5. Research and Development by Country

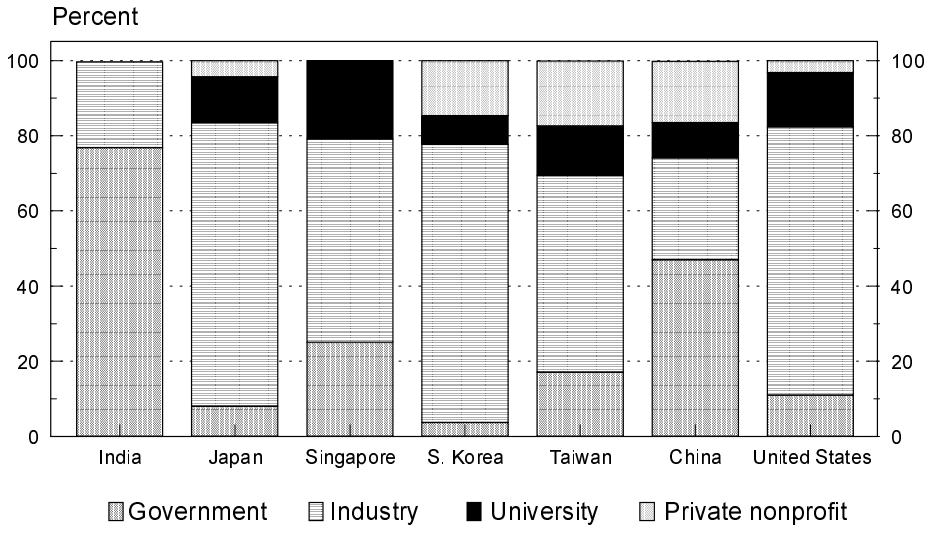
Indigenous capabilities for original research and development (R&D) are central to the industrial restructuring of the Asian developing countries to more knowledge-based industries and high technology production. The performance of R&D in the Asian region is concentrated in Government and industrial laboratories. Figure 30 shows that South Korea and Taiwan have a similar pattern to each other of a large industrial research sector and significant participation of nonprofit institutes in research. China and India are similar in having a large Government research sector. A significant consequence of educational reform in China over the last 10 years is that universities have begun to do research. India does not yet survey universities in its biennial R&D survey, but university-based R&D is estimated to represent about 2 to 3 percent of India's overall research. U.S. universities performed two times more research than the universities of all six Asian countries combined—$20 billion compared with $9.6 billion in 1990 (see table A-18).

China

In 1990 China spent 12.6 billion yuan in overall R&D (in current yuan), equivalent to $21.4 billion. Of this total, the Government financed more than half and "enterprises" financed the rest, as shown in figure 31. Enterprises include large state-owned industry, as well as local, collectively owned businesses and small private enterprises in economic zones.[11] China's reform policies have made a very significant attempt to change the R&D structure and have put a burden

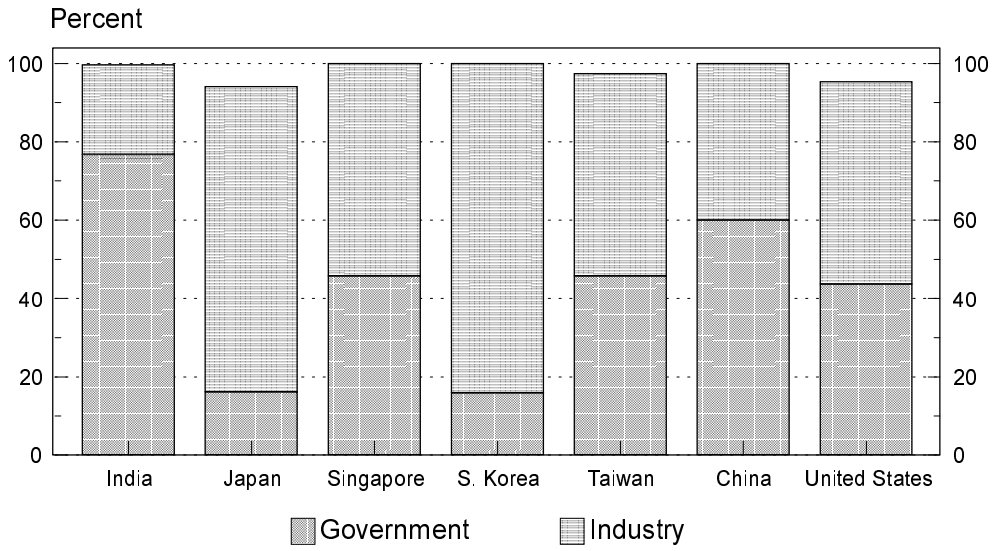
[11] This follows international standards for R&D reporting.

Figure 30. R&D in selected Asian countries and the U.S., by performer: 1990



NOTE: See table A-18.

Figure 31. R&D in selected Asian countries and the U.S., by source of funds: 1990



NOTES: In India, Government includes national industry. In China, industry includes public enterprises. See table A-17.

on industry to spend more; R&D enterprise spending grew remarkably during the 1980s. The non-State enterprise sector is the more dynamic, accounting for most of the increases in R&D. The proportion of Government as a source of funds would be even greater if research support by public industries could be disaggregated from enterprises and counted as Government spending.

China's science policy reforms have also required the large research infrastructure of the Chinese Academy of Science (CAS) to contribute to economic competitiveness. With large Government budget cuts, the CAS has been encouraged to enter cooperative ventures with domestic industry as well as with industries in Hong Kong, Singapore, and Taiwan (Suttmeier 1990a).

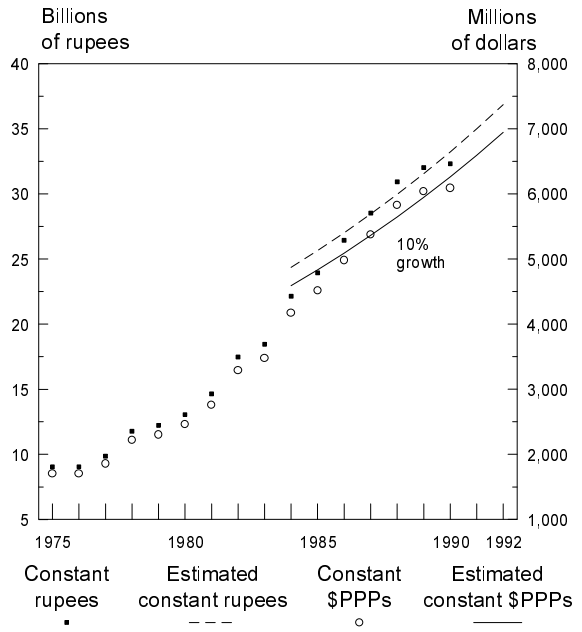
India

India built up a strong Government-dominated, broad-based science infrastructure over many years. The preindependence centers of excellence include the Tata Institute for Fundamental Research in Bombay, the Indian Institute of Science in Bangalore, and the Indian Statistical Institute in Calcutta. In the early 1900s India established advanced medical and agricultural research institutes. Since independence, India has established research centers under the Department of Atomic Energy and 36 national laboratories under the Council for Scientific and Industrial Research (CSIR) outside the university system. More recently, the Department of Space and the Ministry of Biotechnology have established several strong research centers.

India's overall R&D annual investment grew from 3 to 41 billion rupees (in current national currency) over the period 1975–90. In constant dollars, this investment grew from $1.7 to $6 billion.

In 1991, India was not able to continue the previous 10 percent growth rate in R&D (see figure 32). To control the Government's large fiscal deficit, austerity measures were introduced in 1991 which squeezed credit and suppressed growth. Gross domestic product (GDP) growth was only 2 percent; R&D decreased in 1991. India's 36 national labs under CSIR are being asked to help national industries compete globally. More of their funding will have to come from private industry contracts to develop technologies. Whereas

Figure 32. Growth in R&D in India: 1975-92



NOTE: See table A-16.

previously CSIR labs were isolated from industry, they now have a technology transfer mission. Currently, R&D expenditure by private industry is only about 5 percent of the nation's total R&D, the smallest percentage in Asia.

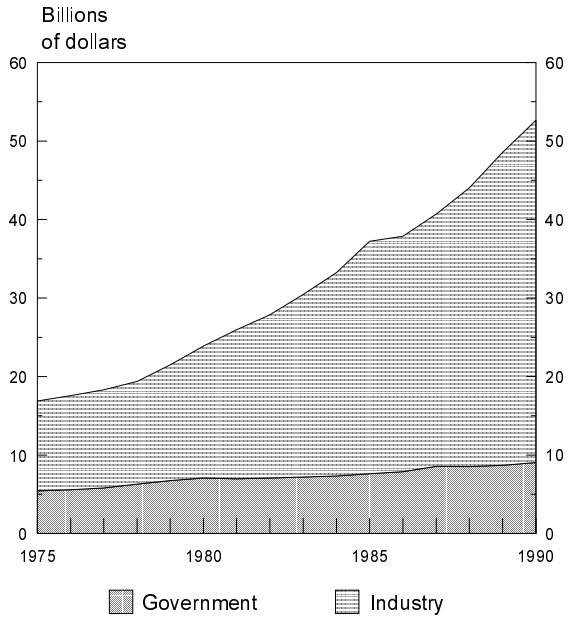
Japan

Japanese R&D is mainly supported by industry. The Japanese Government primarily supports the 16 well-equipped research institutes under the Agency of Industrial Science and Technology. The Japanese White Paper for 1991 states that the Government will double its investment in R&D in the next 5 to 10 years to expand basic research in order to advance knowledge, do ground-breaking research, and create its own technologies (Government of Japan, Science and Technology Agency 1991b).

Japanese White Papers on Science and Technology during the last 20 years have discussed the importance to Japan of increasing the support of basic research. The 1972 White Paper reviewed the accomplishments that had been made through the support of quality engineering and a high ratio of R&D investment targeted at securing competitiveness (Government of Japan, Science and Technology Agency 1972). It was rightly reasoned then that Japan had reached a stage of development in which off-the-shelf technologies were no longer sufficient to meet the challenges of environmental quality and other basic research needs. The Government did increase its support of basic research, but industry also increased its research tremendously; the Government's portion of support has therefore declined over the 15-year period, as shown in figure 33.

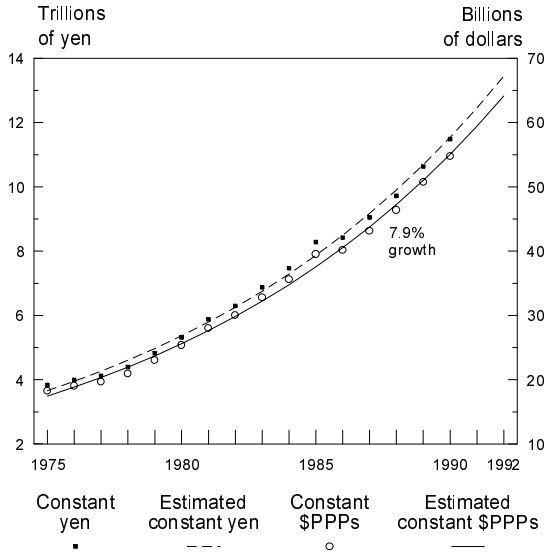
The recently revised science and technology (S&T) policy states: "Progress in basic research is not as great as had been expected" (Government of Japan, Cabinet Decision 1992, p. 5). Further, it states that Japan will now systematically renew the obsolete facilities and equipment of universities and install facilities for conducting leading and advanced research at universities and centers of excellence. Increasing

Figure 33. R&D in Japan, by source of funds: 1975-90



NOTE: See table A-17.

Figure 34. Growth in R&D in Japan: 1975-92



NOTE: See table A-16.

basic research in Japan is no longer stated as important, but rather as urgent.[12]

Japan's overall R&D investment went from 2.7 to 12 trillion yen (current currency) between 1975 and 1990. In constant dollars, this is equivalent to an investment growth from $18 to $56 billion, almost all of it in civilian research. If Japan's R&D expenditure continues this growth rate of 7.9 percent, by 1992 Japan will be spending nearly $64 billion, as shown in figure 34.

Japan's industrially funded R&D has grown faster than overall R&D. If Japan continues its 9.9 percent growth rate in industrially funded R&D, that sector will be 77 percent of that of the United States in 1992 ($52 billion versus $67 billion), as shown in figure 35.

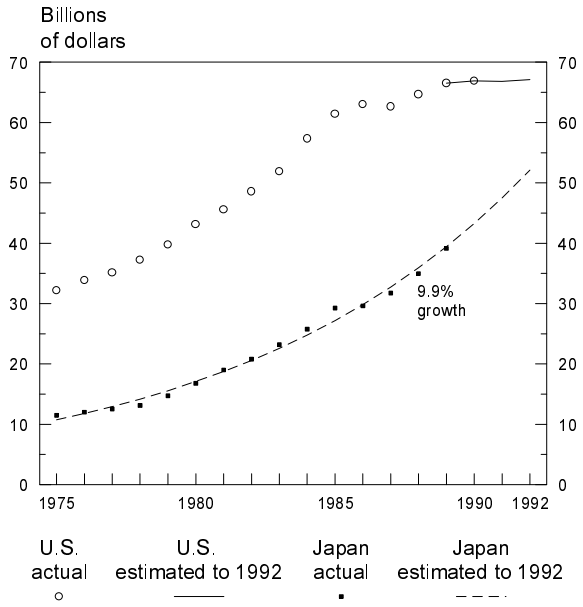
Singapore

Singapore's significance to science and engineering resources in the Asian region has not been in R&D but in its location, services, information and communication infrastructure, and skilled personnel to support multinational corporations. Singapore has developed its technology absorption capability well and now wants to develop its technology creation capability. Interest in R&D to enhance innovation is only very recent.

Singapore's institutional structure for S&T policy, the Singapore Science Council, was revamped in 1991 to become the National Science and Technology Board under the Ministry of Trade and Industry. The National Science and Technology Board sponsors R&D aimed at specific products. To reposition itself as a highly specialized economy, Singapore is setting up several research institutes: the Information Technology Institute, the Institute for Cellular and Molecular Biology, and the Institute for Manufacturing Technologies.

Government support of R&D has risen dramatically to increase the nation's innovative capacity. Multinationals have set up research facilities and initiated joint R&D projects. In addition, Singapore would like to

Figure 35. Industrially funded R&D in the U.S. and Japan: 1975-92



NOTE: See table A-17.

[12] A recent issue of *Nature* (Swinbacks 1992) summarizes the concrete steps that would have to be taken to improve and increase basic research in Japan.

attract overseas talent to the R&D laboratories built in its new Science Park.

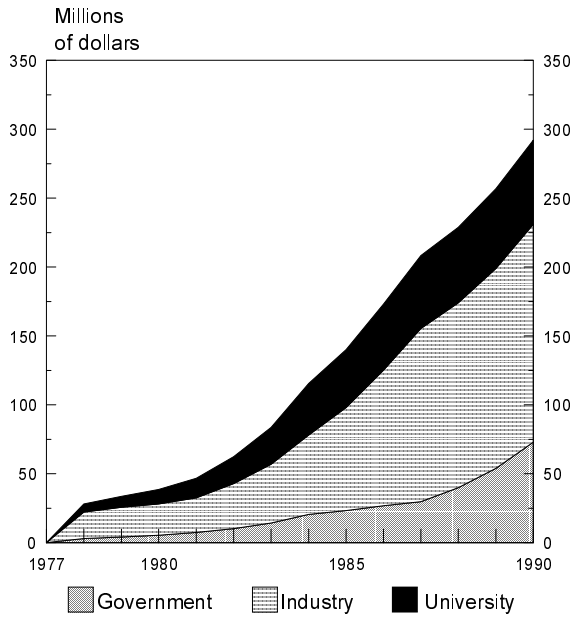
Performance by sector over the last 15 years is shown in figure 36. The private sector accounted for about 60 percent of R&D expenditures in 1989, the bulk of it in the electronics industry, with multinational corporations predominating. Singapore's industrially funded R&D is growing at 25.6 percent annually, equivalent to $158 million in 1990.

Singapore's overall R&D investment went from 38 to 638 million Singapore dollars over a 10-year period. In $PPPs, this is an investment growth from $28 to $292 million. There is a very high growth rate, averaging 20 percent annually between 1975 and 1992, but from a very insignificant R&D base, as shown in figure 37.

South Korea

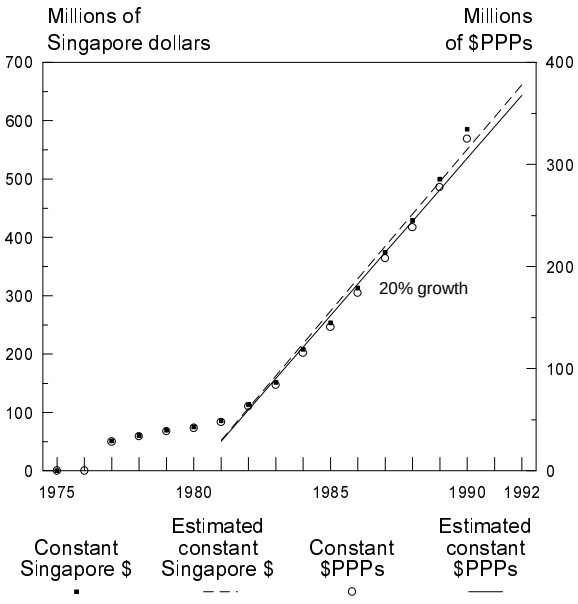
The South Korean Government has, since 1966, supported applied research through a major research and development center, the Korea Institute of Science and Technology (KIST). The Ministry of Science and Technology, established in 1967, has carried out a national R&D program since 1982 to develop long-term, large-scale high technologies that are essential for improving South Korea's comparative advantage in international trade. The program is performed through joint participation of industries, universities, and Government-funded research institutes. The Korean Science and Engineering Foundation, KOSEF, modeled after the National Science Foundation (NSF), supports basic research. Like NSF, South Korea is establishing Science Research Centers and Engineering Research Centers at universities around the country for the common utilization of advanced R&D facilities. The Daeduk Science Town, 150 kilometers south of Seoul, has 50 research institutes and shared facilities. South Korea also strives for regional distribution of research facilities and has established several smaller R&D complexes: genetic engineering in the center (Suweon), new materials in the southeast (Ulsan), and fine chemistry and precision machinery in the southwest (Hanam).

Figure 36. R&D in Singapore, by performer: 1977-90



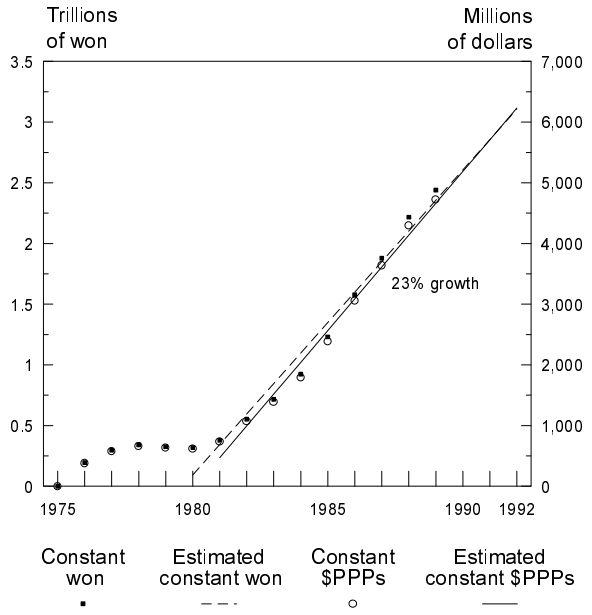
NOTE: See table A-18.

Figure 37. Growth in R&D in Singapore: 1975-92



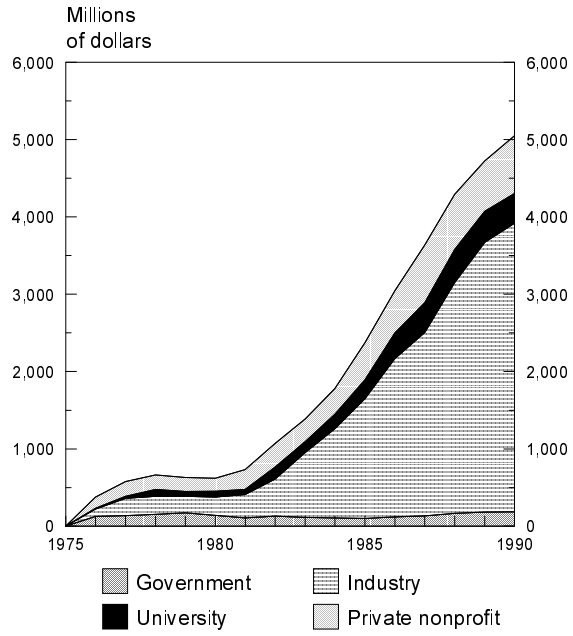
NOTE: See table A-16.

Figure 38. Growth in R&D in South Korea: 1975-92



NOTE: See table A-16.

Figure 39. R&D in South Korea, by performer: 1975-90



NOTE: See table A-18.

South Korea's overall R&D investment went from 60 billion to 3.2 trillion won over the period 1975–90. In dollars, this is equivalent to an investment growth from $378 million in 1976 to $5 billion in 1990. The average annual growth rate in R&D expenditures was around 23 percent over the 15-year period, as shown in figure 38.

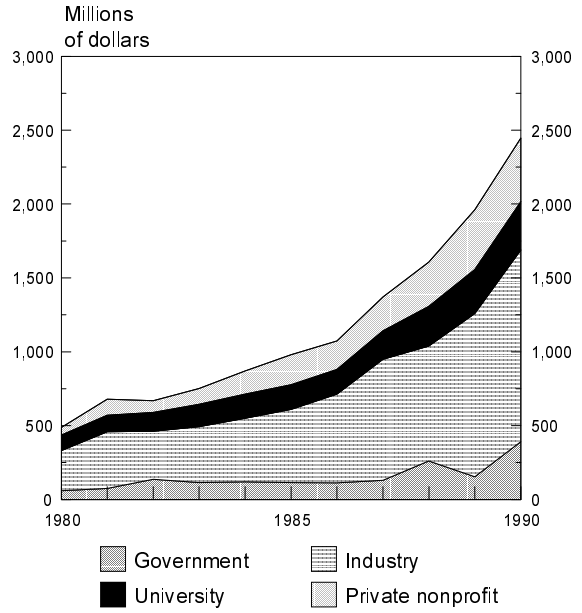
As in Japan, industrially funded R&D in South Korea is growing faster than overall R&D. South Korea went from an annual investment of $133 million in 1976 to an annual investment of $4.2 billion in 1990. This is an average annual growth of 26.2 percent. At this rate of growth, the annual expenditures would reach $5.2 billion in 1992, one-tenth of Japan's industrially supported R&D. South Korean firms have shown an ability to adapt foreign technologies, acquired through licensing agreements, to their production requirements. This would not have been possible without their R&D capability. Half of the approximately 1,000 research institutions in South Korea are in private industry and half of these are heavily concentrated in the 10 largest *chaebol* (industrial conglomerates), particularly the electronics and chemical industries. The growth in industrially performed R&D is shown in figure 39.

Taiwan

Relative to South Korea and Japan, Taiwan's smaller business enterprises do not invest heavily in R&D. They do, however, join forces to conduct combined research for innovative products. Figure 40 shows Taiwan's R&D by sector of performance.

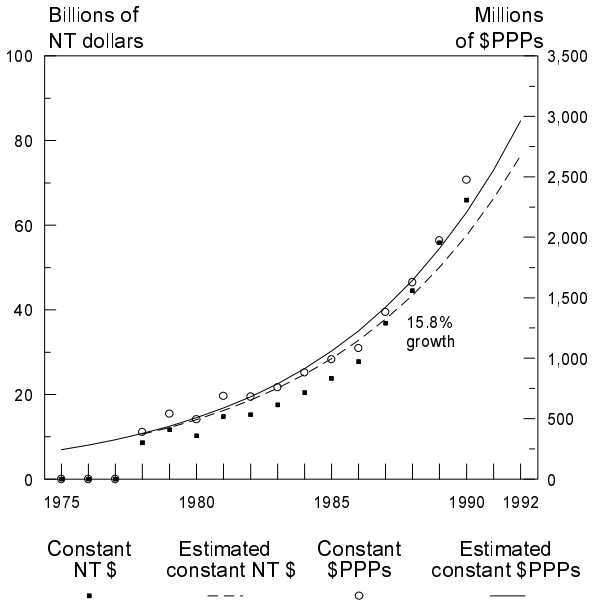
The Government established the Industrial Technology Research Institute (ITRI) in the 1980s to compensate for the small firms' lack of R&D participation. Working through ITRI and other institutions, the Government has boosted R&D spending to 1.7 percent of GDP. Under ITRI, 20 companies joined to successfully make IBM-compatible computers. ITRI's Electronics Research and Service Organization is joining with 47 Taiwanese companies to develop notebook computers. Taiwan's "Silicon Valley" is the Hsinchu Science-based Industrial Park, established in 1980 to benefit from the interaction between foreign

Figure 40. R&D in Taiwan, by performer: 1980-90



NOTE: See table A-18.

Figure 41. Growth in R&D in Taiwan: 1975-92



NOTE: See table A-16.

high technology investment and technology transfer, dynamic R&D consortia, and Taiwan's expanding higher education system in S&T.

Taiwan's overall R&D investment went from 6 to 71 billion New Taiwanese dollars from 1978 to 1990. In dollars, this is an investment growth from $388 million to $2.4 billion, as shown in figure 41. If Taiwan is able to maintain this 15 percent annual growth rate, it will be spending about $2.9 billion in R&D in 1992, approximately equal to the annual budget of the National Science Foundation.