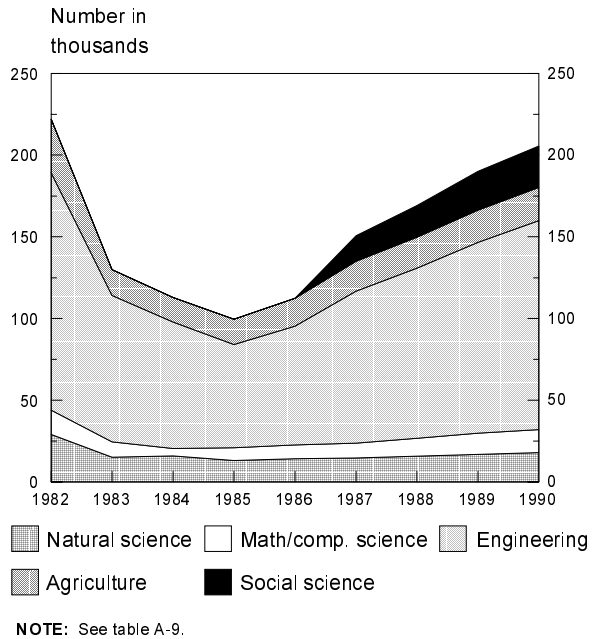
4. Human Resources by Country

Each of the six Asian countries studied for this report—China, India, Japan, Singapore, South Korea, and Taiwan—has a significant educational infrastructure and has invested heavily in its improvement to foster knowledge-based strategies for economic growth and to supply highly skilled human resources in science and engineering (S&E).

China

China's extensive research infrastructure and graduate training were greatly disrupted in the late 1950s, when scholars and researchers were told to learn from the masses during the Great Leap Forward, and when universities were used for "worker-peasant-soldier-scholars" during the Cultural Revolution of the 1960s. During this period, China tripled primary school enrollments and vastly increased enrollment in secondary schools. It was not until 1978, when Chinese Premier Deng Xiaoping announced that intellectual work is a form of labor and that education and scientific research are a form of production, that higher education was again legitimized. China reinstituted entrance exams and only the very best students have been admitted to Chinese universities since then. There are now more than 1,000 higher education institutes in China. Seventy of them provide 4-year university programs; 43 of them, the most sought after, are comprehensive universities.

Figure 19. Bachelor's degrees in S&E in China, by field: 1982-90



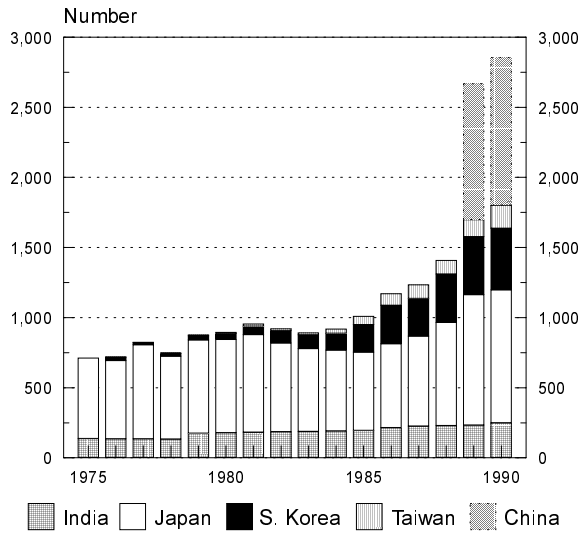
NOTE: See table A-9.

China is trying to upgrade the quality of its domestic higher education to meet high level labor requirements. In 1988, about 86 of the higher education institutes were designated as key point schools, singled out as centers of excellence for priority funding. The central government is financing 35,000 students for study abroad, while also increasing graduate programs to educate scientists and engineers within China so that fewer students have to leave.

Data that represent internationally comparable university degrees are available for China only for the years 1982–90. The very high number of graduates in 1982, the peak in the data in figure 19, reflects the flood of older students completing their degrees in reopened universities in the late 1970s. The number of students then declined and leveled off before beginning a steady increase starting in the mid-1980s.

China has the highest ratio of engineering degrees to total degrees (41 percent; see table A-12) in the Asian region, and produces more doctoral engineering degrees than Japan (see figure 20, for which there are

Figure 20. Doctoral degrees in engineering in selected Asian countries: 1975-90



NOTES: Only data for 1989 and 1990 were available for China.
See table A-11.

only 2 years of data for China).[10] China also has a strong commitment to basic science education, and produced more than twice as many bachelor's degrees in natural sciences as Japan.

India

India, like China, has a long tradition of scholarship and respect for knowledge. India's extensive university system, which has increased in enrollments by a factor of 20 since the country's independence in 1947, was first established during the colonial period. The first three universities created by the British administration were in Calcutta, Madras, and Bombay and several Indian scientists achieved worldwide distinction during the first half of this century. The first non-Western Nobel Laureate was an Indian, C.V. Raman, who received the prize for physics in 1931.

[10] China's educational statistics have doctoral degree data by field of science beginning in 1989.

Ten of India's top universities have 29 Centers of Advanced Study, including, along with those mentioned above, Banaras Hindu, Delhi, Punjab, and the Indian Institute of Science.

In postindependence India, as in China, science and engineering replaced civil service as the high prestige career. Government subsidies to higher education in science and engineering, parental urgings, and higher salaries attracted the best students to S&E fields.

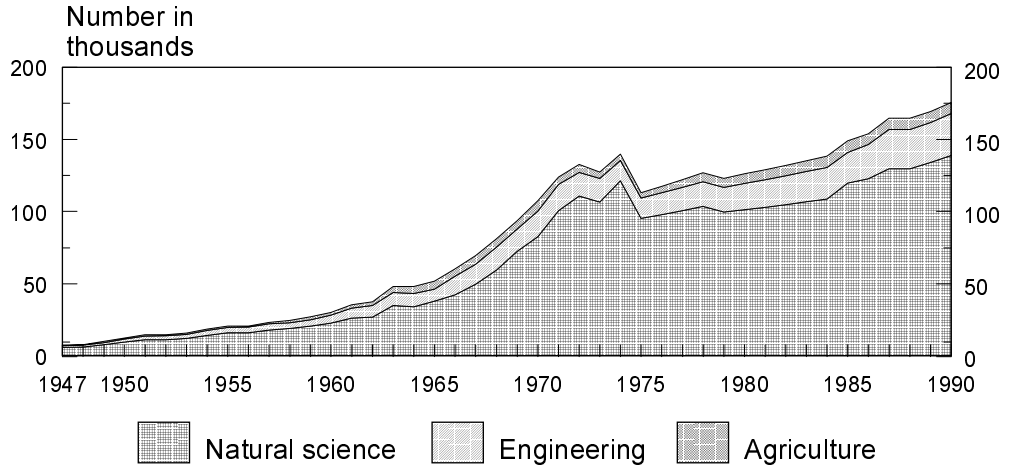
The steepest growth occurred in natural science degrees in the 1950s and 1960s; the great emphasis placed by India on natural science degrees can be seen in figure 21. This emphasis on fields of natural science has resulted in India's scientific strengths in high energy physics, plant biochemistry, solid state and inorganic chemistry, microelectronic materials, polymers, and ceramics (National Science Foundation 1987).

Indian Institutes of Technology (IITs), modeled after the Massachusetts Institute of Technology, were established in the 1950s in five major cities for the study of engineering and computer sciences. They are distinguished by their extreme selectivity; every year 100,000 students take a competitive exam for 2,000 seats at these Institutes. A large number of the IIT graduates continue their studies in the United States. For example, about 20 percent of Bombay IIT graduates immediately go abroad, but the proportion may be as high as 80 percent among computer science graduates (Maddox 1984). It is not known how many of those who obtain graduate degrees return to India with even better qualifications.

The Indian bachelor's degree data from 1975 to 1990 (figure 21) show that engineering degrees are growing faster than science degrees, but are still rather small in number. Of all university degrees, 20 percent are awarded in natural science and only 4 percent are awarded in engineering. There are almost 5,000 institutes of higher education (excluding junior colleges) for the arts and sciences and only 277 for engineering.

The dominance of India in the Asian region in natural sciences can also be seen in advanced degrees (figure 22), of which 4,600 are at the doctoral level.

Figure 21. Bachelor's degrees in S&E in India, by field: 1947-90



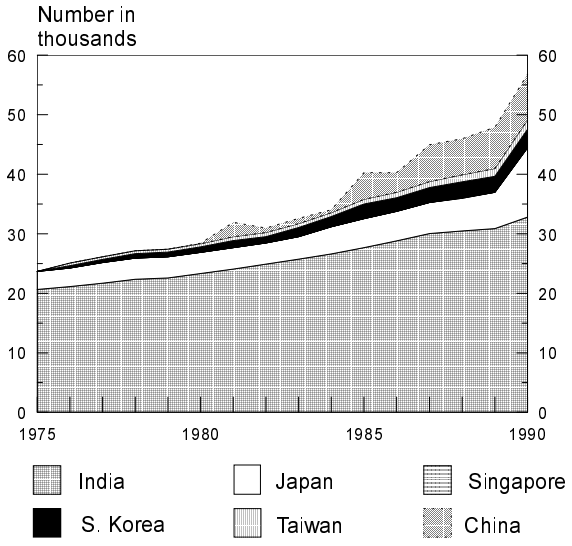
NOTES: India does not report social science degrees; math is included in natural science, computer science in engineering. See table A-9.

About one-third of the students in all levels of university education are female: 33 percent of science students in universities are female; 7.9 percent of engineering students are female (Government of India, Department of Science and Technology n.d.).

Japan

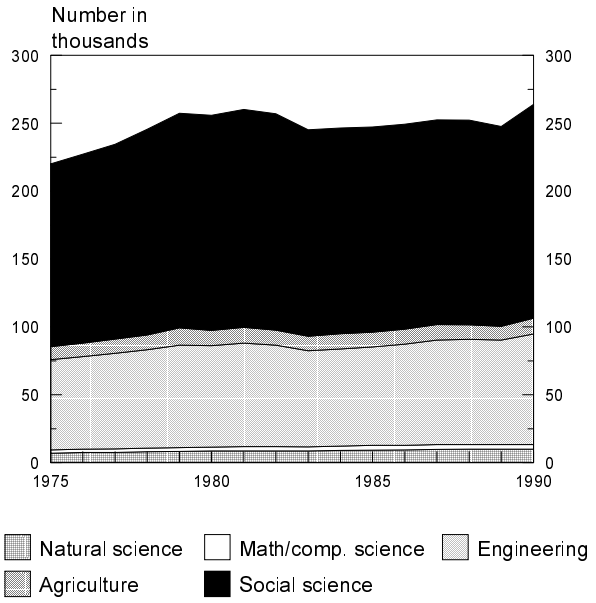
As with India, the brief period of the last 15 years does not cover the more dramatic increase in the number of S&E degrees in Japan. The sharp rise in Japanese enrollments and graduates in science and engineering occurred in the 1950s and 1960s. As part of the reconstruction after World War II, Japan made a concerted effort to increase the number of S&E degrees awarded and to double its gross national product. Over the past 10 years, Japan has educated approximately the same number of engineers annually and has slowly increased the number of natural science graduates. As figure 23 shows, Japan produces a quarter of a million S&E degrees each year, but with a very small base in natural science. The majority of S&E degrees are in engineering and social

Figure 22. Advanced degrees (master's and doctoral) in natural science in selected Asian countries: 1975-90



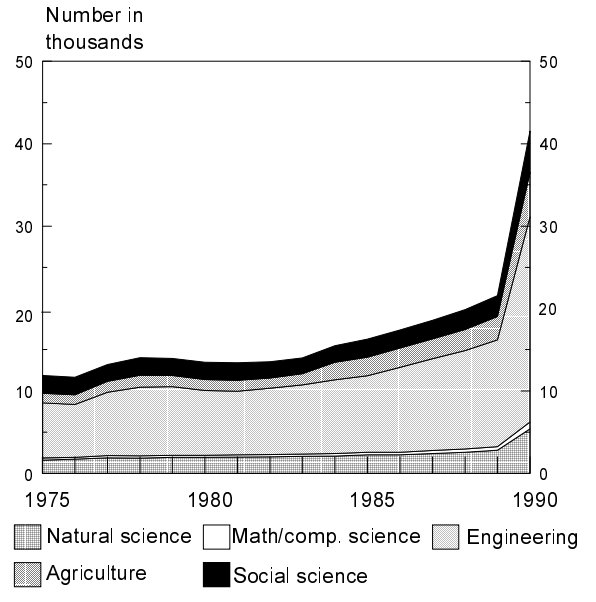
NOTES: Singapore is not visible because of relatively small number. See table A-10.

Figure 23. Bachelor's degrees in S&E in Japan, by field: 1975-90



NOTE: See table A-9.

Figure 24. Advanced degrees (master's and doctoral) in Japan, by field: 1975-90



NOTE: See table A-10.

science. (Business is included in social sciences in Japanese education data.)

Private schools, many at the junior college level, make up 70 percent of all higher education in Japan. The Government provides 20 percent of the cost of private schools and also funds 98 public universities. A small number of these public universities, the seven old imperial universities (including the Universities of Tokyo, Osaka, and Kyoto), are the most prestigious, with very competitive entrance examinations. Japanese private universities are very large, crowded, and far less well equipped than the public universities (Swinbacks 1991), so many Japanese students opt to study abroad. Sixty-one percent of the 30,000 Japanese students in the United States in 1990 were enrolled in an undergraduate degree program (Institute of International Education 1991a).

The participation of females in S&E degrees in Japan is higher in natural sciences than in engineering or social sciences. As in many other countries, female participation in engineering is low (see table 7).

Undergraduate engineering education in Japanese universities is very broad, to expose students to many fields, in contrast to U.S. engineering undergraduate programs, in which students receive more in-depth education in specialized fields. Japanese companies prefer to provide extensive in-house training to young engineers instead of hiring older students with master's or doctoral degrees from Japanese universities. Because advanced degrees have not conferred employment benefits on those who earn them, there have been relatively few advanced degrees in NS&E in Japan.

Recently, however, there has been growth in advanced S&E degrees (master's and doctorates) in Japan, as shown in figure 24.

With the goal of increasing basic research, Japan's science and technology policy statements call for a strengthening of Japan's graduate education, increased financial assistance, and research funds for doctoral students (Government of Japan, Cabinet Decision 1992).

One example of Japan's attempt to improve graduate education is the establishment of the Research Center

Table 7. Participation in S&E degrees in Japan, by sex: 1990

Field	Total	Male		Female	
		Number	Percentage	Number	Percentage
Natural science	25,153	20,221	80	4,932	20
Engineering	81,355	78,705	97	2,650	3
Natural science and engineering	106,508	98,926	93	7,582	7
Social science	157,477	138,958	88	18,519	12
Total all fields	400,103	381,584	73	109,750	27

SOURCE: Government of Japan, Ministry of Education, Science, and Culture 1990

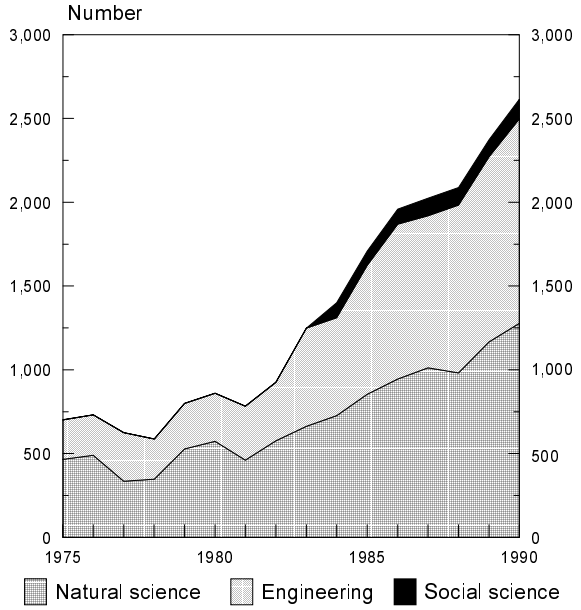
for Advanced Science and Technology at the University of Tokyo. The Tokyo Institute of Technology is also attracting foreign graduate students. Japan recruits the best engineering students from all over Asia and gives them scholarships for master's and doctoral programs at the University of Tokyo. Recruitment includes all the Indian Institutes of Technology, Chinese universities in Beijing and Shanghai, and universities in Pakistan, Bangladesh, Thailand, Indonesia, and Sri Lanka. Doctoral programs are given in English and the generous scholarships, available only to foreign students, are considered an investment. It is assumed that these graduates will serve as a bridge between the businesses of their countries and those of Japan. The Monbusho scholarships for doctoral programs add another 5 years after the doctorate for the foreign students to visit their major professor (Nishino 1992).

Singapore

Singapore has achieved remarkable economic growth because of its strategic emphasis on, and effective policies for, the development of human resources and supporting S&T infrastructure. In the 1960s, Singapore began to attract multinational corporations and embarked on a massive program in industrial training to upgrade the skill levels of workers and increase the supply of technicians and engineers. As the economy has developed, tertiary education has expanded through two polytechnics and the National University, emphasizing NS&E (see figure 25). In the 1990s, Singapore is emphasizing attracting high technology, knowledge-intensive industries and internationalizing its own local firms.

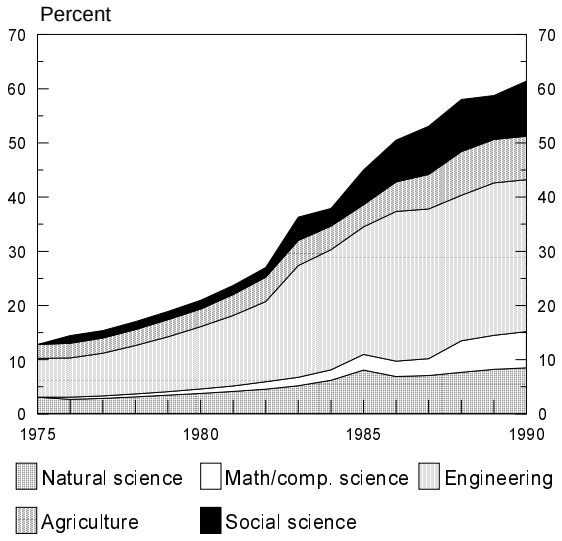
Singapore has invested heavily in the National University of Singapore to supply highly skilled scientists

Figure 25. Bachelor's degrees in S&E in Singapore, by field: 1975-90



NOTE: See table A-9.

Figure 26. Bachelor's degrees in S&E in South Korea, by field: 1975-90



NOTE: See table A-9.

and engineers. More than 32 percent of the State's research and development (R&D) is performed by the University and 40 percent of R&D personnel are there. In addition, Singapore has greatly expanded its overseas education program.

Gradually, Singapore has phased out labor-intensive industry through a high-wage policy. In recent years, the training has shifted to produce a highly specialized professional labor force, especially in the information–technology-related industry. Singapore's graduate education has expanded programs in systems science, microelectronics, advanced computer communications, and computer-integrated manufacturing.

South Korea

South Korea, like many countries in Asia, has aspired to promote coherent and self-sustained development through education. It emphasizes S&E education through special scholarships, exemption from military service, and rewarding employment. The Government's decision to double admissions quotas in 1980 was an attempt to keep up with industry's demand for engineers, computer scientists, and other specialists. New local area colleges had to be added to existing universities to ease the strain on laboratories and computer facilities. Figure 26 shows the fivefold increase in S&E degrees over the last 15 years.

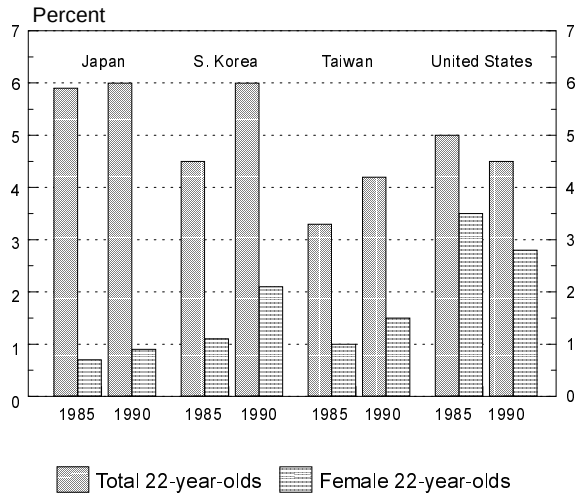
The most prestigious South Korean universities are those that survived the Japanese occupation of 1905-45. Science and engineering graduates from these universities are preferred by major industries. The Korean Advanced Institute of Science and Technology (KAIST) was established to identify gifted students in science, increase support for postgraduate training locally, and strengthen research capacity. KAIST, along with the Ministry of Science and Technology, runs an undergraduate institute for talented students who win national science scholarships. The Government is again considering doubling enrollments in engineering departments. The current S&T policy

Table 8. Participation in S&E degrees in South Korea, by sex: 1990

Field	Total	Male		Female	
		Number	Percentage	Number	Percentage
Natural science	23,195	15,953	69	7,242	31
Engineering	28,071	26,763	95	1,308	5
Natural science and engineering	51,266	42,716	83	8,550	17
Social science	10,211	7,579	74	2,632	26
Total, all fields	165,916	104,627	63	61,289	37

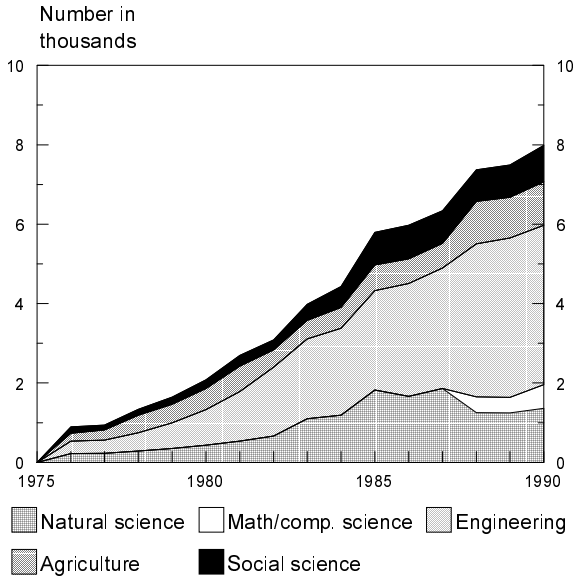
SOURCE: Government of the Republic of Korea, Ministry of Education 1990

Figure 27. Percentage of 22-year-olds with natural science and engineering degrees in selected Asian countries, and the U.S., by total and female population: 1985 and 1990



NOTE: See table A-13.

Figure 28. Advanced degrees (master's and doctoral) in South Korea, by field: 1975-90



NOTE: See table A-10.

states that university advanced degrees will be linked with industrial demands through joint research projects.

In South Korea, women receive almost one third of all bachelor degrees in the natural sciences and over one fourth of the social science degrees (see table 8).

Overall, South Korea has the highest participation of females in natural science and engineering degrees among the three Asian countries shown in figure 27. Although female participation improved slightly in these Asian countries between 1985 and 1990, both female and total 22-year-old participation in NS&E degrees declined in the United States.

South Korean graduate education is expanding rapidly to overcome the shortage of high-level personnel trained beyond the bachelor's level. Whereas there were only 800 master's and doctorate recipients from NS&E faculties in 1976, by 1990 there were 8,000, with 900 doctoral degrees (see figure 28).

To further upgrade the labor force, the Government is expanding programs to send students abroad. The Korean Science and Engineering Foundation has an enlarged scholarship program to allow some 10,000 S&E students to receive postdoctoral training abroad by the year 2000. Expatriate scientists and engineers are returning as salaries and living and working conditions improve in South Korea.

Taiwan

Taiwan, like South Korea, controls enrollments in higher education and emphasizes engineering (33 percent of all university students). Its expansion of S&E education over the last 15 years is shown in figure 29.

There are limited opportunities for graduate study in Taiwan, so students mainly study abroad for advanced degrees. The United States provides approximately 77 percent of Taiwan's doctoral degrees in natural science and engineering.

Female participation in NS&E degrees in higher education in Taiwan has gone from 1 to 1.5 percent of

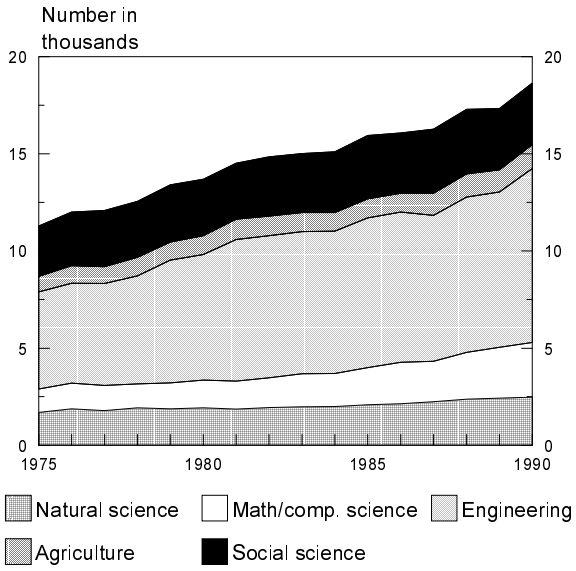
Table 9. Participation in S&E degrees in Taiwan, by sex: 1990

Field	Total	Male		Female	
		Number	Percentage	Number	Percentage
Natural science	6,533	4,723	72	1,810	28
Engineering	8,950	8,110	91	840	09
Natural science and engineering	15,483	12,833	83	2,650	17
Social science	3,174	1,167	37	2,007	63
Total, all fields	49,136	23,556	61	19,396	39

SOURCE: Government of the Republic of China, Ministry of Education 1990

the 22-year-old female population in the last 5 years (figure 27). Of the university degrees in natural sciences, 28 percent are awarded to women (see table 9).

Figure 29. Bachelor's degrees in S&E in Taiwan, by field: 1975-90



NOTE: See table A-9.