity in the late 1970s and early 1980s (Orleans, 1983, p. 23; Tang, 1994, p. 392). Among those who graduated college immediately prior to the Cultural Revolution (beginning in 1966), many were unable to enter graduate school until the late 1970s. In 1978 and 1979, the average age of graduate students was 35 years old (Orleans, 1983, p. 33). In addition, the comparatively few Cultural Revolution-era college graduates (who often gained entry to college based more upon ideological than academic factors) were given the opportunity to earn certification at the more rigorous standards in the 1980s (Orleans, 1983, p. 44).

To counter the effects of an aging S/E workforce, efforts are being made to attract younger Chinese expatriate scientists to return from abroad and to reward the most talented of China's younger scientists (Swinbanks, 1996, p. 5). Award programs that are open only to scientists under age 40 are intended to advance the work and careers of deserving scientists (Swinbanks, 1996, p. 7).[15] In some cases, these awards are sponsored by local governments, such as that of Shanghai, to create local hubs of technological development ("CHINA: Shanghai's," 1997, p. 1). Researchers in their thirties are offered positions of authority despite their comparative youth. Another attempt to counteract the negative effects of an aging scientific workforce is the Academy of Science's recent program to fund the work of visiting, foreign scholars under age 45. However, in numerical terms, this program is comparatively small, with funding for 852 scholars over three years ("CAS," 1998, p. 2).

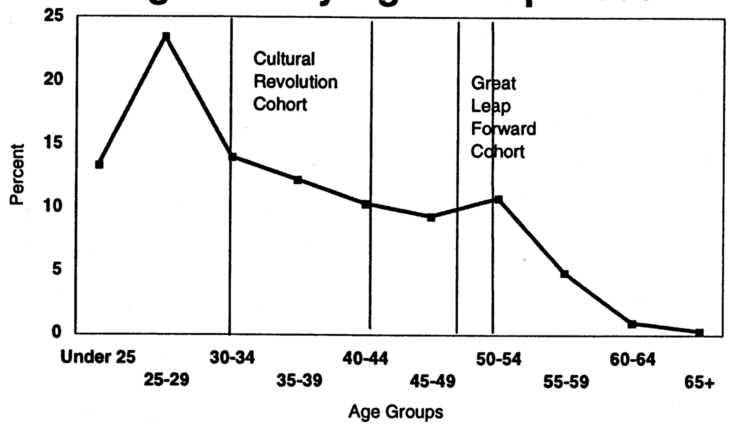
[15]Each year, about 60 scientists under age 40 receive awards of the equivalent of $62,000-75,000 per year for 3 to 5 years (Chen, 1998, p. 1).

Figure 5. Distribution of Scientists and Engineers by Age and Sex: 1990



Source: Table CHIN-1(90).

Figure 6. Distribution of Scientists and Engineers by Age Group: 1990



Source: Table CHIN-1(90).

Scientists and engineers are divided evenly among education levels.

Scientists and engineers in China are educated more highly than the employed work force as a whole, but S/E seriously trail educational attainment in other countries of this series. The share of S/E with a 4-year bachelors degree is 20 percent, the third lowest of all countries in this series. However, this share far exceeds that of the employed work force (2.8 percent in 1996) (Table CH-2(90); Figure 7; Zaslow, 1998a, p. 18; State Statistical Bureau, 1997, p. 135). In China, engineers are more likely than scientists to be college educated, which is the opposite of the situation in other countries in this series (Table CH-2(90)). This may relate to training issues, prestige of specific jobs, or the fact that similar occupational titles may not be associated with similar assignments as in other countries. For males, the share of S/E reporting a bachelors degree or higher is nearly double that for females (24 versus 13 percent, respectively) (Table CH-2(90)). Yet even these low levels (in an international context) may be inflated, as some S/E allegedly report having earned an academic degree when instead they attained their position through alternative means of certification (Orleans, 1983, p. 41).[16]

Chinese S/E are distributed almost evenly across several educational levels. Nearly all (97 percent) scientists and engineers report the five highest levels of education (Table CH-2(90)).[17] Of these, the largest (secondary technical vocational education) accounts for 22 percent of China's S/E, while the smallest of these leading categories (junior high or middle school) comprises 17 percent of all S/E. However, attendance in vocational school does not require that the student have completed the maximum number of years at the previous level of education. Such a wide representation across the educational levels among S/E raises questions about the quality of human capital in China's scientist and engineer population, since just 19 percent have post-secondary vocational training. In fact, if one were to use the World Bank's standard for defining technical personnel, the size of China's scientific and engineering work force would be substantially reduced.[18]

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[16]Self-study students may take college equivalency examinations (Tang, 1994, p. 400). In addition, possible shortcomings of educational training of Chinese scientists and engineers may be masked by misleading bibliometric measures of scientific output. A commonly used measure of research activity is the number of citations to researchers of a country. By this measure, Chinese research has improved dramatically. Between 1986 and 1992, China's international ranking rose from 26th to 12th. However, a Chinese source asserts that many of these citations do not relate to important findings, and the number of papers by Chinese scholars that do provide such important findings is declining ("What Will China," 1995, p. 6). All such descriptions of the relative importance of the citations noted in the international tabulation as being inconsequential are subjective.

[17]These are university, post-secondary technical vocational, secondary technical vocational, high school, and junior high/middle school.

[18]The World Bank defines scientists and engineers in R&D as people trained to work in any field of science (usually requiring completion of tertiary education) who are engaged in professional work in R&D activities (including administrators). Technicians in R&D are people engaged in R&D activities who have received vocational or technical training in any branch of knowledge or technology of a specified standard (usually three years beyond the first stage of secondary education) (World Bank, 1997b, p. 283). No sources reveal the basis for occupational classification by the Chinese, but self definition is likely used.

China relies upon self-study and vocational training due to insufficient enrollment capacity at universities, while technical education programs are plagued by problems that apparently stem from shortages of funding and possibly the need to graduate their students before they are sufficiently trained.[19] Among younger workers who were trained (not exclusively scientific personnel), 10 percent attended formal higher education, while 90 percent instead undertook vocational training or self-study ("Nation," 1996, p. 1).[20] This poses a variety of problems in China's efforts to develop a qualified scientific and technical labor force. Short-term training centers provide six-month to one year training programs for their students, and reportedly are ill equipped and poorly staffed (The World Bank, 1991b, p. 47). By contrast, skilled worker schools provide three years of education that offer academic course work (particularly in mathematics) that is reportedly superior to that found in Western secondary schools. However, the skill set that such schools provide is narrowly defined and would be associated with the abilities of a semiskilled worker. According to German standards, the curriculum at these schools lacks sufficient breadth to make workers adaptable to future technological responsibilities (The World Bank, 1991b, pp. 47, 48).[21] A further criticism of preemployment vocational training in general is that it diverts funding from general education, which might better serve China's interests by producing workers who are better prepared to adapt to new technology (The World Bank, 1991b, pp. 61, 62).[22] As a result of these problems, China's S&T leadership concedes that reliance upon self-study and vocational training will lead to continuing erosion of the country's ability to compete against the skilled workers found in more developed countries, with more advanced educational systems (Cui, 1996, p. 1). Nevertheless, despite shortcomings in China's overall educational system, China's high growth rates suggest that factors other than education may be at least as important to economic growth.

Insufficient capacity at Chinese universities also leads many scientists and engineers to study abroad. As of 1996, approximately 170,000 Chinese students were studying in the United States alone. Although data are incomplete, just one-third of Chinese who study abroad reportedly return to China (Chen, 1998, p. 1).[23] In addition to the loss of students educated

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[19]Just 30.2 million students were enrolled in institutions of higher education, from a total population of 1.2 billion in 1996 (State Statistical Bureau, 1997, pp. 76, 637).

[20]In 1984, 28 percent of the Chinese labor force had no schooling, compared to 0.4 percent of the labor force in developing countries (The World Bank, 1991b, p. 33).

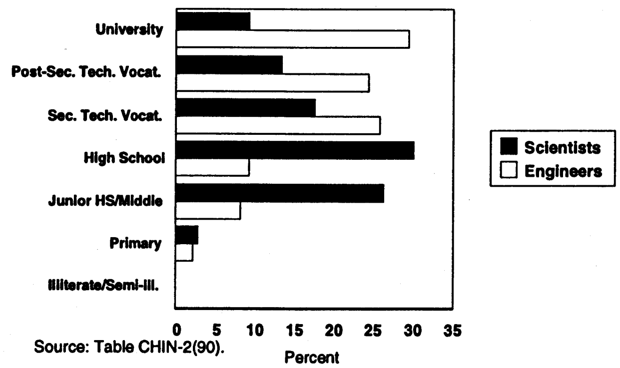
[21]The German Development Institute defined the average graduate of Chinese skilled worker schools as being only semiskilled, by German standards (The World Bank, 1991b, p. 48).

[22]Vocational schools reportedly cost 2 to 3 times as much as general secondary schools (The World Bank, 1991a, p. xi).

[23]One obvious incentive to emigrate, or remain abroad after study, is higher living standards in countries with more abundant educational opportunities. In China, starting salaries for Chinese scientists in academe range between $30-40 per month. No data have been revealed on wages for scientists, engineers and technicians in China's private sector.

abroad, many students trained in key disciplines in China also emigrate.[24] Among scientific and engineering graduates from Fudan University in Shanghai, the largest migration of students is from the electronic engineering department (Fisher, 1996, p. 38). If this is indicative of national trends, then such an exodus probably will make it harder for the electronics industry to grow at its planned 20 percent annual rate during the Ninth Five Year Plan ("China To Be Strong," 1996, p. 3).

Figure 7. Scientists and Engineers, by Educational Attainment: 1990



Source: Table CHIN-2(90).

[24]China is the second leading country, behind India, in applications for special United States' H-1B visas for computer industry workers who are in their home country at the time of their application (Branigin, 1998, p. A1).

Scientists, engineers and technicians are concentrated in manufacturing.

In 1995, most industrial scientists, engineers and technicians in China (83 percent) worked in manufacturing (Table CHIN-3(95); Figure 8).[25] No other sector accounts for more than eight percent of S/E in industry. Within manufacturing, no subsector employs as much as one-fourth of all scientists, engineers and technicians (Figure 9). The two largest subsectors in terms of employment of scientists, engineers and technicians (machinery and equipment, and chemicals and pharmaceuticals) employed 41 percent of scientists, engineers and technicians in independent accounting units of industry in 1995 (Table CHIN-4(95)).[26] In turn, these sectors had the highest shares of scientists, engineers and technicians among their total employees, roughly 10 percent, while most other manufacturing subsectors had no more than six percent of their employees being scientists, engineers and technicians (Editor, 1997, pp. 198-229). The miscellaneous manufacturing, and the food, beverages, and tobacco subsectors have the highest ratios of gross values of output (GVO) to scientists, engineers, and technicians, by subsector of manufacturing in independent accounting units (for 1995). Somewhat surprisingly, machinery and equipment has the second lowest ratio of GVO to scientists, engineers, and technicians in manufacturing (non-metal minerals is lowest) (State Statistical Bureau, 1996, p. 414; Table CHIN-4(95)). However, with human capital being just one of many determinants of economic development, it would be inappropriate to suggest that the technical personnel in any subsector are more productive than in another based upon this evidence.

Other factors, such as insufficient funding for research and development, also play a role in economic development. The pharmaceutical industry is an example of how insufficient funding impairs the most highly advanced work of S/E in manufacturing. New products reportedly take a long time to be developed, and insufficient numbers of clinical trials are executed ("Research," 1998, p. 2). However, foreign companies have compensated somewhat for the shortage of research funding, and new products are being developed, albeit more slowly than if funding were more plentiful ("The Chinese Pharmaceutical Market," 1997, pp. 1, 2; Zhang, 1996, p. 1).[27]

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[25]Other industries, besides manufacturing, include mining, construction, utilities, and "others," as indicated in Table CHIN-3(95). China's manufacturing sector includes subsectors that typically are included in the sector in other countries of this series (State Statistical Bureau,1997, p. 440; Zaslow, 1995, 1996a-c, 1997a-d, 1998, a-b, Table 4). Data for tables CHIN-3 (95), and CHIN-4(95) refer to scientists, engineers and technicians in independent accounting units of industry. Comparisons of the sectoral breakdown of S/E can not be made with other countries in this series as Chinese data exclude scientists and engineers in non-industrial fields.

[26]Two measures which quantify concentration are the Herfindahl-Hirschman Index (H Index) (the concentration of market shares held by particular suppliers) and the coefficient of variation (the standard deviation divided by the mean). The H Index for scientists, engineers and technicians in manufacturing was .14, while the coefficient of variation was .70.

[27]In particular, foreign companies' R&D activities for pharmaceuticals in China relate to herbal medicines (Shen, 1996, p. 18).

China has been more successful in developing low-end pharmaceutical products. Bulk pharmaceuticals sales grew an annual average of 20 percent for the past 15 years, with output reaching $11.5 billion in 1997. However, Chinese factories are not yet in compliance with Good Manufacturing Practices standards (a list of good manufacturing practices), which constrains growth. Their inability to reach these standards reportedly is due to funding shortages, although until Asia's economy began experiencing economic shocks in mid-1997, many financial observers believe that most worthwhile projects in Asia can find financing ("China Emerges," 1998, p. 23; Sender, 1996, pp. 42-48).[28]

Just as foreign companies have contributed to research funding in China, Chinese manufacturing firms rely heavily upon technology transfer to modernize their products. In the computer industry, the government may concede market share to foreign computer companies in exchange for their transferring technology for advanced computers and networks from which Chinese companies then can learn to create indigenous products ("China Computer," 1997, p. 1).[29] To increase technology transfer, China encourages joint ventures and foreign venture capital. One means by which this is done is with the creation of technology parks (housing both foreign and domestic firms), which offer subsidized infrastructure, lower land prices and tax concessions.[30] However, many Western companies view China more as a market than as a research base. Much of the technology transfer takes place in the form of imported equipment, buttressing the perception of China as a market, but also supporting the Chinese desire to become a more important producer.[31]

To date, there has been little integration of new equipment into production processes. New, imported equipment are rarely used as designed. Not surprisingly, China devotes far smaller shares of technology acquisition funds for integration with existing equipment than do Japan or South Korea, countries which purportedly excel at this task ("A Decade of Reform," 1997, p. 12). Reports indicate that many Chinese companies do not perform routine preventive maintenance, instead permitting equipment to break through overuse (Teague and Bak, 1997, p. 75). This may be due to shortages of technicians and spare parts, a problem that impairs

[28]China has attempted to make its accounting practices more consistent with international standards, so that foreign financing bodies may better evaluate the financial status of Chinese firms, to better attract foreign financing (Harris, 1996, p. 57).

[29]A Chinese government report asserted that "technology imports which are not absorbable should be rejected" ("Statistics," 1997, p. 2).

[30]In 1995, foreign trade of technology development zones in Nanjing, Wuxi, Suzhou, Yixing, Chanzhou, among other (unspecified) cities with such zones reached $425 million, with over two-thirds being exports ("PRC: Jiangsu," 1996, p. 1). In 1996, the 52 high technology zones in China generated revenues in excess of 100 billion yuan (approximately $12 billion) (FBIS, 1996, p. 1).

[31]Imports of machinery and transport equipment is a commonly used proxy for technology transfer (Ho, 1997, p. 85). The value of these imports rose more than tenfold between 1980 and 1996, in constant dollars (State Statistical Bureau, 1997, p. 590). In addition, exchanges of information also are an important means of technology transfer (OECD, 1997, p. 41), but are less readily quantified.

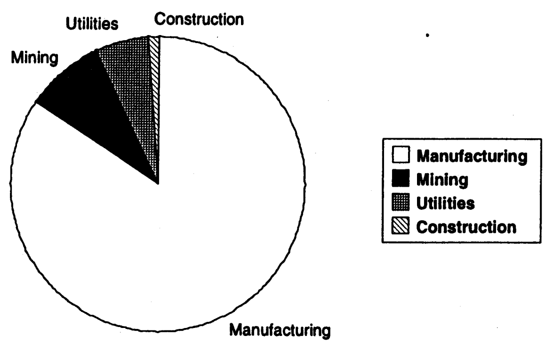
efficiency of both new and old equipment (The World Bank, 1991b, p. 54). In light of these problems, ministries have crafted their own definition of "expanded" technology use, to put the best spin on what has been a disappointing record. Usage by as little as four percent of potential domestic customers is considered "expanded" use of the technology ("What Will China," 1995, pp. 4, 5). While the degree of integration could far exceed this level, a more useful statistic would be to know how the Chinese define "potential" customers. It would be worthwhile to determine if this refers to all enterprises that had attempted to obtain new technology, or if it is all enterprises in a respective ministry. Also, it would be useful to calculate the opportunity cost of the failure to modernize adequately--requiring information on the size and output of each firm that cannot modernize. Nevertheless, the low threshold cited above suggests minimal use of new technology.

Despite these shortcomings, China has made impressive gains in high technology production. In 1995, approximately 10 percent of industry's output was in high technology fields, a major increase from two percent in 1985 ("A Decade of Reform," 1997, p. 85).[32] China's high technology products accounted for 19 percent of manufactured exports in 1995, compared with 43 percent for the United States.[33] Among other low income economies, only Senegal and Nicaragua have higher shares of high technology products among their manufactured exports (39 and 38 percent, respectively) (The World Bank, 1997b, pp. 280- 282).

[32]This order of increase probably understates the improvement in output, as hedonic techniques should be applied to adjust for improvements in quality of high technology products (OECD, 1997, p. 69). For instance, the improved performance of a computer costing a fixed price over a period would need to be considered in analyzing computer sales or production.

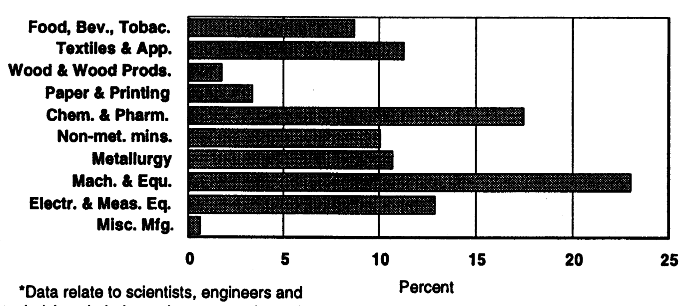
[33]High technology exports are those produced by the top 10 industries (based on U.S. industries) according to R&D intensity-- the R&D expenditures required to produce a certain manufactured good (World Bank, 1997b, p. 283).

Figure 8. Scientists, Engineers, and Technicians, by Industrial Sector: 1995



Source: Table CHIN-3(95).

Figure 9. Scientists, Engineers and Technicians in Manufacturing, by Industry: 1995*



*Data relate to scientists, engineers and technicians in independent accounting units.
Source: Table CHIN-4(95).

Scientific Research in China

The accelerated development of science and technology was intended to be a linchpin in Deng Xiaopeng's efforts to reform the economy in the late 1970s.[34] Science and technology was one of the "four modernizations" which were to be employed to improve living standards and raise the country's international economic profile.[35] However, initial analysis casts some doubt upon that connection, considering China's high growth rates while the country's share of gross domestic product (GDP) devoted to R&D lags far behind other countries (although growth rates depend upon the beginning level of development) (Figures 10, 11).[36]

China has not devoted substantial sums to R&D, and at least in the state sector, the goals set for expanded funding in the last half of the 1990s are not being met. In 1995, President Jiang Zemin stated that China would triple its share of GDP used for R&D, from 0.5 to 1.5 percent during the current Five Year Plan.[37] The shortage of R&D funding reportedly has been somewhat offset by improved allocation of resources due to the increased market orientation of Chinese research and increased personal choice in deciding place of employment, better communication between research facilities (to reduce duplication of efforts), and greater openness to foreign trade and outside investment, as the economy has adopted market mechanisms (Hu and Khan, 1997, p. 120; "A Decade of Reform," 1997, pp. 151, 152).[38] Nevertheless, China trails more developed countries in capital infusion, the quality of facilities, depth of research, quality of personnel and the breadth of international exchanges. Although China has cooperative S&T agreements with 145 countries, many research institutes lack the funding even to purchase foreign academic journals ("A Decade of Reform," 1997, p. 144). As a

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[34]Even earlier, Mao Zedong had called science one of the three great revolutionary movements for building a strong socialist state (Orleans, 1983, p. 11).

[35]The others, agriculture, industry, and national defense were dependent upon science for their own development (Orleans, 1983, p. 3). The 1978 policy statements grew out of the National Conference on Science and Technology ("A Decade of Reform," 1997, p. 83).

[36]According to a Chinese source, China's 1993 R&D spending was just 56 percent of that spent by the Siemens company ("What Will China," 1995, p. 5). There is a weak correlation (.19) between R&D's share of GDP and GDP growth rates between 1981 and 1990 for the countries in this series. An economic model of the effects of research and development on changes in GDP per capita, using the explanatory variables of shares of R&D in GDP, land, growth in capital stock per worker between 1981 and 1990, and labor force growth between 1980 and 1990 yields an adjusted coefficient of determination (adjusted R-squared) of .45, with no apparent diagnostic problems. However, growth of capital stock per worker seems to be the only explanatory variable that is statistically significant, and the model would be improved by substituting change in R&D's share of GDP for a static share of R&D in GDP. This substitution has not yet been made due to a lack of adequate data.

[37]China's share of GDP spent on R&D may be slightly higher than the 0.5 percent of GDP in the mid-1990s, as coverage of R&D spending by private companies reportedly is incomplete. Many R&D goals are combined into programs such as "863" (so named as it was conceived in March of 1986), Spark (agricultural issues), and Torch (high technology research), so named perhaps to facilitate their publicity campaigns.

[38]"Openness" (exports plus imports, divided by GDP) more than doubled between 1978 and 1992, from 13.2 to 33.5 (Penn World Tables, 1998).

result, basic research reportedly has stagnated, and efforts to commercialize new products have been impaired ("What Will China," 1995, p. 2).

Until the mid- to late 1980s, the contribution of Chinese scientific personnel to the economy was diminished by inherent inefficiencies in the organization of the scientific-research system. As in the former Soviet Union, researchers were concentrated in institutes that were not affiliated with either industrial enterprises or academic institutions.[39] This separated researchers from contributing to the "socialist construction" that political leaders asserted was to be the key task of researchers (Suttmeier, 1989, p. 1005). In addition to the lack of communication with industrial enterprises, poor communication within the research field led to duplication of research. China's technological development has also been hampered by the country's incomplete efforts to protect intellectual property. China has a limited tradition in enforcing patent laws, which limits the potential rewards for innovation (Plafker, 1997, p. 6), and stifles both foreign and domestic investment. Other problems include insufficient performance incentives, due to the institutes operating on a nonprofit basis ("R&D," 1986, p. 89; Worden, et.al, 1987, p. 1). Furthermore, many of China's best scientists and engineers were diverted from straight R&D to work on defense-related projects, particularly after 1960, when the rupture of relations with the Soviet Union spurred China to develop nuclear weapons (Suttmeier, 1990, p. 904). Finally, projects have often been selected for funding based upon whether the resulting technology would be considered advanced in an international context, rather than whether there was a market for the product ("R&D," 1986, p. 89).

More recently, there has been a growing partnership between the research and business communities. Since the mid-1980s, many government research institutes and universities have set up businesses to generate income to support research. Such enterprises are especially common in the coastal regions. By 1992, 44 percent of China's 4,871 state-owned R&D units had established links with enterprises. These links may help the enterprises integrate foreign technology.[40] The closer relationship between the institutes and their economic enterprises allows research to focus more directly on areas of study that will most benefit the economy. Along with this reorganization, governmental research funding is now more often awarded in grants (presumably based upon the merit of a proposal), rather than exclusively on the continuation of long-standing funding of research organizations (Swinbanks, 1996, p. 5). Nevertheless, in 1995, nearly 70 percent of S/E still worked in research institutions that were not affiliated with industry ("What Will China," 1995, p. 5). This continued high employment of S/E in state sponsored research institutes is by government design, as official policy calls for institutes to be maintained by government funding (to support basic research) and supplemented

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[39]Only the largest enterprises had any research facilities prior to the mid-1980s (Worden, et.al., 1987, p. 1).

[40]Since 1994, enterprise institutes have been permitted to operate independently if they can generate $500,000 in hard currency each year (the threshold for machine building institutes is $1 million for three consecutive years) ("What Will China," 1995, p. 7). Some research institutes have also been permitted to operate independently.

by privately raised funds for their applied research. In contrast, private sector R&D is slated to expand more rapidly, focusing only on applied research (Plafker, 1997, p. 6).[41]

Progress in developing a market oriented system of research funding should not be overestimated. Institutional traditions may be diminishing the impact of China's limited science and technology spending. Even researchers who received grants assert that favoritism, rather than merit, often dictates funding decisions (Rozelle, et. al., 1997, p. 42). Scientists at some provincial science and technology institutions that were described as being successful claimed that only national institutions received funding from the State Science and Technology Commission ("A Decade of Reform," 1997, p. 11). Material incentives are also problematic. A survey of rice research institutes indicates that insufficient shares of revenues are being devoted to funding research (with most proceeds being directed towards salaries and bonuses) (Rozelle, et. al., 1997, p. 44), despite marked increases in revenue.[42]

To get around some of these problems in organization and funding levels, China has begun to collaborate with foreign companies. For example, China relies upon partnerships with Western companies to advance its aerospace technology.[43] The shipbuilding industry is said to be the world's third largest, in part due to collaboration with Japanese and Korean companies (Pike, 1998, p. 1). China currently has three nuclear reactors built with foreign assistance[44] and is developing improved methods to extract oil that would maximize output from fields of varying

[41]The slogan to promote this policy states, in Chinese *"wen zhu yi tou, fang kai yi pian"* (stabilize one end, and let loose the other) (Plafker, 1997, p. 6).

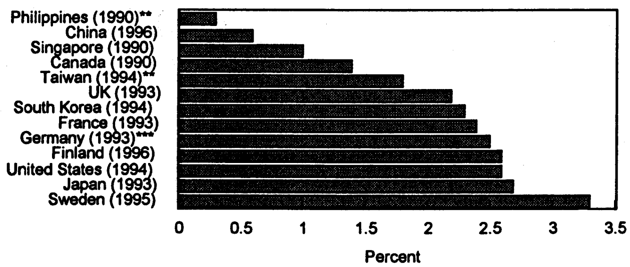
[42]No further evidence has been revealed to indicate if this is typical of a larger, and possibly more representative sample.

[43]For instance, Chinese workers produce tail sections for Boeing 737 jets, although Boeing owns the rights to the production process (Dinell, 1997, p. 1).

[44] These include two 900 MW reactors at Daya Bay -in Guangdong-less than 50 miles from Hong Kong, and a 300 MW reactor at Qinshan (Lewis, 1998, p. 1). In addition, another plant, with two 985 MW reactors, is under construction at Lingao, just 1 kilometer from Daya Bay ("Daya Bay," 1998, p. 6). Adequate energy supplies for Guangdong province are important to China's efforts to attract foreign investment. For the first half of 1993, Guangdong accounted for 55 percent of China's exports from foreign invested enterprises (Prime, 1993, p. 9).

geological configurations ("PRC: Official," 1996, p. 1).[45] The computer industry's development also relies upon foreign involvement: in 1996, China produced just 17 percent of domestically installed computer chips.[46]

Figure 10. Share of Gross Domestic Product Used for R&D*



* Research and Development; ** Non-defense R&D; *** Estimate
Source: Zaslow, 1998a, p. 16; Fisher, 1996, p. 37.

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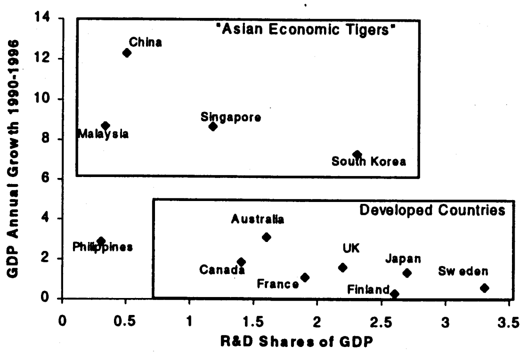
[45] China's interest in nuclear fuels stems from economic, geographic and environmental considerations. China's coastal regions have insufficient energy supplies, in part because much of the country's coal and hydroelectric resources are located in the center and the west of China. In 1994, the coastal provinces consumed 46 percent of China's energy, while producing 28 percent. In addition, nuclear power is seen by its proponents as a cleaner alternative to coal, which accounts for more than three-fourths of China's energy consumption (76 percent), compared to less than one-fourth in the United States (23 percent) ("Daya Bay," 1998, pp. 2,3). Another factor arguing for the development of nuclear power is that 40 percent of China's rail capacity is reserved for coal transport, creating bottlenecks in the transport of other commodities ("A Decade of Reform," 1997, p. 25).

[46] The government considers this to be excessive dependence on imports (the current Five Year Plan calls for China to produce one-third of its computer chips by the year 2000) ("China's Chip Industry," 1997, p. 1). In addition, information exchanges take place in areas such as agriculture, environmental protection, public health and other fields between China and the United States. Many of these are coordinated by professional associations ("Scientists," 1997, p. 1). China may be increasing contacts with Taiwan in areas of technological development. The first Chinese cabinet minister to visit Taiwan (albeit in a private capacity) was the Minister of Science and Technology (Zhu Lilan), on July 14th, 1998 (Hung, 1998, p. 1). Also, an agreement between Russia and China (August 1998) renews collaboration in research, development and production of military equipment until 2005. However, this seems unlikely to match the scale of earlier collaborative research efforts (Pomfret, 1998, p. A13).

Figure 11. R&D Shares of GDP and GDP Annual Growth Rates (1990-1996)



Source: The World Bank, 1998; Zaslow, 1999.

Conclusions

China's concentration of scientists and engineers in its economically active population lies at the low end of the countries in this series. China's scientists and engineers are less concentrated among the younger age groups than in the economically active population. Males account for the majority of scientists and engineers, comprising 64 percent of S/E. The gender distribution of China's scientists and engineers favors males more than the economically active population, of which males comprise 55 percent. Female S/E are concentrated more heavily in the younger age groups than are males and are more likely to be scientists than engineers.

China's scientists and engineers have been constrained by shortages of research funding and inadequate opportunities for higher education. Coupled with the virtual lack of formal educational opportunities during the Cultural Revolution, an entire generation of Chinese scientists and engineers have relied upon a less formal and comprehensive means of professional training than exists in more developed countries. This may suggest that other factors affect economic development more than any characteristic of scientists and engineers. Future analysis might include a comparison of Chinese technological development with other countries at similar stages of development (Suttmeier, 1993, p. 288). Such an effort might address the validity of Deng Xiaopeng's assertion that science and technology was the key to economic growth.

Tables

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CHIN-1(90)

Table 1. Scientists, Engineers, and Technicians by Age Group and Sex, in China: 1990

Both Sexes

Occupations	Total	Under 25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
SCIENTISTS, ENGINEERS, TECHNICIANS	7,362,481	1,079,240	1,629,571	1,015,935	931,609	807,952	722,059	733,283	328,317	75,003	39,512
SCIENTISTS AND ENGINEERS	3,907,498	524,633	917,125	548,869	481,421	405,441	369,026	421,241	191,221	36,711	11,810
SCIENTISTS	1,799,598	227,569	403,699	313,356	281,989	209,466	147,533	129,574	66,947	14,837	4,628
Sociologists	4,311	228	951	676	644	399	348	408	413	165	79
Economists	9,876	579	2,318	1,327	1,131	922	890	1,043	995	476	195
Economic Planners	399,107	24,909	71,201	60,023	63,939	58,696	43,528	41,874	28,230	5,546	1,161
Statisticians	1,193,034	183,689	285,977	228,160	197,586	136,583	80,253	50,357	22,941	5,517	1,971
Meteorologists, Seismologists	50,333	7,087	11,631	8,264	6,614	4,305	4,368	6,146	1,786	105	27
Natural Scientists	27,643	1,675	5,563	2,574	2,060	1,688	3,835	6,559	2,867	554	268
Industrial Scientists	61,242	5,042	12,985	5,686	4,804	3,834	9,166	13,927	4,739	842	217
Agricultural Researchers	30,160	2,241	7,119	3,561	2,634	1,500	2,890	6,060	2,968	849	338
Medical Researchers	16,375	1,426	4,132	2,173	1,773	963	1,502	2,158	1,399	587	262
Other Researchers	7,517	693	1,822	912	804	576	753	1,042	609	196	110
ENGINEERS	2,107,900	297,064	513,426	235,513	199,432	195,975	221,493	291,667	124,274	21,874	7,182
Urban Planners	47,811	9,238	13,520	5,983	4,429	3,250	3,369	4,887	2,378	535	222
Civil Engineers	604,215	93,503	148,886	72,404	63,377	52,577	51,217	71,973	37,985	8,899	3,394
Mechanical Engineers	838,533	98,462	194,155	92,929	78,450	94,039	101,597	120,192	49,612	7,070	2,027
Chemical Engineers	273,247	47,379	68,665	27,030	22,551	22,436	32,951	36,769	12,021	2,520	925
Metallurgical Engineers	92,829	12,058	21,474	8,616	8,096	7,724	10,762	16,609	6,104	1,093	293
Mining Engineers	111,524	19,303	33,734	11,890	9,936	7,670	8,462	13,499	5,958	896	176
Geological Engineers	139,741	17,121	32,992	16,661	12,593	8,279	13,135	27,738	10,216	861	145

CHIN-1(90)

Table 1. Scientists, Engineers, and Technicians by Age Group and Sex, in China: 1990–Continued

											Both Sexes
Occupations	Total	Under 25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
TECHNICIANS	3,454,983	554,607	712,446	467,066	450,188	402,511	353,033	312,042	137,096	38,292	27,702
Industrial Control Technicians	303,962	39,767	70,054	37,129	33,939	36,564	34,742	34,747	14,483	1,996	541
Surveying, Hydrological Tech.	90,644	13,114	20,030	12,105	10,180	6,223	7,997	13,815	6,075	894	211
Electric & Electronic Tech.	699,326	103,132	174,456	87,308	66,093	67,406	82,976	84,454	27,987	4,395	1,119
Light Industry, Textile Tech.	191,158	36,996	54,239	28,129	18,950	15,344	12,230	12,585	8,400	2,852	1,433
Food & Drink Technicians	61,945	15,513	17,521	7,228	5,708	4,507	4,173	4,083	2,105	729	378
Agricultural Technicians	400,548	72,558	94,456	53,113	51,194	35,086	33,619	38,577	17,221	3,621	1,103
Forestry Technicians	133,023	26,178	33,289	17,023	14,358	10,248	11,001	13,281	6,141	1,142	362
Other Eng. & Agri-Forestry Tech.	122,039	16,219	28,015	16,073	14,625	14,142	12,644	12,893	5,922	1,142	364
Scientific Technology Managers	23,829	1,783	4,325	2,887	2,829	2,415	3,240	4,076	1,831	348	95
Scientific Technology Assistants	54,815	8,322	12,203	8,922	7,400	5,260	5,212	4,813	1,953	497	233
Airplane Mechanical Technicians	4,652	630	1,057	794	656	495	386	432	184	17	1
Ship Turbine Technicians	49,791	4,407	7,258	7,848	8,578	7,729	6,343	4,974	2,312	309	33
Other Plane and Ship Technicians	7,336	921	1,285	962	1,001	877	906	857	431	76	20
Rural Medical Technicians	736,117	87,762	72,719	89,774	126,992	137,305	98,236	54,666	30,586	17,728	20,349
Other Health Technicians	361,131	63,700	76,876	66,406	59,432	32,583	26,803	21,268	10,213	2,417	1,433
Geological Surveyors	214,667	63,605	44,663	31,365	28,253	26,327	12,525	6,521	1,252	129	27

CHIN-1(90)

Table 1. Scientists, Engineers, and Technicians by Age Group and Sex, in China: 1990--Continued

Occupations	Total	Under 25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	Male 65+
SCIENTISTS, ENGINEERS AND TECHNICIANS	5,053,908	695,380	1,088,971	622,643	583,404	557,967	514,577	579,703	302,508	71,045	37,710
SCIENTISTS AND ENGINEERS	2,509,516	314,429	578,553	301,763	263,821	250,907	249,104	328,296	176,222	34,986	11,435
SCIENTISTS	821,086	88,944	175,112	118,403	105,225	89,754	78,602	87,999	59,073	13,622	4,352
Sociologists	3,258	132	691	495	479	308	264	318	344	154	73
Economists	7,399	378	1,652	977	794	649	621	826	873	441	188
Economic Planners	276,982	15,502	47,209	39,188	41,538	38,765	29,758	32,253	26,378	5,273	1,118
Statisticians	401,155	61,224	95,541	63,047	50,893	41,538	33,494	28,839	19,604	5,091	1,884
Meteorologists, Seismologists	32,774	4,354	7,366	4,901	4,041	2,853	2,834	4,636	1,664	99	26
Natural Scientists	19,790	1,154	4,211	1,790	1,361	1,131	2,536	4,717	2,203	452	235
Industrial Scientists	44,037	3,443	9,583	3,860	3,093	2,616	6,002	10,308	4,148	787	197
Agricultural Researchers	21,262	1,546	5,222	2,380	1,703	1,012	1,799	4,110	2,440	737	313
Medical Researchers	9,129	745	2,351	1,135	797	503	809	1,250	912	412	215
Other Researchers	5,300	466	1,286	630	526	379	485	742	507	176	103
ENGINEERS	1,688,430	225,485	403,441	183,360	158,596	161,153	170,502	240,297	117,149	21,364	7,083
Urban Planners	36,701	6,427	10,030	4,543	3,375	2,668	2,712	4,033	2,172	520	221
Civil Engineers	506,094	73,301	119,984	59,933	54,554	47,051	43,126	60,476	35,558	8,742	3,369
Mechanical Engineers	666,901	73,876	149,476	69,962	60,281	76,315	78,871	101,359	47,785	6,964	2,012
Chemical Engineers	187,822	32,396	48,476	18,168	14,749	14,823	20,077	25,409	10,498	2,349	877
Metallurgical Engineers	72,867	8,885	16,749	6,611	6,207	6,141	7,842	13,399	5,680	1,065	288
Mining Engineers	100,388	16,728	30,736	10,801	9,056	7,110	7,312	11,853	5,731	886	175
Geological Engineers	117,657	13,872	27,990	13,342	10,374	7,045	10,562	23,768	9,725	838	141

CHIN-1(90)

Table 1. Scientists, Engineers, and Technicians by Age Group and Sex, in China: 1990--Continued

Occupations	Total	Under 25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	Male 65+
TECHNICIANS	2,544,392	380,951	510,418	320,880	319,583	307,060	265,473	251,407	126,286	36,059	26,275
Industrial Control Technicians	215,872	26,831	48,179	24,800	22,913	25,740	23,932	27,277	13,728	1,939	533
Surveying, Hydrological Technicians	74,709	10,195	16,078	9,293	8,263	5,372	6,678	11,904	5,835	881	210
Electric & Electronic Technicians	517,876	69,826	126,552	61,462	47,204	52,087	60,588	68,432	26,331	4,298	1,096
Light Industry, Textile Technicians	114,530	20,091	31,478	15,940	10,134	9,044	7,401	8,887	7,453	2,708	1,394
Food & Drink Technicians	43,476	10,195	12,378	4,926	3,838	3,195	2,892	3,080	1,903	701	368
Agricultural Technicians	331,239	55,605	77,332	42,540	41,613	30,550	28,972	33,637	16,392	3,518	1,080
Forestry Technicians	110,399	20,208	27,099	14,046	11,943	8,838	9,318	11,570	5,904	1,121	352
Other Eng. & Agri-Forestry Technicians	96,147	11,873	21,477	12,244	11,412	11,580	9,812	10,660	5,622	1,110	357
Scientific Technology Managers	17,337	1,226	3,257	2,057	1,930	1,644	2,136	3,026	1,639	332	90
Scientific Technology Assistants	25,042	3,803	5,691	3,625	2,911	2,046	2,083	2,617	1,604	451	211
Airplane Mechanical Technicians	4,295	553	974	743	618	463	340	410	176	17	1
Ship Turbine Technicians	49,154	4,297	7,109	7,719	8,450	7,669	6,306	4,954	2,309	309	32
Other Plane and Ship Technicians	6,632	781	1,146	873	910	819	804	780	424	75	20
Rural Medical Technicians	554,217	55,552	48,845	59,369	93,092	107,093	79,867	46,723	27,938	16,514	19,224
Other Health Technicians	182,528	32,982	41,974	31,677	26,962	14,960	11,986	10,967	7,782	1,957	1,281
Geological Surveyors	200,939	56,933	40,849	29,566	27,390	25,960	12,358	6,483	1,246	128	26

CHIN-1(90)

Female

Table 1. Scientists, Engineers, and Technicians by Age Group and Sex, in China: 1990--Continued

Occupations	Total	Under 25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
SCIENTISTS, ENGINEERS, AND TECHNICIANS	2,308,573	383,860	540,600	393,292	348,205	249,985	207,482	153,580	25,809	3,958	1,802
SCIENTISTS AND ENGINEERS	1,397,982	210,204	338,572	247,106	217,600	154,534	119,922	92,945	14,999	1,725	375
SCIENTISTS	978,512	138,625	228,587	194,953	176,764	119,712	68,931	41,575	7,874	1,215	276
Sociologists	1,053	96	260	181	165	91	84	90	69	11	6
Economists	2,477	201	666	350	337	273	269	217	122	35	7
Economic Planners	122,125	9,407	23,992	20,835	22,401	19,931	13,770	9,621	1,852	273	43
Statisticians	791,879	122,465	190,436	165,113	146,693	95,045	46,759	21,518	3,337	426	87
Meteorologists, Seismologists	17,559	2,733	4,265	3,363	2,573	1,452	1,534	1,510	122	6	1
Natural Scientists	7,853	521	1,352	784	699	557	1,299	1,842	664	102	33
Industrial Scientists	17,205	1,599	3,402	1,826	1,711	1,218	3,164	3,619	591	55	20
Agricultural Researchers	8,898	695	1,897	1,181	931	488	1,091	1,950	528	112	25
Medical Researchers	7,246	681	1,781	1,038	976	460	693	908	487	175	47
Other Researchers	2,217	227	536	282	278	197	268	300	102	20	7
ENGINEERS	419,470	71,579	109,985	52,153	40,836	34,822	50,991	51,370	7,125	510	99
Urban Planners	11,110	2,811	3,490	1,440	1,054	582	657	854	206	15	1
Civil Engineers	98,121	20,202	28,902	12,471	8,823	5,526	8,091	11,497	2,427	157	25
Mechanical Engineers	171,632	24,586	44,679	22,967	18,169	17,724	22,726	18,833	1,827	106	15
Chemical Engineers	85,425	14,983	20,189	8,862	7,802	7,613	12,874	11,360	1,523	171	48
Metallurgical Engineers	19,962	3,173	4,725	2,005	1,889	1,583	2,920	3,210	424	28	5
Mining Engineers	11,136	2,575	2,998	1,089	880	560	1,150	1,646	227	10	1
Geological Engineers	22,084	3,249	5,002	3,319	2,219	1,234	2,573	3,970	491	23	4

CHIN-1(90)

Female

Table 1. Scientists, Engineers, and Technicians by Age Group and Sex, in China: 1990--Continued

Occupations	Total	Under 25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
TECHNICIANS	910,591	173,656	202,028	146,186	130,605	95,451	87,560	60,635	10,810	2,233	1,427
Industrial Control Technicians	88,090	12,936	21,875	12,329	11,026	10,824	10,810	7,470	755	57	8
Surveying, Hydrological Technicians	15,935	2,919	3,952	2,812	1,917	851	1,319	1,911	240	13	1
Electric & Electronic Technicians	181,450	33,306	47,904	25,846	18,889	15,319	22,388	16,022	1,656	97	23
Light Industry, Textile Technicians	76,628	16,905	22,761	12,189	8,816	6,300	4,829	3,698	947	144	39
Food & Drink Technicians	18,469	5,318	5,143	2,302	1,870	1,312	1,281	1,003	202	28	10
Agricultural Technicians	69,309	16,953	17,124	10,573	9,581	4,536	4,647	4,940	829	103	23
Forestry Technicians	22,624	5,970	6,190	2,977	2,415	1,410	1,683	1,711	237	21	10
Other Eng. & Agri-Forestry Technicians	25,892	4,346	6,538	3,829	3,213	2,562	2,832	2,233	300	32	7
Scientific Technology Managers	6,492	557	1,068	830	899	771	1,104	1,050	192	16	5
Scientific Technology Assistants	29,773	4,519	6,512	5,297	4,489	3,214	3,129	2,196	349	46	22
Airplane Mechanical Technicians	357	77	83	51	38	32	46	22	8	0	0
Ship Turbine Technicians	637	110	149	129	128	60	37	20	3	0	1
Other Plane and Ship Technicians	704	140	139	89	91	58	102	77	7	1	0
Rural Medical Technicians	181,900	32,210	23,874	30,405	33,900	30,212	18,369	7,943	2,648	1,214	1,125
Other Health Technicians	178,603	30,718	34,902	34,729	32,470	17,623	14,817	10,301	2,431	460	152
Geological Surveyors	13,728	6,672	3,814	1,799	863	367	167	38	6	1	1

Source:

Data based upon 1990 Population Census. Reported data are not consistent between tables (See Table CH-2(90)).

CHIN-2(90)

Table 2. Scientists, Engineers, and Technicians, by Educational Attainment and Sex, for China: 1990*

Both Sexes

Occupations	Total	University	Post-Secondary Technical Vocational	Secondary Technical Vocational	High School	Junior High/ Middle	Primary	Illiterate or Semi-literate
SCIENTISTS, ENGINEERS, AND TECHNICIANS	7,377,288	1,300,561	1,246,445	1,581,683	1,300,357	1,541,263	392,166	14,813
SCIENTISTS AND ENGINEERS	3,909,395	792,118	759,500	867,329	741,666	647,599	99,286	1,897
SCIENTISTS	1,799,960	167,625	242,825	318,644	544,185	474,272	52,047	362
Sociologists	4,313	2,810	948	208	170	142	33	2
Economists	9,879	5,085	2,225	1,073	724	656	113	3
Economic Planners	399,162	34,927	90,337	86,398	87,909	87,725	11,811	55
Statisticians	1,193,249	18,973	120,574	196,655	442,346	375,800	38,686	215
Meteorologists, Seismologists	50,350	7,691	7,122	19,978	8,329	6,607	606	17
Natural Scientists	27,651	21,858	3,067	1,514	801	333	70	8
Industrial Scientists	61,253	42,960	9,856	5,593	1,648	1,020	165	11
Agricultural Researchers	30,180	17,989	4,544	4,870	1,175	1,208	374	20
Medical Researchers	16,403	10,937	2,686	1,682	574	382	114	28
Other Researchers	7,520	4,395	1,466	673	509	399	75	3
ENGINEERS	2,109,435	624,493	516,675	548,685	197,481	173,327	47,239	1,535
Urban Planners	47,836	12,763	12,111	12,422	6,336	3,566	613	25
Civil Engineers	604,723	129,369	131,717	159,529	84,472	77,297	21,831	508
Mechanical Engineers	838,704	272,162	235,750	208,800	57,439	51,661	12,721	171
Chemical Engineers	273,352	96,961	66,613	61,230	25,036	19,017	4,390	105
Metallurgical Engineers	92,862	39,265	22,795	18,761	5,657	4,898	1,453	33
Mining Engineers	112,124	27,354	21,488	40,113	8,871	9,131	4,567	600
Geological Engineers	139,834	46,619	26,201	47,830	9,670	7,757	1,664	93

CHIN-2(90)

Table 2. Scientists, Engineers, and Technicians by Educational Attainment and Sex, for China: 1990*–Continued

Both Sexes

Occupations	Total	University	Post-Secondary Technical Vocational	Secondary Technical Vocational	High School	Junior High/ Middle	Primary	Illiterate or Semi-literate
TECHNICIANS	3,467,893	508,443	486,945	714,354	558,691	893,664	292,880	12,916
Industrial Control Technicians	304,237	72,040	80,897	72,138	35,248	34,621	9,018	275
Surveying, Hydrological Tech.	90,701	13,395	13,909	31,162	15,394	14,313	2,471	57
Electric & Electronic Tech.	699,392	263,415	194,598	154,256	52,145	30,508	4,404	66
Light Industry, Textile Tech.	191,541	26,339	39,025	39,941	38,523	37,735	9,595	383
Food & Drink Technicians	62,200	10,318	11,292	14,527	9,975	11,810	4,023	255
Agricultural Technicians	402,092	43,748	46,962	138,096	61,125	80,774	29,843	1,544
Forestry Technicians	133,677	17,305	15,146	43,035	21,470	26,910	9,157	654
Other Eng. & Agri-Forestry Tech.	122,152	26,336	28,053	29,033	16,066	17,847	4,704	113
Scientific Technology Managers	23,836	10,240	6,091	4,328	1,684	1,233	253	7
Scientific Technology Assistants	55,083	9,167	10,285	8,693	13,383	10,791	2,496	268
Airplane Mechanical Technicians	4,656	588	690	1,286	1,431	585	72	4
Ship Turbine Technicians	50,962	1,713	2,091	5,840	6,846	18,790	14,511	1,171
Other Plane and Ship Technicians	7,408	1,674	1,161	1,320	1,046	1,287	848	72
Rural Medical Technicians	740,196	1,391	9,303	44,080	147,552	392,803	140,988	4,079
Other Health Technicians	362,323	9,048	25,103	119,106	87,642	101,732	18,500	1,192
Geological Surveyors	217,437	1,726	2,339	7,513	49,161	111,925	41,997	2,776

CHIN-2(90)

Table 2. Scientists, Engineers, and Technicians by Educational Attainment and Sex, for China: 1990--Continued*

Males

Occupations	Total	University	Post-Secondary Technical Vocational	Secondary Technical Vocational	High School	Junior High/ Middle	Primary	Illiterate or Semi-literate
SCIENTISTS, ENGINEERS, AND TECHNICIANS	2,327,473	305,716	377,782	503,564	534,241	1,034,495	311,664	9,915
SCIENTISTS AND ENGINEERS	2,511,113	612,987	525,079	583,602	363,724	346,428	77,696	1,597
SCIENTISTS	821,282	118,027	130,409	152,434	197,806	189,942	32,468	196
Sociologists	3,259	2,111	721	161	130	112	23	1
Economists	7,400	3,940	1,646	703	524	496	90	1
Economic Planners	277,020	25,664	63,437	57,356	57,421	62,975	10,129	38
Statisticians	401,275	9,928	45,556	72,182	132,062	120,131	21,296	120
Meteorologists, Seismologists	32,786	5,591	5,073	12,915	4,760	4,004	431	12
Natural Scientists	19,795	16,182	1,967	919	461	212	49	5
Industrial Scientists	44,046	32,315	6,353	3,462	1,028	743	136	9
Agricultural Researchers	21,268	12,741	3,159	3,559	781	804	218	6
Medical Researchers	9,133	6,376	1,493	739	290	193	38	4
Other Researchers	5,300	3,179	1,004	438	349	272	58	0
ENGINEERS	1,689,831	494,960	394,670	431,168	165,918	156,486	45,228	1,401
Urban Planners	36,716	9,802	8,915	9,327	5,018	3,077	562	15
Civil Engineers	506,556	103,042	102,474	129,800	75,779	73,591	21,408	462
Mechanical Engineers	667,048	220,087	180,096	161,588	47,032	45,936	12,162	147
Chemical Engineers	187,905	67,058	44,790	39,783	18,075	14,462	3,654	83
Metallurgical Engineers	72,898	31,264	17,418	14,220	4,418	4,190	1,357	31
Mining Engineers	100,981	24,028	19,194	35,948	8,106	8,611	4,501	593
Geological Engineers	117,727	39,679	21,783	40,502	7,490	6,619	1,584	70

CHIN-2(90)

Table 2. Scientists, Engineers, and Technicians by Educational Attainment and Sex, for China: 1990--Continued*

Males

Occupations	Total	University	Post-Secondary Technical Vocational	Secondary Technical Vocational	High School	Junior High/ Middle	Primary	Illiterate or Semi-literate
TECHNICIANS	2,552,704	381,858	343,584	494,517	402,392	688,067	233,968	8,318
Industrial Control Technicians	216,125	52,693	54,830	48,764	24,694	26,858	8,033	253
Surveying, Hydrological Tech.	74,760	11,053	11,202	25,539	12,406	12,225	2,284	51
Electric & Electronic Tech.	517,926	201,379	138,011	111,104	38,243	25,155	3,984	50
Light Industry, Textile Tech.	114,719	17,599	25,060	23,461	21,275	21,093	6,042	189
Food & Drink Technicians	43,661	7,070	7,850	10,116	6,955	8,371	3,114	185
Agricultural Technicians	332,298	33,713	36,713	110,649	52,727	70,806	26,631	1,059
Forestry Technicians	110,919	13,233	11,717	34,500	18,777	23,894	8,278	520
Other Eng. & Agri-Forestry Tech.	96,240	20,026	21,023	22,220	13,139	15,422	4,317	93
Scientific Technology Managers	17,340	7,691	4,263	2,955	1,225	982	221	3
Scientific Technology Assistants	25,166	5,666	5,001	3,653	4,894	4,504	1,324	124
Airplane Mechanical Technicians	4,298	503	611	1,216	1,354	550	61	3
Ship Turbine Technicians	50,233	1,650	2,053	5,796	6,805	18,651	14,199	1,079
Other Plane and Ship Technicians	6,704	1,454	1,002	1,188	947	1,212	829	72
Rural Medical Technicians	555,760	1,200	7,958	30,076	111,743	300,000	103,240	1,543
Other Health Technicians	182,973	5,384	14,291	56,575	43,315	52,887	10,076	445
Geological Surveyors	203,582	1,544	1,999	6,705	43,893	105,457	41,335	2,649

CHIN-2(90)

Table 2. Scientists, Engineers, and Technicians by Educational Attainment and Sex, for China: 1990--Continued*

Female

Occupations	Total	University	Post-Secondary Technical Vocational	Secondary Technical Vocational	High School	Junior High/ Middle	Primary	Illiterate or Semi-literate
SCIENTISTS, ENGINEERS, AND TECHNICIANS	2,313,471	305,716	377,782	503,564	534,241	506,768	80,502	4,898
SCIENTISTS AND ENGINEERS	1,398,282	179,131	234,421	283,727	377,942	301,171	21,590	300
SCIENTISTS	978,678	49,598	112,416	166,210	346,379	284,330	19,579	166
Sociologists	1,054	699	227	47	40	30	10	1
Economists	2,479	1,145	579	370	200	160	23	2
Economic Planners	122,142	9,263	26,900	29,042	30,488	24,750	1,682	17
Statisticians	791,974	9,045	75,018	124,473	310,284	255,669	17,390	95
Meteorologists, Seismologists	17,564	2,100	2,049	7,063	3,569	2,603	175	5
Natural Scientists	7,856	5,676	1,100	595	340	121	21	3
Industrial Scientists	17,207	10,645	3,503	2,131	620	277	29	2
Agricultural Researchers	8,912	5,248	1,385	1,311	394	404	156	14
Medical Researchers	7,270	4,561	1,193	943	284	189	76	24
Other Researchers	2,220	1,216	462	235	160	127	17	3
ENGINEERS	419,604	129,533	122,005	117,517	31,563	16,841	2,011	134
Urban Planners	11,120	2,961	3,196	3,095	1,318	489	51	10
Civil Engineers	98,167	26,327	29,243	29,729	8,693	3,706	423	46
Mechanical Engineers	171,656	52,075	55,654	47,212	10,407	5,725	559	24
Chemical Engineers	85,447	29,903	21,823	21,447	6,961	4,555	736	22
Metallurgical Engineers	19,964	8,001	5,377	4,541	1,239	708	96	2
Mining Engineers	11,143	3,326	2,294	4,165	765	520	66	7
Geological Engineers	22,107	6,940	4,418	7,328	2,180	1,138	80	23

CHIN-2(90)

Table 2. Scientists, Engineers, and Technicians by Educational Attainment and Sex, for China: 1990--Continued*

Female

Occupations	Total	University	Post-Secondary Technical Vocational	Secondary Technical Vocational	High School	Junior High/ Middle	Primary	Illiterate or Semi-literate
TECHNICIANS	915,189	126,585	143,361	219,837	156,299	205,597	58,912	4,598
Industrial Control Technicians	88,112	19,347	26,067	23,374	10,554	7,763	985	22
Surveying, Hydrological Tech.	15,941	2,342	2,707	5,623	2,988	2,088	187	6
Electric & Electronic Tech.	181,466	62,036	56,587	43,152	13,902	5,353	420	16
Light Industry, Textile Tech.	76,822	8,740	13,965	16,480	17,248	16,642	3,553	194
Food & Drink Technicians	18,539	3,248	3,442	4,411	3,020	3,439	909	70
Agricultural Technicians	69,794	10,035	10,249	27,447	8,398	9,968	3,212	485
Forestry Technicians	22,758	4,072	3,429	8,535	2,693	3,016	879	134
Other Eng. & Agri-Forestry Tech.	25,912	6,310	7,030	6,813	2,927	2,425	387	20
Scientific Technology Managers	6,496	2,549	1,828	1,373	459	251	32	4
Scientific Technology Assistants	29,917	3,501	5,284	5,040	8,489	6,287	1,172	144
Airplane Mechanical Technicians	358	85	79	70	77	35	11	1
Ship Turbine Technicians	729	63	38	44	41	139	312	92
Other Plane and Ship Technicians	704	220	159	132	99	75	19	0
Rural Medical Technicians	184,436	191	1,345	14,004	35,809	92,803	37,748	2,536
Other Health Technicians	179,350	3,664	10,812	62,531	44,327	48,845	8,424	747
Geological Surveyors	13,855	182	340	808	5,268	6,468	662	127

* Reported data may not match totals reported in Table 1.

Source:

"Tabulation of the 1990 Population Census of the People's Republic of China," Volume 2, pp. 728-771.

CHIN-3(95)

Table 3. Scientists, Engineers, and Technicians by Industry and Sex, for China: 1995*

Both Sexes

Total	5,104,300
Mining	407,200
Construction	55,800
Manufacturing	4,238,500
Utilities	281,100
Others	121,700

* Refers only to scientists, engineers, and technicians in independent accounting units at or above the township level.

Source: Editor, 1997, pp. 198-229.

CHIN-4(95)

Table 4.Scientists, Engineers, and Technicians by Manufacturing Industry, in China: 1995*

Both Sexes

Total	4,238,500
Food, Beverages, and Tobacco	368,200
Textiles and Apparel	477,200
Wood and Wood Products	77,600
Paper and Printing	143,800
Chemicals and Pharmaceuticals	740,800
Non-metal Minerals	426,600
Metallurgy	453,300
Machinery and Equipment	977,100
Electronic and Measuring Equipment	546,100
Miscellaneous Manufacturing	27,800

*Refers only to scientists, engineers, and technicians in independent accounting units at or above the township level.

Source: Editor, 1998, pp. 198-229.

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