7. Prospects for the Future

Will the production of scientists and engineers in the six Asian countries studied be sufficient to meet future needs of this dynamic world region? How this question is answered will be important for scientific, technological, and educational policies of these countries and will have consequences for related policies in other regions of the world, such as the effect on supply in countries that depend on immigration of scientists and engineers from these regions.

Many Asian countries are concerned about the adequacy of their supply of scientists and engineers. The following section discusses assessments of the scientific workforce from the perspective of the countries in the region. It also discusses some of the policies and programs being put into place in these countries in order to address their perceived demand for scientists and engineers.

Japan has been concerned about an adequate supply of scientists and engineers because of the decline in the number of 20- to 24-year-olds. The Japan Science and Technology Agency (STA) has been trying to estimate future supply and demand for numbers of research scientists and engineers (RSEs). In one initial study it commissioned, a simple regression model was used to estimate demand as a function of real gross domestic product (GDP) and supply as a function of the population of the labor force (Nagata n.d.).[13]

The methodology of the above study utilizes various projections of GDP and the size of the labor force for future years. Using this simple regression, future estimates for the demand for RSEs were computed to present two possible demand and supply scenarios, one for continued GDP growth of 4 percent, and one for a lower GDP growth of 3 percent. Under both of these scenarios, there appeared to be a problem in meeting the necessary supply.

Although a precise estimate for demand is difficult to determine, Japan is already implementing policies to avoid a possible gap in supply and demand for RSE. Japan's new science and technology (S&T) policy calls for simplifying administrative work so that researchers can concentrate more on R&D, encouraging female participation, and allowing the elderly to continue working.

A key part of this policy is to attract researchers from all over the world and intensify cooperation in cultivating human resources with countries in the Pacific Rim (Government of Japan, Cabinet Decision 1992). Japan is also expanding employment and fellowships for foreign researchers. *Science* magazine recently reported that about one-third of the graduate students in Japanese university laboratories are Chinese (Myers 1992) and, in 1991, 40 percent of all of Japan's doctoral students in engineering came from overseas.

Singapore, South Korea, and Taiwan also report projected labor shortages in 1992 (Low 1992). With greater prospects of direct foreign investment flowing across the Pacific Rim, there will be higher demand for scientists and engineers as well as for administrative and managerial personnel.

Singapore faces a labor shortage at all skill levels. Foreign workers allowed into the service sector number 200,000–250,000, or about 15 percent of the total labor force. Singapore's drive toward restructuring the economy to high technology exports has required tapping skilled labor from South Korea,

[13] This is only one approach used in Japan's analysis of future science and engineering labor markets. The Japanese Government is planning a major new study to determine the current and future supply of scientists and engineers in its labor force.

Taiwan, Hong Kong, and China. Singapore has been successful in recruiting 60 doctorate holders from China for new research institutes in its science park (Wong 1992), but still lacks the critical mass of trained doctorate recipients to do original research.

South Korea has a labor shortage in highly skilled workers and technicians and a decline in the size of the absolute labor force. In Taiwan, the service sector has become the main employment sector, increasing the need for professional and technical workers (Low 1992). These countries, like Japan, are implementing policies to avert a lack of RSEs in the 1990s. South Korea is rapidly expanding graduate education to overcome the shortage of high-level personnel trained beyond the bachelor's level. To further upgrade the labor force, the Korean Government is expanding programs to send students abroad. The Korean Science and Engineering Foundation (KOSEF) has an enlarged scholarship program to allow some 10,000 science and engineering (S&E) students to receive postdoctoral training abroad by the year 2000.

In addition, the Government has attracted Korean scientists and engineers who had been living abroad back to South Korea, as salaries and living and working conditions have improved. In the late 1960s, South Korea recruited 300 experienced and new doctorate holders with very attractive positions and salaries in a Battelle-type research institute, the Korea Institute of Science and Technology (KIST). Five years later, a similar recruitment successfully brought back 300 S&T personnel to be faculty in the Korean Advanced Institute of Science and Technology (KAIST). In the late 1980s, POSEK, an S&T institute modeled after the Massachusetts Institute of Technology, convinced 200 Koreans with doctorates working in the United States to come back. POSEK is the second most prestigious teaching institute after the Seoul National University (Hong 1992).

Taiwan makes a concerted effort to attract back S&T personnel educated in the United States. Its Manpower Planning Department assesses required manpower with advanced degrees for strategic industries, plans for recruitment from abroad, and designs the expansion of S&T university education in Taiwan. The pay scale for high-level experts is made attractive and the equipment and research environments of S&T departments at universities are improved. During the period 1976–91, the number of S&T returnees registered by the Government's Youth Employment Service Agency increased from 393 to 1,157. A far greater number return for employment without the assistance of this agency. National Conferences on Science and Technology are often held in Taiwan to establish channels of communication with overseas scholars so they can be recruited more easily when their services are needed. The National Six Year Plan for S&T Development 1991–1996 includes a Project for the Development, Recruiting, and Utilization of S&T Human Resources. The Plan also calls for 25 new universities to increase S&T higher education, expand graduate education, and improve S&T instructors at all levels of education (Chang 1992, p. 8).

China's Ministry of Personnel has a 10-year program for developing human resources for an export-oriented economy in coastal and river areas. One such area, the city of Shanghai, has 30,000 S&T personnel, but estimates a need of 90,000 by 1995 (Shengyun 1992). One obstacle to China's export-oriented economic development is the severe lack of qualified personnel with the required knowledge and technical ability. To overcome this, China will strengthen on-the-job training, greatly expand special fields of study, and encourage the return home of students studying abroad.

Given its very high production of natural science doctorates, India will have many more graduates than could be hired by its research community. If China and India are able to maintain their level of production of S&E graduates in the next several years, they may be able to provide the research personnel in demand in other Asian countries in the next decade. The difficulty for China will be to continue producing more scientists and engineers for rapid economic development while moving slowly in the political arena. Although waves of reform have allowed goods and capital to move relatively freely around China, labor does not follow the rules of the market, but rather the rules of the state bureaucracy. "[F]or the most part, people still need formal permission to move from place to place" (Survey of China 1992, p. 8).

Needs for Further Research

More research must be performed in each of the areas covered in this report to develop a complete analysis of the S&T human resources situation in the Asian region. For example, more data are needed on China's stock of S&E personnel, as well as on China's quantitative accomplishments in strengthening S&T education for economic development and its technically qualified cadre of young professionals. Attention should be given to the interrelationships between Asian S&T capacity and higher education training in other countries, especially the United States. How big a role do Asian-born U.S.-trained scientists who are working in the United States play in Asian S&T development? Further study should also explore mobility among these Asian countries and throughout the world for graduate degrees in S&E and research employment in industry, government institutes, and universities. In 1991, Japan received 41,000 students from the Asian region for university and advanced education, the United States about 230,000. Further research is needed on how Japan is changing to make its universities accessible and to transfer technology and engage in cooperative technology development. The extent to which Japan will look to China, India, and Russia for tapping the S&E pool has implications for the supply to the United States and the producing countries.

The effect of contact of S&E personnel from China and India with the smaller dynamic Asian economies in getting research activities out of government research institutes and into industrial enterprises should also be studied. In particular, interaction between mainland China and Asia's newly industrialized economies (NIEs) with linguistic and cultural similarities (Singapore, Hong Kong, Taiwan, and Malaysia) should be studied to see how the NIEs' knowledge of markets, contribution of venture capital, and managerial talent will facilitate China's manufacturing, financial, and marketing capabilities.

More research is needed on the factors contributing to economic growth in the region including the effects of various national strategies for economic growth, e.g., policies toward foreign direct investment and import substitution. Of particular interest to Western countries is to examine the path of open markets taken by some Asian economies (Hong Kong, Taiwan, Singapore, South Korea, and recently India). More work is needed on developing the methodologies and data necessary for estimating supply and demand for scientists and engineers in all countries.

Since many S&T initiatives in Asian nations are similar (e.g., information industry, advanced materials, biotechnology), the particular scientific strengths and the research niche of each country should be assessed in regional and international scientific workshops. Scientists and engineers should identify opportunities for increased collaboration with the United States and with each other that would blend strengths in both research and product development.

Implications for the United States

The following conclusions can be drawn from this study:

- The six Asian countries studied will continue to use the U.S. higher education system. The sharp jump in the value of Asian currencies relative to the dollar has greatly increased the number of Asian students with the financial capacity to study in the United States, and will continue to do so. The countries' continued expansion of graduate education in science and engineering does not decrease their need for overseas study. China has begun a "self-reliant" effort to educate doctoral students within China, possibly because the majority educated in the United States remain here (see table 10). However, the need for foreign and domestic education grows together (Cummings n.d.). These Asian countries cannot meet the demand for quality higher education fast enough nor can they staff new or expanded domestic institutions without relying on graduate training abroad, often in the United States.

- Foreign graduate student enrollment in U.S. universities and preference for natural science and engineering (NS&E) degrees will help to maintain U.S. doctoral programs' emphasis in these subjects. Doctoral programs in S&E fields in the United States have grown relatively faster than in non-S&E fields. Between 1975 and 1990, the ratio of NS&E degrees to total doctoral degrees in the United States increased from 35 to 45 percent. Since Asian foreign graduate students come mainly for science and engineering fields, they are and will continue to be an integral part of U.S. universities' S&E strengths.

- These Asian countries will begin to challenge the United States for the S&T personnel educated in U.S. universities for their own high technology economies. Asians have accounted for more than half of all scientists and engineers immigrating to the United States between 1970 and 1985 and were still over half in 1988 (National Science Foundation 1986 and 1990). In 1988, about 3,600 Asian scientists and engineers were certified for entry visas (including temporary visas) by the U.S. Department of Labor; twice as many may receive entry by relatives rather than by certification and eventually work as scientists and engineers in the U.S. labor force. In 1991, more than 2,600 new Asian doctorate holders in S&E from U.S. universities planned to stay in the United States (see table 10).

  However, since the Asian region will be an economically and scientifically important area needing S&E personnel, these Asian countries will be increasingly attractive to their students who have academic and industrial experience in the United States (Pedersen n.d.). Taiwan and South Korea have been particularly successful in attracting their students to return, offering large incentives to start companies in critical technologies. (Table 10 shows the decreasing percentage of Taiwanese and Koreans who plan to stay in the United States.)

- Continued linkage with Asian scientists and engineers trained in the United States through international S&T collaboration would foster a free flow of RSE personnel between the East and West. U.S.-trained Asian scientists and engineers are our natural counterparts in international collaboration.[14]

[14] For areas of scientific excellence in Asia, see the quarterly publication *Scientific Information Bulletin* of the Office of Naval Research, Asian Office, Unit 45002, APO AP 96337-007. The Tokyo Office of the National Science Foundation has reports available on STIS, NSF's on-line Science and Technology Information System.

Table 10. Asian doctoral recipients in natural science and engineering from U.S. universities who plan to stay in the United States: 1980, 1990, and 1991

Country	Total [1]	Plan to stay [2]		Firm plans to stay [3]	
		Number	Percentage	Number	Percentage
1980					
China [4]	280	157	56.1	131	46.8
India	339	248	73.2	201	59.3
Japan	47	19	40.4	13	27.7
South Korea	87	51	58.6	44	50.6
Taiwan	399	255	63.9	214	53.6
Total	1,152	730	63.4	603	52.3
1990					
China	964	585	60.7	413	42.8
India	630	430	68.3	341	54.1
Japan	75	36	48.0	29	38.7
South Korea	766	271	35.4	200	26.1
Taiwan	931	428	46.0	287	30.8
Total	3,366	1,750	52.0	1,270	37.7
1991					
China	1,520	1,265	83.2	778	51.2
India	633	496	78.4	364	57.5
Japan	73	32	43.8	23	31.5
South Korea	827	334	40.4	209	25.3
Taiwan	981	539	54.9	313	31.9
Total	4,034	2,666	66.1	1,687	41.8

(1) Total doctoral recipients in natural science and engineering
(2) Doctoral recipients who think they will locate in the United States
(3) Doctoral recipients who have postdoctoral research appointments or academic, industrial, or other firm employment in the United States
(4) China data are for 1987, the earliest year for which data are available.

SOURCE: National Research Council 1992