DOCUMENT RESUME

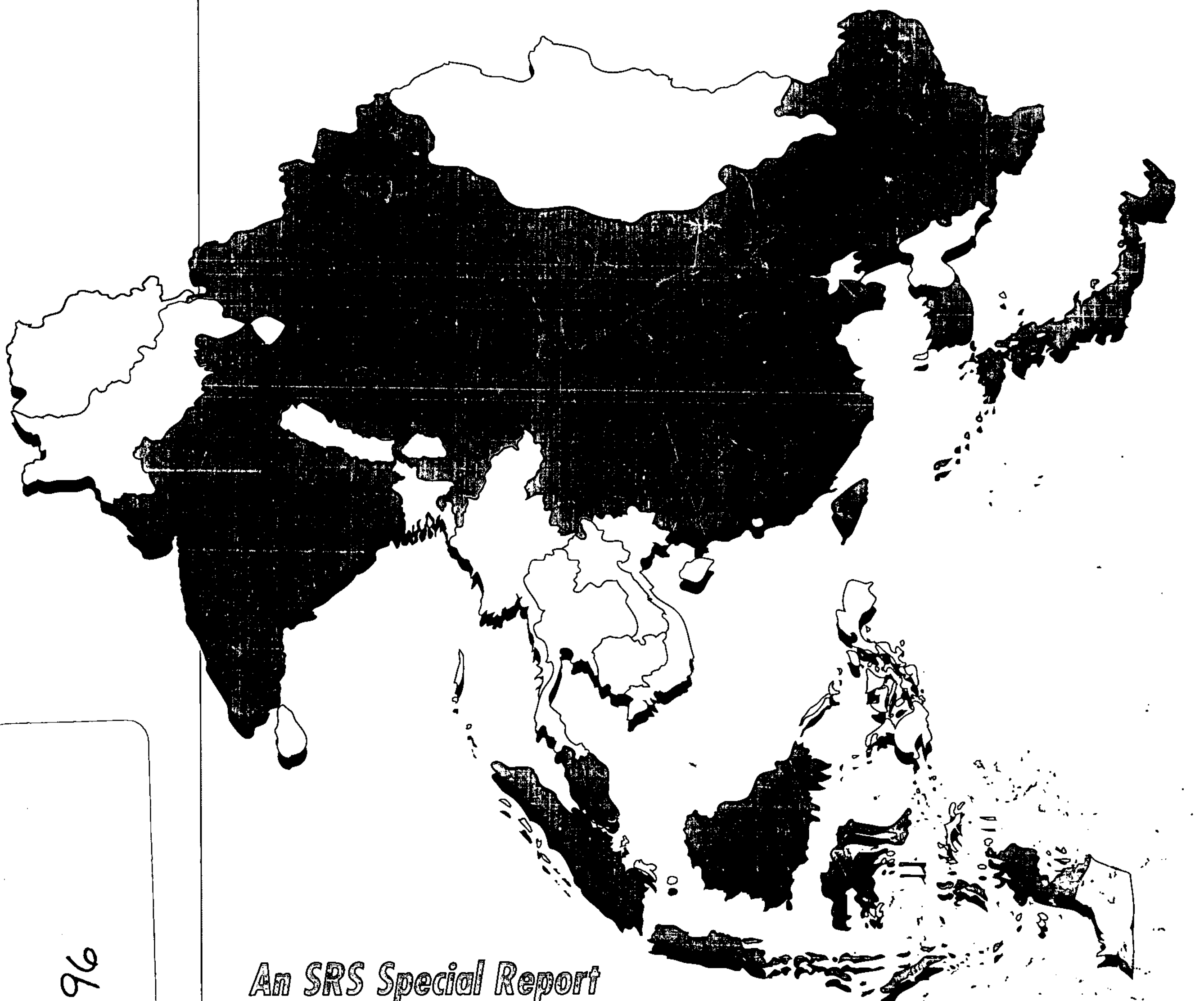
ED 401 216 SO 026 996

AUTHOR	Rausch, Lawrence M.
TITLE	Asia's New High-Tech Competitors: An SRS Special Report.
INSTITUTION	National Science Foundation, Arlington, VA. Div. of Science Resources Studies.
PUB DATE	95
CONTRACT	NSF-95-309
NOTE	84p.
AVAILABLE FROM	National Science Foundation, Forms and Publications Unit, 4201 Wilson Blvd., Room P-15, Arlington, VA 22230; 703-306-1130; fax: 703-644-4278; e-mail: pubs@nsf.gov
PUB TYPE	Reports - Descriptive (141) -- Statistical Data (110)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	*Asian Studies; Business; *Competition; Developing Nations; Development; Economic Development; Economic Impact; *Economics; Foreign Countries; Higher Education; *International Trade; *Manufacturing; Manufacturing Industry; Technological Advancement; *Technology
IDENTIFIERS	China; Hong Kong; India; Indonesia; Japan; Malaysia; Singapore; South Korea; Taiwan

ABSTRACT

This report profiles nine economies linked by Asian identity, yet marked by great economic and technological disparity, in order to project which economies will be full-fledged participants and competitors in tomorrow's high-tech product markets. Based on the various indicators of technological activity and competitiveness presented in this report, several Asian economies stand out. They are apparently headed toward greater prominenced as developers of technology and will become visible competitors in product markets. Japan stands alone as the most advanced industrialized country in the region. Four others--Hong Kong, Singapore, South Korea, and Taiwan--often referred to as the "four tigers" or as the newly industrialized economies, have made dramatic leaps forward in the global economy over the past decade. The remaining four countries--China, India, Malaysia, and Indonesia--lag far behind these other countries in economic and technological development. Yet each of these four countries has exhibited tremendous growth in terms of economic and technological development. Appendices which comprise half of the document are detailed data tables. (EH)

Asia's New High-Tech Competitors



An SRS Special Report

Division of Science Resources Studies
Directorate for Social, Behavioral and Economic Sciences

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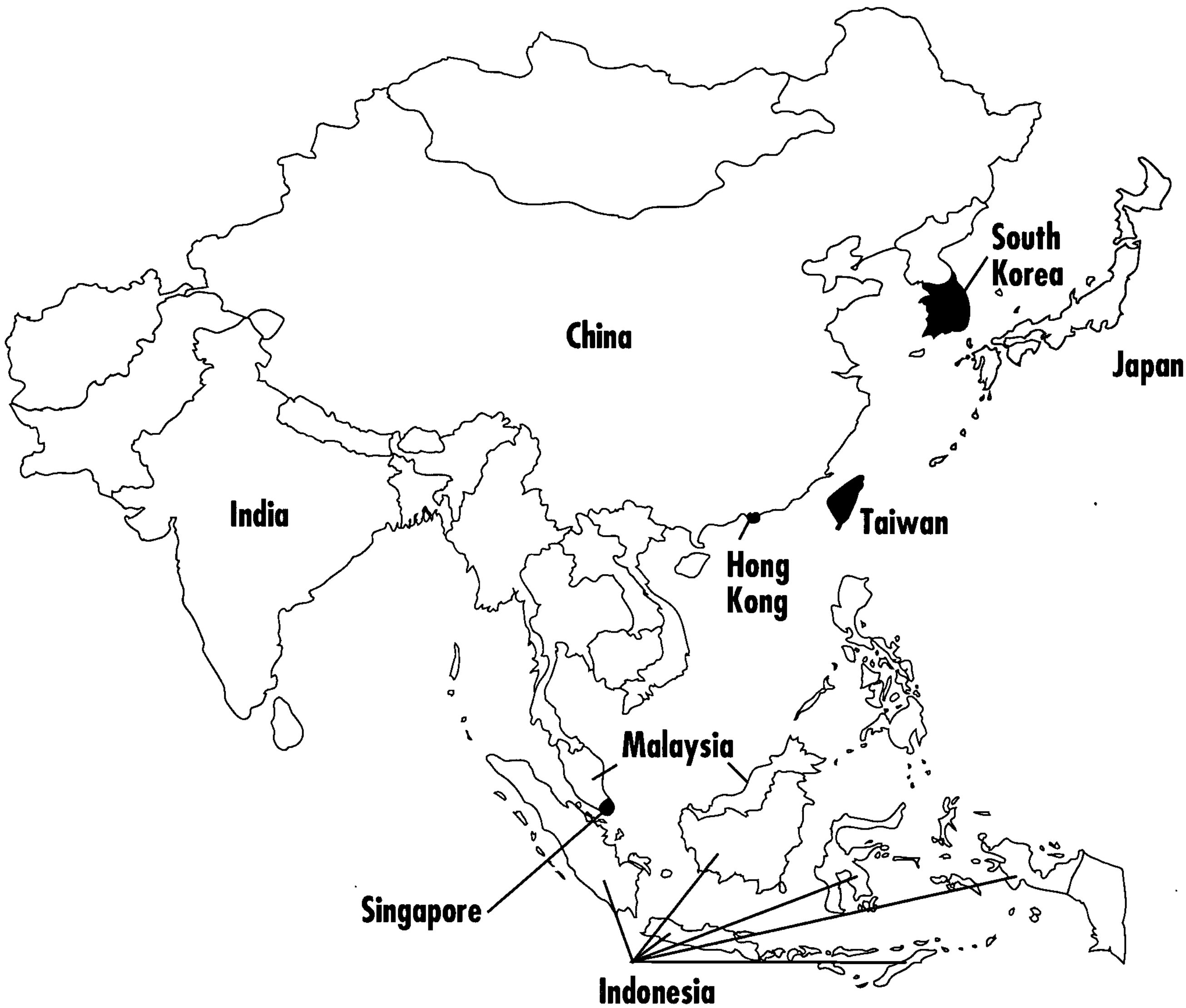
NSF 95-64 (Replaces NSF 94-4)

Asia's New High-Tech Competitors



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NSF 95-309

Suggested Citation

National Science Foundation, *Asia's New High-Tech Competitors,* NSF 95-309 (Arlington, VA, 1995).

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ACKNOWLEDGMENTS

This report was prepared by Lawrence M. Rausch, Senior Analyst, Science & Engineering Indicators Program, Division of Science Resources Studies (SRS), National Science Foundation (NSF). Guidance and review were provided by Jennifer Bond, Director of the Science & Engineering Indicators Program and by Kenneth M. Brown, Director of SRS.

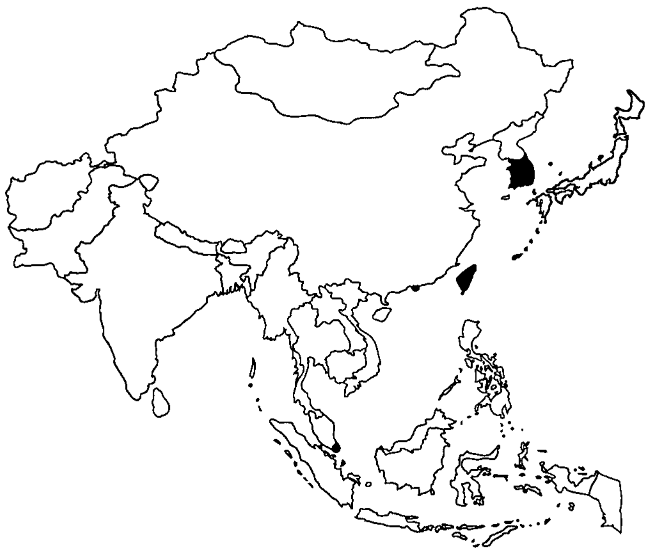
NSF extends sincere appreciation to the outside expert review provided by Dr. Donald Dalton, U.S. Department of Commerce, Drs. J. David Roessner and Alan L. Porter, Georgia Institute of Technology, and Dr. Richard P. Suttmeier, Director, Center for Asian & Pacific Studies, University of Oregon.

The report was made more readable and its presentation more pleasing through the efforts of Nita Congress (editor) and David Saia, SRS's Publications Manager.

The author also wishes to thank Vellamo M. Lahti for her support and assistance throughout the many phases of this project.

CONTENTS

Report Overview



Japan
NIEs
Hong Kong
Singapore
South Korea
Taiwan
EAEs
China
India
Indonesia
Malaysia

Decades of market success in general manufactures gave Japan the revenues and rationale for even larger investments in education and in research and development (R&D). These investments, in turn, propelled that country's entry into technology areas previously dominated by the West. Today, several other Asian economies are exhibiting similar patterns of industrialization (see Balk 1991). Once considered a locus for labor-intensive, low-skilled manufacturing, Asia now boasts several economies that are active, if not prominent, suppliers of a growing number of high-technology products in the global marketplace.

Which of these economies will be full-fledged participants in the technology development efforts of the future? Which will be the competitors in tomorrow's high-tech product market? To provide a basis for answering these questions, this report profiles nine economies linked by an Asian identity, yet marked by great economic and technological disparity.

Japan stands alone as the most advanced industrialized country in the region, on a par with the world's leading industrialized nations. It is included here as a benchmark to compare and contrast technology-related activity in the other eight Asian economies.

A group of four – *Hong Kong, Singapore, South Korea,* and *Taiwan* – often referred to as the "four tigers" or as *newly industrialized economies* (NIEs) have made dramatic leaps forward in the global economy over the past decade. Still, they do not yet measure up technologically to Japan.

The remaining four countries, *China, India, Indonesia,* and *Malaysia,* lag far behind Japan and the NIEs in terms of economic and technological development. Yet each of these four countries has exhibited tremendous growth on both these fronts. Recent commitments voiced by the governments of these countries to pursue technology-based economic growth might mean that one or more of these countries could be the next "tiger" of Asia. These four countries are herein collectively referred to as the *emerging Asian economies* (EAEs).

FINDINGS

Based on the various indicators of technological activity and competitiveness presented in this report, several Asian economies stand out, apparently headed toward greater prominence as developers of technology and as more visible competitors in high-tech product markets.

Taiwan and South Korea seem best positioned to move closer to Japan's technological stature.

Among the group of Asian NIEs, *Taiwan* and *South Korea* are likely to increase their competitiveness in technology-related fields and product markets. This conclusion is based on both economies' strong patent activity in the United States in electronics and telecommunications, data showing both economies increasing their licensing of U.S. technological know-how, and data showing both economies' rapidly rising imports of U.S. products that incorporate advanced technologies. Other indicators highlight the technological infrastructure (defined by the existence of a system of intellectual property rights, R&D activities closely connected to industrial applications, large number of qualified scientists and engineers, etc.) in place in both economies that should serve to support further growth in high-tech industries.

The other two Asian NIEs, *Singapore* and *Hong Kong*, also show strong signs of technological strength and scored impressively on many of the indicators. However, both seem to be functioning on a somewhat narrower technology foundation than either Taiwan or South Korea. *Singapore* and *Hong Kong* have not shown the same level of patent activity or the same presence in global technology markets as have the other two NIEs. Their comparatively small populations will limit their ability to make a major impact across any broad spectrum of technology areas. In addition, the pace of Hong Kong's technological development will soon be altered by its integration with China in 1997: the extent and direction of this alteration is difficult to predict with any certainty. However, the prospect of a "greater China" — a China that is not limited by geographical boundaries, but rather is formed around networks of expatriate Chinese peoples and resources spread throughout Asia — also looms in the background. Hong Kong's considerable capital and technology resources will be highly valued in either scenario.

Malaysia is the single emerging Asian economy that, on the basis of these indicators, could likely develop into the next Asian "tiger" – that is, move closer in technological mastery and high-tech production to the more developed NIEs.

Malaysia is purchasing increasing amounts of U.S. high-tech products and has attracted large amounts of foreign investment, much of it in the form of high-tech manufacturing facilities. Even if these facilities are mostly platform (assembly) operations today, Malaysia's strong national orientation (defined by the existence of national technology strategies and an accepting environment for foreign investment), socioeconomic structure (evidence of functioning capital markets and rising levels of foreign investment and investments in education), and productive capacity (future capacity suggested through assessments of current level of high-tech production combined with evidence of skilled labor and innovative management) suggest that as it gains technological capabilities, more complex processing will likely follow. While it still has a long way to go before joining the ranks of the NIEs, Malaysia shows many signs of developing the resources it will need to compete in global technology markets.

India shows considerable strengths in certain of the indicators, but also shows weaknesses. India has a long tradition of educating highly qualified scientists and engineers and of excellence in basic research, yet it harbors one of the highest illiteracy rates in the region. This anomaly produced one of the lowest scores among the eight economies for the socioeconomic infrastructure indicator. Uneven acceptance of foreign products and investment have inhibited internal competition that otherwise may have motivated India to better capitalize on its engineering strengths. Now, evidence of change underway in India's regulations and policies opening the economy to more foreign investment and goods may allow the country to leverage its many science and technology (S&T) strengths, such as in software development.

China and *Indonesia* show many mixed signs in these indicators of technology development and competitiveness. On the positive side, both countries have enjoyed tremendous economic growth and have attracted large amounts of foreign investment. Both have large populations that could support a large domestic market, abundant natural resources, and a central Government that has placed a high priority on technical training and development. But many challenges remain. China will face many difficulties in the years ahead as it continues to transform its centrally planned economy to one directed by market forces. These difficulties should not be underestimated. Indonesia's challenge is different. A continuity in leadership for over 30 years has produced a certain stability but may have also masked growing social and ethnic discontent among the peoples of Indonesia. With a change in the presidency expected soon, many wonder whether the economic and technological progress achieved over the past decade will continue. Consequently, political and social uncertainties for both countries prevent any direct projection of their technological future based on their recent technological achievements.

Implications for the United States

The rapid technological development currently taking place in Asia poses both challenges and opportunities for the United States:

The Challenges...

This report provides new evidence of a broadening technological capability in the group of four newly industrialized economies and indications that several from the group of emerging Asian economies are laying a foundation to support future technological development and competency. If these nations continue to progress technologically, U.S. high-tech industries can expect the competition for global market shares to intensify.

Yet, the challenges to the United States from Asia's technological and economic growth extend beyond the marketplace and are already reaching into the pool of talent available for U.S. business and universities. As Asia's economies grow, so too will the competition for the best science and technology (S&T) talent. Over the years, Asia has sent many of its brightest students to the United States for university training. Many of these students stayed and worked in U.S. industries. As opportunities to work at the technological cutting edge are created back in Asia, these students will return to Asia in greater numbers. The increased competition for S&T talent will not be restricted to the Asian-born scientists and engineers, but will likely affect the ability of the United States to retain the top American S&T talent now available to its industrial, university, and government sectors.[1]

But Also New Opportunities...

A broadening of the community of technologically advanced nations also provides new opportunities for U.S. high-tech industries and the U.S. S&T enterprise as a whole (universities, institutes, etc.) in the form of larger markets for goods and services and new collaborators in scientific and technological research.

For Business. With the end of the Cold War and the pending implementation of the General Agreement on Tariffs and Trade (GATT) — a new world trade agreement that calls for a worldwide reduction in both tariff and nontariff barriers — the climate for global trade has never been better. The nine Asian countries profiled in this report account for nearly half the world's population, and many of these countries have the world's fastest growing economies—two regional dynamics quite apparent to U.S. business. Market opportunities for U.S. high-tech products and services in Asia can be seen in China's demand for new computing and telecommunication hardware and services, or in India's varied technological needs in computer hardware and pollution-control technologies. U.S. aircraft and aerospace technologies already find great demand all across Asia, and these business opportunities will expand as the region's economy continues to open up.

For Research. The same events that create new business opportunities — the end of the Cold War, the growing technological sophistication in a broader set of Asian countries, and the relaxation of restrictions on international business — also create many new opportunities for the U.S. science and technology research community. The many new, well-funded research institutes and technology-oriented universities surfacing across Asia will broaden the region's scientific and technological expertise and will almost certainly generate new opportunities for collaborations between Asian and U.S. researchers. Evidence of such collaboration can already be seen in the increase in new bilateral S&T agreements that facilitate cooperation involving U.S. researchers and researchers from nearly all of the nations profiled in this report.[2] With the nations of Asia each making explicit commitments to building technology-based economies, the prospects for growth in these research opportunities are quite good.[3]

[1] See NSF (1993).

[2] Science, Technology and American Diplomacy, *16th Annual Report to Congress by the President, 1994*, Appendix 1: "U.S. International S&T Agreements by Country."

[3] For a recent examination of national technology strategies in Asia, see Dahlman (1994).

On November 19, 1993, President Clinton addressed national representatives meeting in Seattle at the conference for Asia-Pacific Economic Cooperation (APEC) and marveled at the economic transformation that has already taken place in Asia, saying "...these economies have gone from being dominoes to dynamos, ..."[4] President Clinton went on to say, "Much of what Asia needs to continue in its growth pattern are goods and services in which we (the United States) are strong: aircraft, financial services, telecommunications, infrastructure, and others." In response to Asia's development, U.S. agencies with export promotion policies are making adjustments to reflect the growing importance of the Asian region to the United States.[5] U.S. participation in international organizations that include or focus on relations with Asia is now given higher priority.[6]

[4] See U.S. Department of State, Bureau of Public Affairs, Office of Public Communication, *Dispatch* ,Vol. 4, No. 48, "The APEC Role in Creating Jobs, Opportunities, and Security," President Clinton's address on November 19, 1993, to the Seattle APEC Host Committee.

[5] See "Coordination of U.S. Export Promotion Activities in Pacific Rim Countries," United States General Accounting Office Report (GAO/GGD-94-192) August 1994

[6] See U.S. Department of State, Bureau of Public Affairs, Office of Public Communication, *Dispatch*,Vol. 5, No. 48, "America and the Asia-Pacific Future," Secretary Christopher's address to the Asia Society, New York City, May 27, 1994.

Introduction

This report presents indicators of technological development and competitiveness in technology-based product markets for a group of Asian economies. It is a companion volume to the previously released National Science Foundation publication *Human Resources for Science and Technology: The Asian Region* (NSF 93-303). That report used six economies to comprise the region – Japan, China, India, Singapore, South Korea, and Taiwan. This report covers nine, adding Hong Kong, Indonesia, and Malaysia, since these latter economies are playing increasingly significant roles in the region's growing technology trade and economic competitiveness.[7]

The report is divided into three sections. The first examines Asian technology development, both indigenous and that acquired from other nations.

The second section looks at the region's competitiveness, mainly through an examination of its ability to sell manufactured goods in the United States.

In the third section, the report identifies those Asian countries that seem positioned to become more prominent competitors in global high-tech markets over the next 15 years.

Throughout this report, special attention is given to firms that produce goods that incorporate advanced technologies (hereafter referred to as "high-tech firms and industries").

High-tech industries are important for several reasons:

- High-tech firms are associated with innovation. Firms that are innovative tend to gain market share, create new product markets, and/or use resources more productively;
- High-tech firms are associated with high value-added manufacturing and success in foreign markets;
- The R&D performed by high-tech industries has spillover effects. These effects benefit other commercial sectors by generating new products and processes that can lead to productivity gains, new manufacturing opportunities, and the creation of higher wage jobs; and
- High-tech industries have also been among the fastest growing industries in the United States (see ITA 1993, p. 21, tables 3 and 4).

These characteristics underscore the importance of high-tech industries to U.S. policymakers and the need to identify and track the progress of new competitors.

For many of the indicators presented in the first two sections, U.S. data sources are used to assess the technological progress of the nine Asian economies based on their trade and technology relationships with the United States. These data allow for cross-country analyses of the region's technology-related activities in arguably the single most important market in the world. These assessments would be strengthened, however, if more data were available on the extensive and critical intraregional exchanges that are very much a part of Asia's technological development.

[7] Data for Indonesia and Malaysia are not available for several of the indicators presented in this report. In those instances, the Asian region is defined by the remaining seven economies.

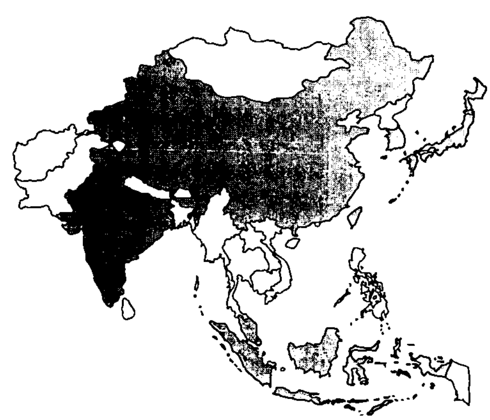
Technology Development 1

Developing countries can follow any of a number of paths as they pursue economic development. Japan provides a highly successful model that, in part, draws its strength from large national investments in education and R&D as well as from a willingness to learn and build on technological advances discovered elsewhere.[8] Several other Asian economies appear to be following development strategies based on the Japanese model.[9]

In this section, Asian technology development is viewed from two perspectives – technology developed internally and technology obtained externally. Internal technology development is gauged by an analysis of patents and patenting trends, a measure of inventive activity. External sources of technology are identified and compared by examining Asian purchases of U.S. high-tech products, licensing of U.S. technological know-how, acquisition of U.S. high-tech companies, and acceptance of foreign investment.

Internal Technology Development

Research and development activities serve as an incubator for new ideas that lead to new processes, products, and even industries. While not the only source of new innovations, R&D activities are associated with many of the important new ideas that have helped shape modern technology. Japanese society is widely recognized for the importance it places on education, especially education in technical fields. Similarly, Japanese industry is widely recognized for its large investments in applied research and development. Figures 1, 2, and 3 suggest that these characteristics might be attributed to several other Asian economies, as well.[10]



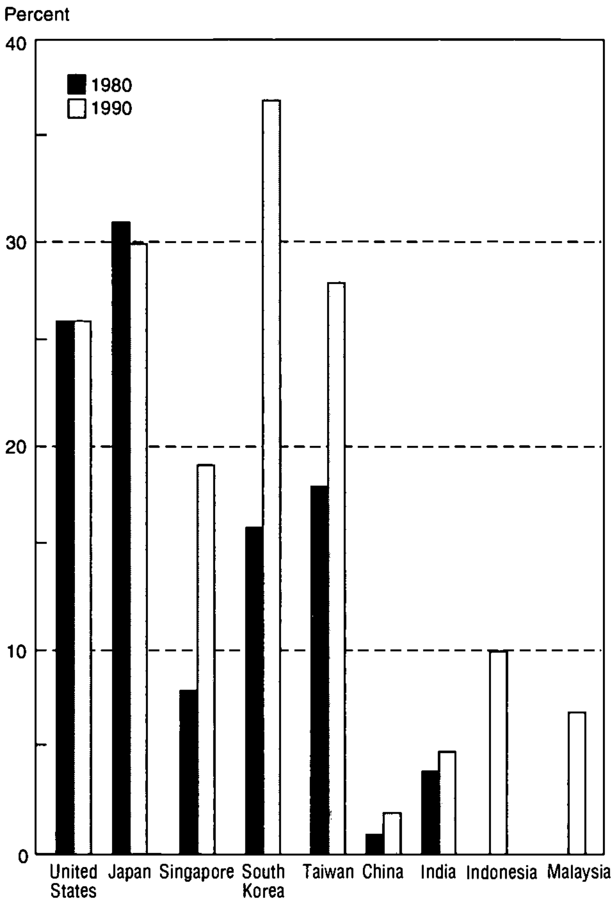
[8] See Reischauer (1981) and Vogel (1979) for discussions of Japanese history, culture, and organizational structures, all of which shaped Japan's approach to industrialization.

[9] See Dahlman (1994) for an extensive discussion of technology strategies underway in eight East Asian developing economies.

[10] See NSF (1993) for a more extensive analysis of human resource development and R&D investments in the Asian region.

One of the important benefits derived from the Asian investments in both human and R&D capital is the development of new technical inventions that often lead to innovations – i.e., in new or improved products, and in more efficient manufacturing processes and services. One indicator of inventiveness is the patenting activities of a nation's inventors. A review of the literature shows patent data to be valuable indicators of technical change and inventive output (see Griliches 1990).

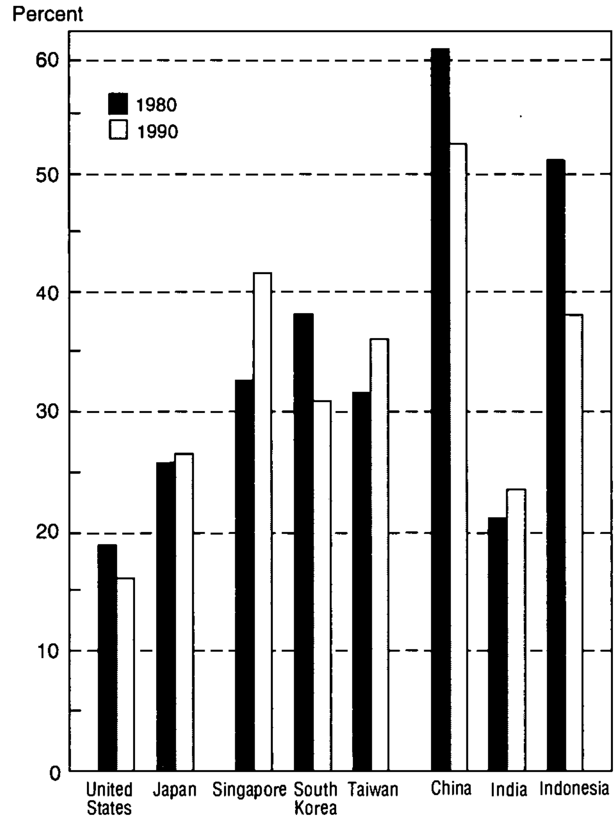
FIGURE 1: Percentage of 20- to 24-Year-Old Population in Universities



NOTES: The earliest data available for China are for 1982. Data for Indonesia and Malaysia are for 1989.

SOURCES: National Science Foundation, Science Resources Studies Division, *Human Resources for Science and Technology: The Asian Region*, by Jean Johnson, NSF 93-303 (Washington, DC: 1993), table A-2; and *Science & Technology Indicators of Indonesia 1993*, 1st edition (Republic of Indonesia, Science and Technology for Industrial Development: 1993).

FIGURE 2: Natural Science and Engineering Bachelors Degrees as a Share of All Bachelors Degrees



NOTES: The earliest data available for China are for 1982. Ratios for Indonesia are estimated.

SOURCE: Appendix table 1.

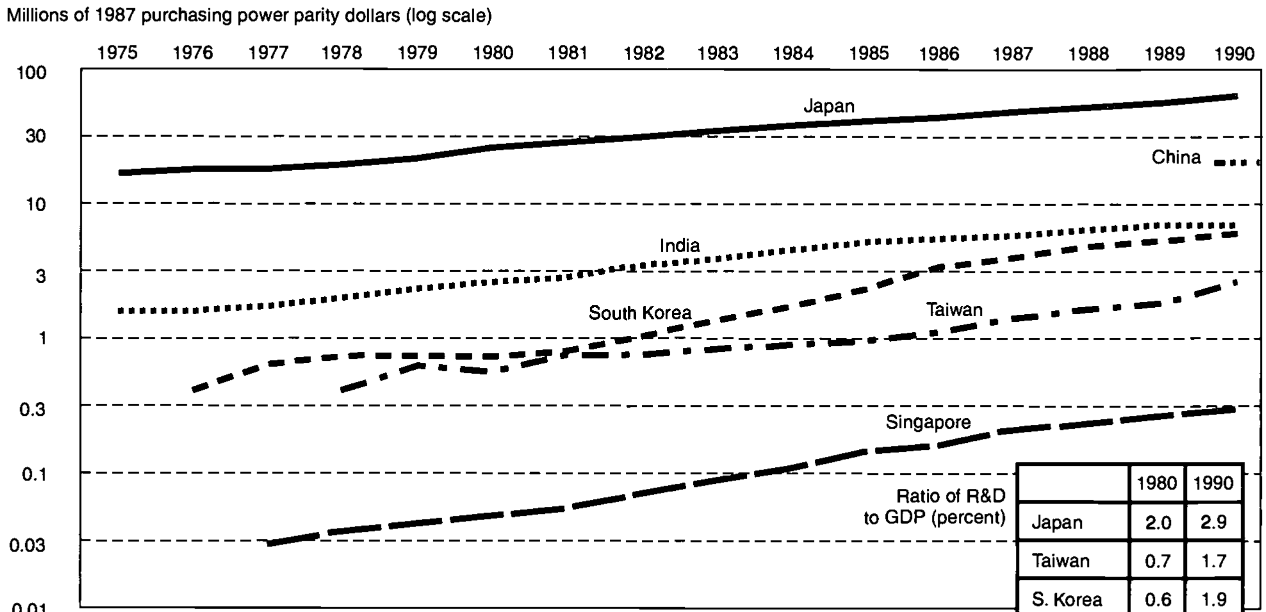
Domestic Patenting.

Examining domestic patent activity provides the following information about a nation's technology development:

- Patenting trends help identify countries that are loci of inventive activity;
- Patent activity by resident inventors provides a measure of productivity for a nation's science and technology human resources; and
- Patenting by foreign inventors highlights a nation's attractiveness as a market for new technologies.

Reported patent activity in seven Asian economies highlights the rapid technological growth that took place during the late 1980s. From 1985 to 1990, the number of patents granted within a seven-economy Asian region increased at nearly twice the

FIGURE 3: Asian R&D Expenditures



Ratio of R&D to GDP (percent)

	1980	1990
Japan	2.0	2.9
Taiwan	0.7	1.7
S. Korea	0.6	1.9
Singapore	0.3	0.9
India	0.6	0.8
China	NA	0.7

SOURCE: Appendix table 2.

rate as in the United States.[11] The number of patents granted in the Asian region increased by 44 percent during that period, rising from 65,000 new patents in 1985 to 93,000 in 1990. (See figure 4 and appendix table 3.) In comparison, 70,000 patents were granted in the United States in 1985, and 88,000 in 1990.[12] Patenting growth was especially rapid in China, South Korea, and Taiwan.

In 1990, nearly one-third more patents were granted to resident inventors in the Asian region than in 1985. This increase would be still greater if not for the more moderate increase recorded (19 percent) on the far larger number of Japanese patents. Domestic patenting by residents of the NIEs and EAEs alone doubled between 1985 and 1990.

These data also reveal that foreign inventors have been patenting in Asia at an even faster pace than the region's resident inventors.[13] Due to the greater difficulty and costs associated with gaining patent protection in a foreign country, this trend suggests that foreign inventors see marketing opportunities in the region that justify the time and expense involved in patenting.

The numerical relationship between resident and foreign patenting also suggests a nation's openness to, need for, and dependence on foreign-developed science and technology. Within the region, the level of this foreign activity varies widely. Japan had the lowest percentage of patents awarded to foreign inventors (15 percent in 1990): nearly 6 patents were granted to resident inventors for every one awarded to a foreign inventor. Singapore and Hong Kong had the highest percentages of patents awarded to nonresident inventors – 99 percent and 98 percent, respectively. Taiwan is squarely in the middle of these two extremes, with 51 percent of its 1990 patents granted to foreigners. Taiwan's resident/nonresident patenting ratio is similar to that of the United States. (See figure 5.)

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[11] These data are provided by the World Intellectual Property Organization (WIPO), Geneva, Switzerland; and the Taiwan Coordination Council for North American Affairs. Patenting activity data for Indonesia and Malaysia were excluded from this discussion since, during the period examined, they reported to WIPO only on the number of patent applications; even these data are suspect, however, given the inadequacy of laws covering IPR in those two countries before 1991 (see box).

[12] U.S. patent data as reported by the World Intellectual Property Organization. Official data from the U.S. Patent and Trademark Office report nearly 72, 000 U.S. patents granted in 1985 and 90,000 in 1990.

[13] During this period, growth in the United States in foreign-inventor patenting also exceeded that for resident inventors.

Laws Governing Intellectual Property Rights in Asia

Japan, Hong Kong, South Korea, and Taiwan have a complete system of laws for protecting intellectual property. Notwithstanding, South Korea and Taiwan have been watched by the Office of the U.S. Trade Representative (USTR) for uneven or inadequate enforcement of intellectual property rights (IPR) legislation. Elsewhere in the region, IPR laws tend to be either relatively new or simply not up to international standards, as the following illustrates (Office of the U.S. Trade Representative 1993).

- **Singapore.** IPR legislation is new to Singapore: comprehensive copyright legislation was first enacted in 1987, and a new trademark law was enacted in 1991. Nevertheless, charges of pirated software and the manufacturing of "knock-off" watches and pharmaceuticals concern the USTR.
- **Indonesia.** IPR laws have been recently enacted, but shortcomings in them have already been brought to the government's attention. Indonesia's first patent law came into effect in August 1991, providing for a relatively short term of protection (14 to16 years), and excluding several important technology areas from coverage such as biotechnology products and integrated circuits.
- **Malaysia.** Before 1991, Malaysia's IPR laws were not up to international standards. At that time, Malaysia's laws were made to conform to international IPR accords and are now considered to provide one of the strongest IPR environments in the region.
- **China.** China's IPR laws have been a concern in the international community for some time. The United States investigated numerous charges of inadequate IPR protection before reaching an agreement with China whereby China pledged to strengthen its patent law, enact trade-secret legislation, and otherwise adhere to international conventions.
- **India.** India's IPR laws are also not consistent with international standards. IPRs are conferred only after striking a balance between the interests of the property owner and social interests as defined by the state. For example, India's Patent Act excludes from patent protection any new drugs, medicines, or foods prepared or produced by chemical processes. U.S.-invented drugs have thus been reproduced and distributed in India without regard to claims of U.S. ownership. Following a USTR review of India's IPR laws and practices, the United States suspended duty-free entry privileges on a portion of its trade with India.

Foreign Inventors Patenting in Asia

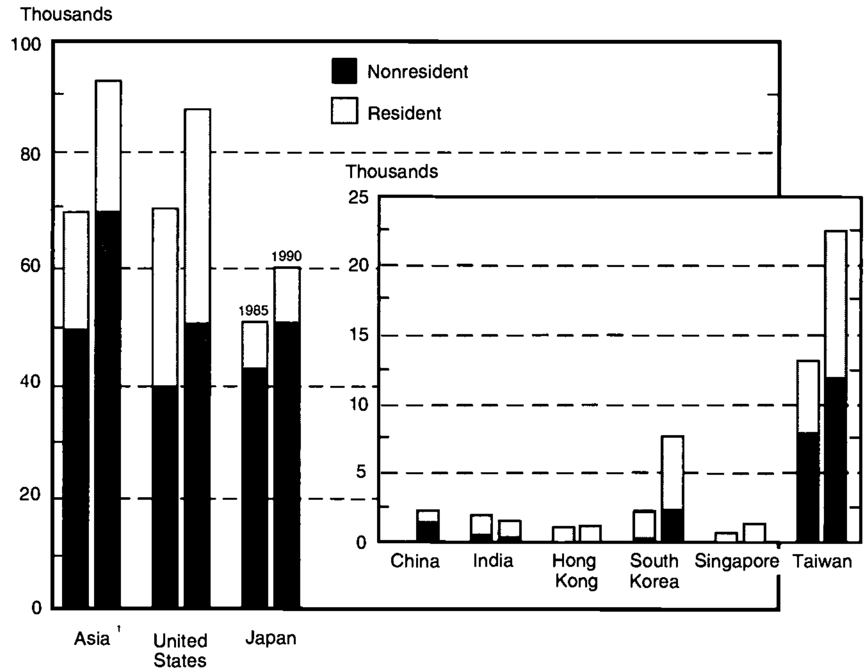
U.S. inventors are well-represented among the foreign inventors awarded patents in Asia. In 1990, U.S. inventors accounted for 44 percent of patents granted to foreign resident inventors in Japan (see text table 1). This share represented twice as many as were granted to German inventors. U.S. inventors accounted for 37 percent of nonresident patents granted in Hong Kong, and 35 percent in India. Japanese inventors demonstrated similar patenting strength in several other Asian economies, notably South Korea and China.

TEXT TABLE 1: Percentage of Total Nonresident Patents: 1990

	COUNTRY OF INVENTOR		
Host country	United States	Germany	Japan
Japan	44.4	21.2	—
Hong Kong	37.1	6.4	29.7
South Korea	30.7	5.1	50.6
China	19.1	11.7	42.8
India	35.4	14.0	6.8

SOURCE: World Intellectual Property Organization, *Industrial Property Statistics* (Geneva, Switzerland: 1985-90)

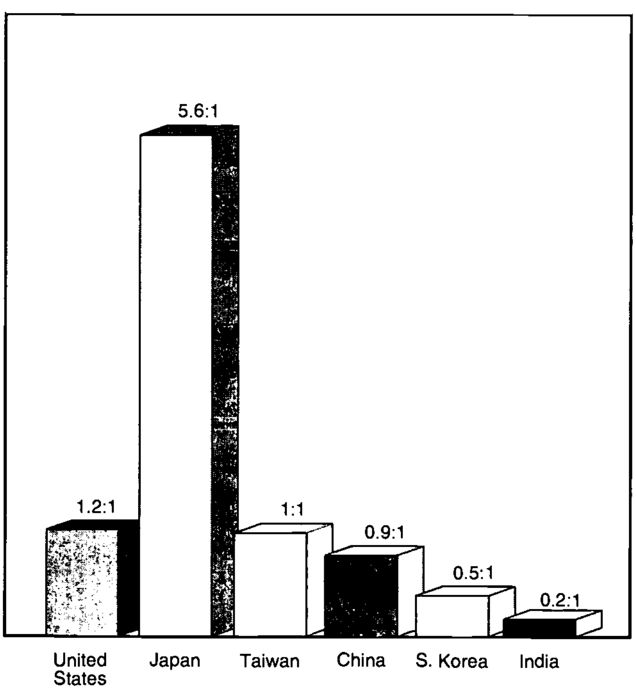
FIGURE 4: Patents Granted in Asian Economies



[1] Patents granted in seven-country Asian region.

SOURCE: Appendix table 3.

FIGURE 5: Patenting: Resident/ Nonresident Inventor Ratio, 1990



NOTE: Data for China are for 1989.
SOURCE: Appendix table 3.

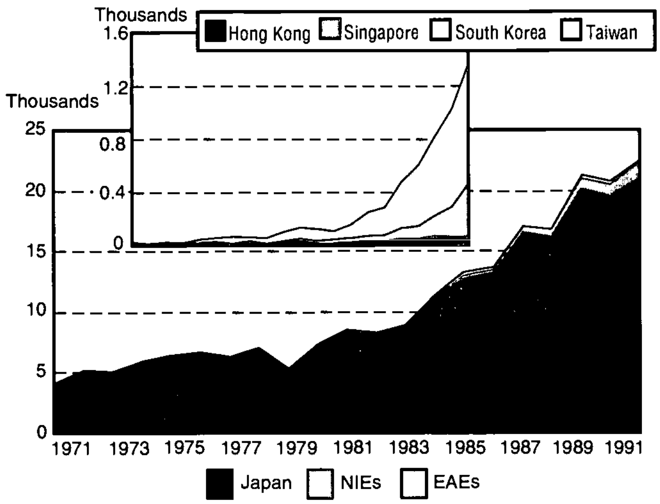
Asian Patenting Trends in the United States.

Analysis of Asian inventiveness using patent activity in the individual economies is complicated by differences in patent laws and processes. These differences are eliminated by examining Asian patenting in a country located outside the region, such as the United States. Research has shown that the United States' patent system serves this purpose well: the United States is a large, wealthy country whose market dynamics tend to attract cutting-edge technologies from around the world.[14]

During the 1970s, the number of U.S. patents granted to Asian inventors nearly doubled; it tripled during the 1980s. Not surprisingly, given its economic position vis-à-vis the other economies in the Asian region, Japan represented about 95 percent of Asia's patent activity over these two decades. (See Figure 6 and appendix table 4.)

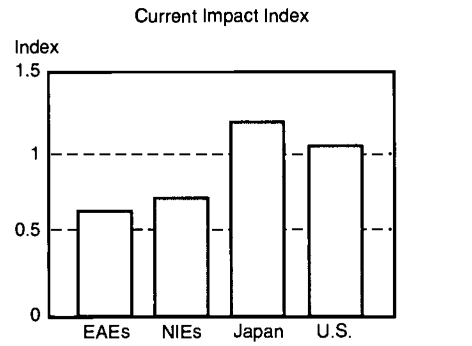
[14] For a more extensive discussion of the value of examining foreign patenting in the United States, see Pavitt (1985).

FIGURE 6: Asian Patenting in the United States

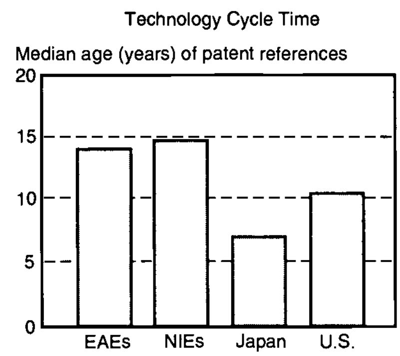


SOURCE: Appendix table 4.

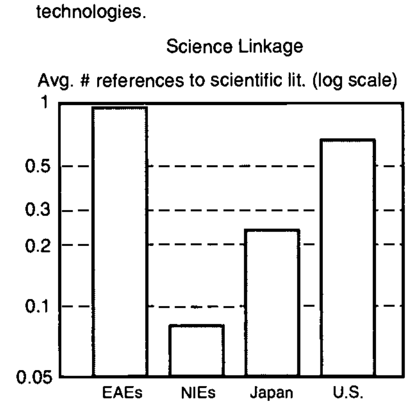
FIGURE 7: Technological Performance Indicators



This index measures how often a country's patents are cited (as "prior art" on new patents) relative to other countries' patents.



On this indicator, shorter cycle times suggest that a country's inventors are improving upon younger technologies.



Science linkage is a measure of how closely a country's technology is linked to science.

NOTE: Indicators were calculated using U.S. patents granted.

SOURCE: Appendix table 13.

The most rapid growth in U.S. patenting among Asian inventors was recorded by those from Asia's newly industrialized economies. Paced by inventors from Taiwan and South Korea, NIE patenting in the United States quadrupled during the 1970s, and increased tenfold during the 1980s, with the most dramatic growth registered after 1987. The sharp rise in U.S. patenting by inventors from Taiwan and South Korea closely tracks the rapid growth in industrially funded R&D spending in those two countries. (See figure 3 and NSF 1993.)

Patenting in the United States by inventors from the emerging Asian economies was more erratic – declining during the seventies, and rising during the eighties and into the nineties. Chinese inventors led the EAEs in patents awarded after 1986, making particularly impressive strides during the last few years. Since 1988, inventors from China have obtained more U.S. patents than have inventors from Singapore and as many as inventors from Hong Kong.

In 1990, Asian inventors were awarded a large number of U.S. patents in the semiconductor field, fields associated with television and other telecommunication technologies, and several computer-related fields. Inventors from each of the Asian economies showed a tendency to patent in these fields; theavored other electronics-related technologies. (See appendix tables 5 to 11.) There is considerable consensus among experts in the United States that leadership in these kinds of facilitating technologies will play a role in future economic competitiveness.[15]

[15] See Competitiveness Policy Council (1993), National Critical Technologies Panel (1993), and Technology Administration (1990).

For analytic purposes, U.S. patents can be classified by industry sector, with each patent fractionally distributed according to the number of industry-related product fields to which it is pertinent.[16] Six commercially significant industries are examined here: computer hardware, industrial machinery, radio and television equipment, electronics, automobiles, and aircraft. (See appendix table 12.) Among these six industries, Japanese patenting in the United States grew fastest in computer-related technologies. NIE patenting grew fastest in electronics (led by South Korean inventors), as did EAE patenting, led by China.

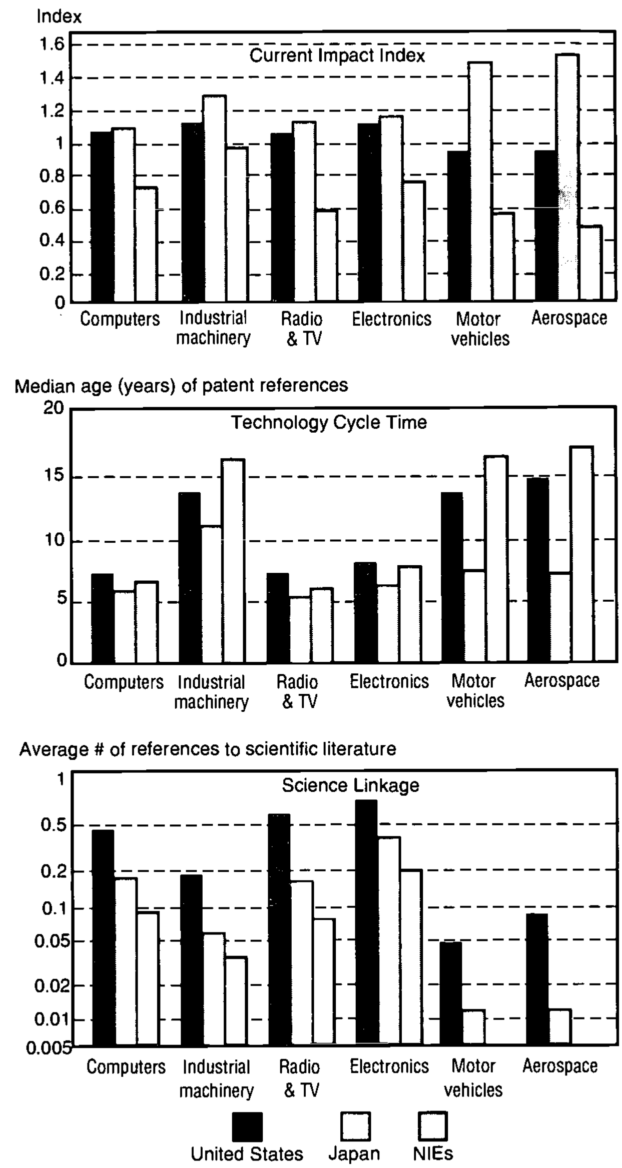
TECHNOLOGICAL IMPORTANCE OF ASIAN PATENTS

Indicators of Technological Importance.

Information contained in patent documents suggests that many Asian patents represent seminal advances in technology and that they tend to be concentrated in rapidly changing fields of technology. Yet, when compared to U.S. inventions, Asian patents appear to have weaker ties to the fundamental sciences. (See figure 7 and appendix table 13.) Those assessments are drawn from an analysis of Asia's U.S. patents using three indicators:

1. *The Current Impact Index* (CII) attempts to capture the impact of a country's patents on the technological community and the degree to which its patents contain important technological advances by calculating how frequently a country's recent patents are cited by all of the current year's patents.[17] This normalized indicator has an expected value of 1.0.

FIGURE 8: Technological Performance Indicators, by Industry



SOURCE: Appendix table 13.

2. *Technology cycle time* attempts to identify those countries that are inventing (patenting) in rapidly changing technology fields. This indicator identifies fast-changing technologies by measuring the median age of the patents cited as prior art.

3. *Science linkage* attempts to measure the degree to which a country's technology is linked to science by calculating the number of references to the scientific literature indicated on the front pages of the patent. This indicator attempts to measure a country's activity in leading-edge technology and how close its new technology is to the scientific frontier.

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[16] In this classification system, each patent class is associated with the Standard Industrial Classification (SIC) industry that would produce that class's product or apparatus or carry out its process steps. See OTAF (1985), p. 26.

[17] On the front page of a newly issued patent, the patent examiner lists any "prior art" that led to, or borders, the new technology. These citations can be to the scientific literature, to other patents, or to other technologies. When an earlier patent is included as a citation on a new patent, it indicates that that earlier patented invention was important to the creation of the newly patented invention. When a previously patented invention receives many citations, that patent has probably led to many subsequent inventions and, more than likely, contained an important or seminal advance in its field.

In the following sections, a more disaggregated examination of Asian patent activity in the commercially important industries listed earlier underscores the observations made for Asian U.S. patent activity in general.

Technological Importance of Japan's Patents.

Using the three indicators to analyze the technological importance of patenting by inventors from Japan reveals the following.

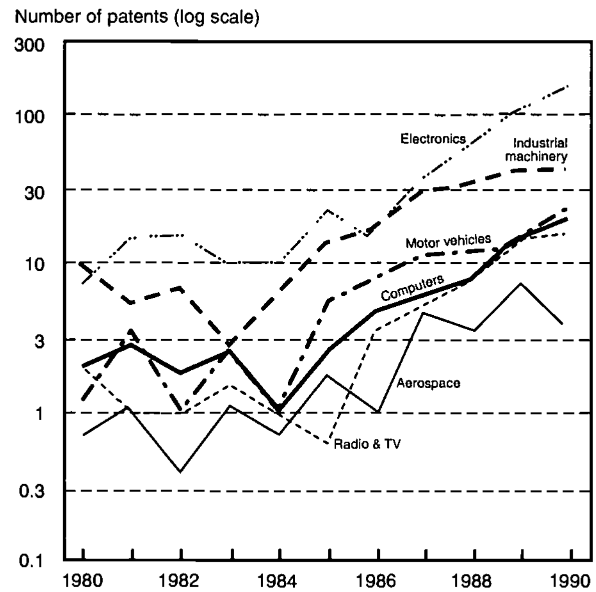
Current Impact. In the six commercially important industries, Japan's U.S. patents were cited more often (i.e., they had higher CII scores) than U.S. inventor patents, suggesting that Japan's patents tended to be more influential or have more impact on the advancement of those technologies. Of the six technology fields, Japan's widest margins over the United States were registered in aerospace and automotive technologies. (See figure 8.) While the high scores in the aerospace field may be the result of application crossovers from Japan's automotive patents, that can only be a partial explanation. There is widespread interest in Asia to improve aerospace manufacturing capability within the region. Several Asian economies besides Japan are also active in aerospace technologies, notably South Korea, Indonesia, and Taiwan. Japan, South Korea, and Taiwan have also pursued joint ventures with U.S. aerospace companies, seeking technology transfer through licensing agreements and joint production agreements.

Technology Cycle Time. Compared to those granted to American inventors, patents awarded to inventors from Japan improve upon younger technologies. This is true for all six technology areas examined, although the disparity was greatest in aerospace and automotive technologies. (See figure 8.)

Science Linkage. U.S. inventors showed stronger ties to science in all six technology areas than did inventors from Japan. The technology areas in which U.S. patents held the greatest margin were coincidentally the same areas in which Asian patents held the greatest margin in current impact and technology cycle time – aerospace and automotive technologies. (See figure 8.)

The indicators seem to affirm the conventional wisdom in science and technology communities – that U.S. inventions tend to be more fundamental or "groundbreaking" than Japanese patents, while

FIGURE 9: U.S. Patents Granted to Inventors From the NIEs, by Technology Field



SOURCE: Appendix table 12.

inventors from Japan seem to take the important next steps in improving upon the original technology. The commercial implication of these patenting characteristics for U.S. inventions is obvious. Rapid, successive improvements to the breakthrough technology can quickly reduce a technology's market life and its attendant long-run commercial value.

Technological Importance of NIE Patents.

With inventors from Japan garnering over 95 percent of Asia's U.S. patents, the scores assigned to the region in the various technologies in large part reflect Japanese patenting. Yet the four NIEs also demonstrate important gains in technology development. (See figure 9.) During the 1980s, NIE patenting rose sharply in all six selected technologies. This rise was especially dramatic in the field of electronics, and was led by inventors from Taiwan and South Korea. The NIEs' weakest gain during the past decade was recorded in the aerospace field.

Overall, the NIEs' patents scored significantly lower than those of the United States and Japan on all three technological performance indicators. But in those fields related to electronics and computer technologies, the NIEs appear to be following the Japanese model for economic advancement – i.e., rapidly advancing the state of the art in consumeroriented technologies. As illustrated by the NIEs' technology cycle time score in the patent classes covering computer hardware, radio and television, and electronics, patents held by inventors from the four tigers improved upon more recent technologies than did inventors from the United States patenting in those categories.

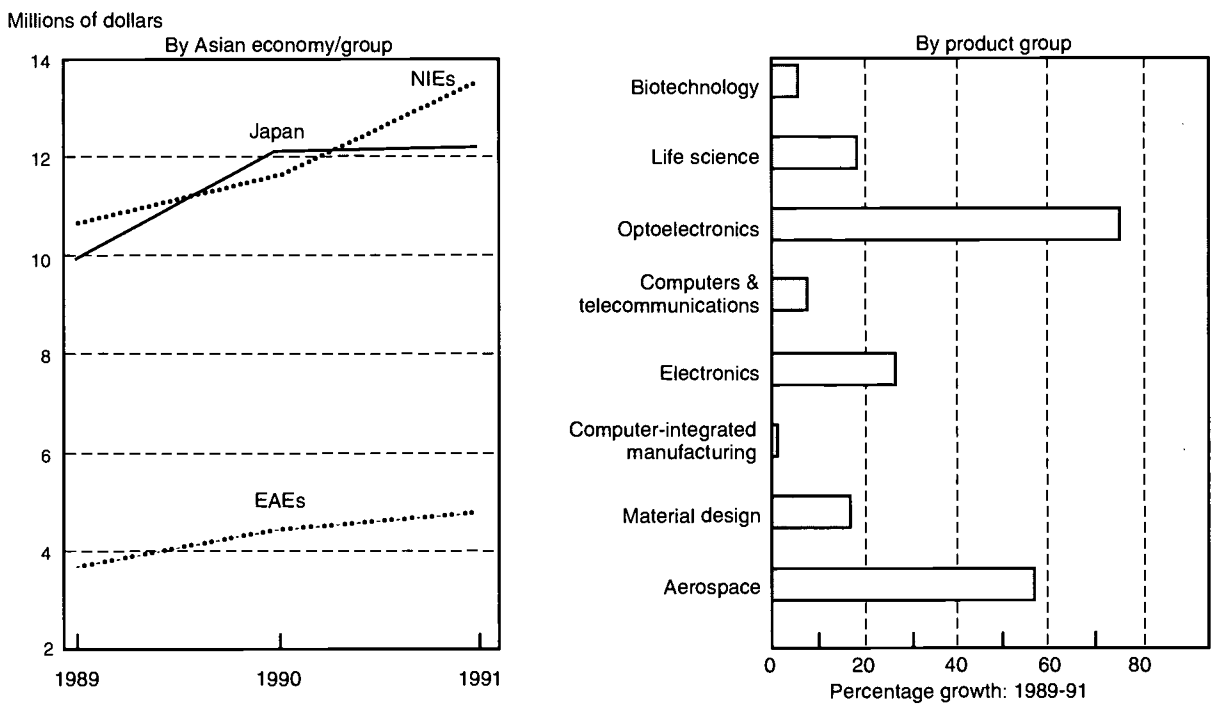
Technological Importance of EAE Patents.

The small number of U.S. patents awarded to the four EAEs weakens the reliability of these indicators to judge the technological importance of their patents, but some preliminary judgments can be made. In the commercially important industry in which the EAEs were awarded the most patents – the electronics industry – patents by residents of China tended to show a strong science linkage, while patents by residents of India had garnered more citations to their patents (a CII above 1.0) than the average for that category. Given the small number of patents, these indicators can only call attention to the direction of technological development in these two countries.

External Sourcing of Technology

Four methods of gaining access to externally developed technological advances are examined in this section: importing high-tech products, licensing foreign technical know-how, acquiring companies active in high-technology fields, and encouraging foreign investment.[18] Nations that acquire access to technological advancements through these mechanisms can often accelerate their competency in particular technologies. The Asian region's external sourcing of technology is viewed through its interactions with U.S. firms.

FIGURE 10: Asian Imports of U.S. High-Tech Products



NOTE: Asian imports are estimated by U.S. exports to the nine Asian economies.
SOURCE: Appendix table 14.

[18] Another very important means of technology transfer is the education of a country's students in foreign institutions. Data describing trends in Asian students studying in the United States and their return rates are presented in NSF (1993).

Purchasing High-Tech Products.

Trends in the region's purchases of foreign-made products that contain cutting-edge technologies give some indication of the economies' degree of technological sophistication and of their national direction regarding technology development. Data on U.S. exports of high-tech products to the nine-country Asian region provide a measure of these trends.[19] This category includes those products that embody new or leading-edge technology, and comprises 10 classes of technology: biotechnology, life science technologies (i.e., the application of scientific advances to medical science), optoelectronics, computers and telecommunications technologies, electronics, computer-integrated manufacturing (e.g., robotics), material design, aerospace, weapons, and nuclear technologies.[20]

Asia is an important customer for U.S. high-tech products. The region's purchases during a recent 3-year period increased annually from $24 billion in 1989 to over $30 billion in 1991. (See figure 10 and appendix table 14.) High-tech products account for over one-quarter of all merchandise purchased from the United States by Asia, and this share is rising. In 1991, Asia consumed 28 percent of U.S. exports of high-tech products.

The value of Japan's high-tech product purchases from the United States is nearly three times that of the next largest U.S. customer in the region, South Korea. Among the emerging Asian economies, Malaysia buys more high-tech products from the United States than the others, although China increased its purchases significantly in 1990 and 1991.

Aerospace products, which include both commercial and military aircraft, account for over 35 percent of U.S. high-tech exports to the region and led all other technology fields in terms of sales. Computers and telecommunication technologies ranked second. (See text table 2.)

The fastest growing groups of U.S. high-tech products sold to the region during the 1989-91 period were optoelectronic and aerospace technologies; growth in these product areas was driven in large part by purchases from Japan. (See figure 10.) Elsewhere

TEXT TABLE 2: Composition of U.S. High-Tech Sales in Asia, by Product Field: 1991

		Newly industrialized economies				Emerging Asian economies			
Product field	Japan	Hong Kong	Singapore	S. Korea	Taiwan	China	India	Indonesia	Malaysia
		MILLIONS OF DOLLARS							
All high-tech fields	12,196.7	2,180.6	3,748.3	4,040.2	3,497.9	1,700.6	210.8	245.0	2,588.2
		PERCENT							
Biotechnology	1.4	0.2	0.1	0.1	0.2	0.1	0.4	1.0	0.0
Life science	6.0	3.3	1.7	5.1	2.7	7.0	23.4	5.3	0.5
Optoelectronics	1.2	0.5	0.3	0.6	0.5	0.1	0.4	0.2	0.1
Computers and telecommunications	34.5	23.6	26.9	20.6	19.9	13.5	39.5	34.1	8.4
Electronics	9.2	21.3	16.6	6.9	22.4	1.3	13.7	3.2	11.7
Computer-integrated manufacturing	5.4	2.0	2.5	7.2	4.2	5.2	8.6	2.2	2.1
Material design	4.1	14.1	18.4	15.6	11.1	0.2	0.7	2.7	51.4
Aerospace	30.8	34.4	32.5	41.1	37.6	70.9	9.6	49.1	25.5
Weapons	0.8	0.5	1.0	0.9	0.5	1.3	2.9	1.9	0.1
Nuclear	6.7	0.1	0.0	1.9	0.8	0.3	0.9	0.3	0.0

SOURCE: Appendix table 14.

[19] The United States is just one of several suppliers of high-tech products to the Asian region and should not be seen as the region's dominant foreign supplier. Intraregional trade in high-tech products, especially from Japan, is – in most cases – the primary source of foreign technology products.

[20] For an explanation of the methodologies used to identify the products included in this definition of "high technology," see Abbott (1991) and Bureau of the Census (1989). See appendix table 14 for more complete descriptions and examples of the high-tech products included in this discussion.

in the region, the U.S. technology groups that showed the greatest sales growth varied:

- China—biotechnology, aerospace
- Hong Kong—weapons, aerospace
- South Korea—optoelectronics, weapons
- Singapore—weapons, optoelectronics
- Taiwan—aerospace, electronics
- Indonesia—weapons, electronics
- Malaysia—aerospace, computers and telecommunications

In contrast to the above-described trends, sales of U.S. high-tech products to India declined during this 3-year period. An uneven acceptance of foreign-made products and weak IPR laws contributed to this decline.

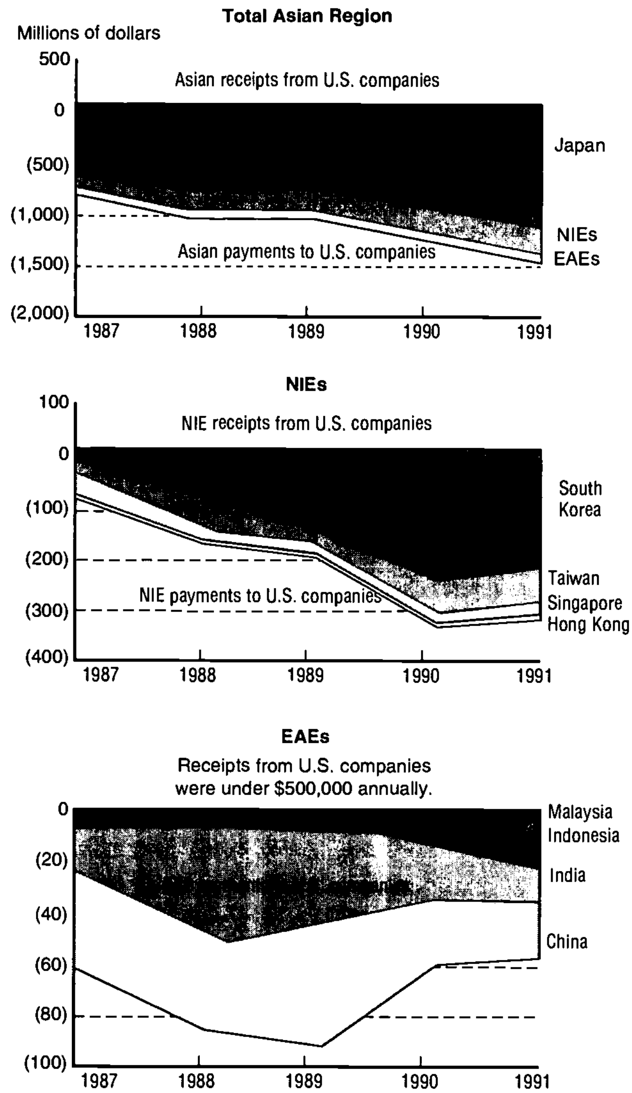
Licensing Technology.

The data discussed in this section examine transactions between unaffiliated firms buying and selling technological know-how through licensing agreements.[21] These transactions, where market prices are set through a market-related bargaining process, tend to reflect the value of the technological know-how exchanged at that point in time. The record of the resulting receipts and payments provides an indicator of the production and diffusion of technical knowledge.

Unlike the trade trends between Asia and the United States for manufactured goods and high-tech products, Asia is a net importer of U.S. technological know-how sold as intellectual property. Royalties and fees paid to U.S. firms to license use of their proprietary industrial processes nearly doubled during the 1987-91 period; these were, on average, 10 times that paid to Asian firms by U.S. companies. (See figure 11 and appendix table 16.) Japan is the largest

[21] Due to data availability, the discussion focuses on exchanges between Asia and the United States. Specifically, it covers royalties and fees from transactions between unaffiliated parties for the use or exchange of technological know-how such as patents and other proprietary inventions and technology; data on royalties and fees paid between affiliated parties were not available. Appendix table 15 provides data on royalties and fees generated between both affiliated and unaffiliated parties for all intellectual property, including not only fees generated from agreements exchanging industrial processes, but also franchise fees and fees paid and received for use of all types of media (books, tapes, movies, etc.). In 1991 Asian payments to the United States for access to all intellectual property (all transactions between all parties) were about twice those for transactions involving only industrial processes between unaffiliated parties.

FIGURE 11: Asian Trade With the United States in Intellectual Property



NOTES: Data represent receipts and payments from the exchange of industrial processes based on royalties and fees paid to unaffiliated companies. NIE receipts from U.S. companies were under $1 million annually.

SOURCE: Appendix table 16.

Asian consumer of U.S. technology sold in this manner, and, during the 5-year period studied, it steadily increased its purchases of U.S. technological know-how.

Japanese purchases accounted for about 75 percent of the region's payments to the United States. Japan's share generally declined, however, as several of the NIEs' payments to the United States increased. (See figure 11.)

As a group, purchases by the EAEs grew from 1987 to 1989; these then declined through 1991 as purchases by China and India fell off. China led EAE technological know-how purchases for 4 of the 5 years examined and, until 1990, purchased more U.S. technological know-how than several NIEs. Indonesia's purchases, though small, have risen steadily since 1988. (See figure 11.)

Acquiring High-Tech Companies.

The acquisition of existing high-tech companies can provide fast transfers of technology to the acquiring firm while facilitating easier market access for its own technologies. About 11 percent of small newly formed companies operating in the various high-tech fields are foreign-owned; only about 2 percent are owned by Asian companies.[22] (See text table 3.) Japan of course leads the region in foreign business acquisitions, with much smaller ownership positions by Taiwan and South Korea. (See appendix table 17.)

The largest share of Asian-owned, U.S. high-tech companies are involved in computer hardware development. Seventeen percent of all the U.S. high-tech firms owned by Japan are computer hardware companies. Companies in this field account for over a quarter of NIE U.S. high-tech company acquisitions (26 percent for Hong Kong and Singapore acquisitions, 27 percent for South Korea, and 29 percent for Taiwan). U.S. companies developing electronic components and systems also appear to attract NIE interest.

Encouraging Foreign Investment.

Prior to the 1980s, many of the Asian economies under consideration here had policies that restricted investment by foreign corporations. By the late seventies and early eighties, many of these barriers were lowered as domestic industries began to outgrow internal capital, technological, and managerial resources. Foreign investment was sought to fill the gap, especially among the NIEs and EAEs. (See Dahlman 1994.)

Singapore was the leading recipient of foreign direct investment among the NIEs during the eighties. In the late 1980s, foreign investors were drawn by the rapid economic growth taking place in several EAEs – in particular Malaysia, but also China and Indonesia. In Singapore and Malaysia, the investment financed by domestic sources did not keep pace with the large and growing amounts of foreign investment in those countries; consequently, foreign investment accounts for a significant share of total domestic investment. Net flows of foreign direct investment represented over 25 percent of Singapore's gross domestic fixed investment in 1990 and 18 percent of Malaysia's. (See figure 12 and appendix table 18.) In comparison, the

TEXT TABLE 3: Ownership of Companies Active in High-Tech Fields Operating in the United States, by Country of Ownership: March 1992

Country	All fields	Automation	Biotechnology	Computer hardware	Advanced materials	Photonics & optics	Software	Telecommunications	Electronic components
	NUMBER OF COMPANIES								
Japan	600	66	15	101	42	51	16	66	66
Taiwan	35	0	0	10	0	2	1	6	6
South Korea	22	1	1	6	1	0	1	3	5
Hong Kong	19	1	0	5	0	0	0	1	9
Singapore	15	0	0	4	0	0	2	0	1
India	6	2	0	0	0	0	2	0	0

SOURCE: Appendix table 17.

22 This discussion is based on information compiled in the CorpTech database, Corporate Technology Information Services, Inc., Woburn, Massachusetts. This database is one of the most current sources of information on small newly formed companies active in high-tech fields, and includes many of the new start-up and private companies missed by or not yet part of other databases. The CorpTech database does not claim to include all such U.S. companies, but estimates that it contains 65 percent of the high-tech companies with under 250 employees, 75 percent of medium-sized companies with 250 to 1,000 employees, and 99 percent of large companies (over 1,000 employees). Foreign ownership is determined by the national identity of the majority owner.

ratio of foreign direct investment (net flows) to gross domestic fixed investment in Taiwan and South Korea did not exceed 2.2 percent throughout the 1980s.

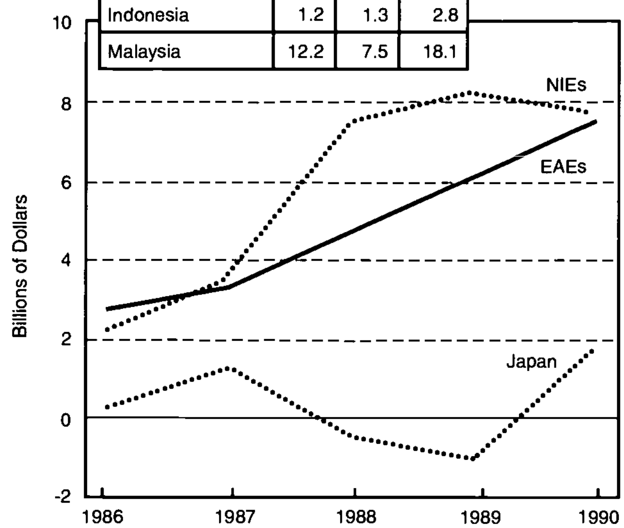
The Western industrialized nations have been major investors in Asia for many years. But during the 1980s, other Asian nations replaced the United States and Western Europe as major suppliers of foreign capital. India is the sole exception to this trend; it still received over 80 percent of its inward foreign investment from the United States and Western Europe. (See text table 4.) Elsewhere in the region, U.S. importance as a source of foreign investment diminished as Japan's investments increased during the mid- to late 1980s.[23] By the decade's end, supported by revenues generated by their successes in international markets, the Asian NIEs also became a major source of capital within the region – especially to the EAEs, as they invested in Malaysia, Indonesia, and, increasingly, China.

FIGURE 12: Foreign Investment in Asia

Foreign investors' share of total gross domestic fixed investment

	1980	1985	1990
Singapore	23.9	10.8	25.7
S. Korea	0.0	0.8	(0.1)
Taiwan	0.0	2.2	(11.1)
Indonesia	1.2	1.3	2.8
Malaysia	12.2	7.5	18.1

NOTE: Negative numbers denote a net outflow.



SOURCE: Appendix table 18; and U.S. International Trade Commission, *East Asia: Regional Economic Integration and Implications for the United States*. USITC Publication 2621 (Washington, DC: U.S. Government Printing Office, 1993), table 5-14. Data compiled by International Monetary Fund, Central Bank of China, and Taiwan District, The Republic of China.

TEXT TABLE 4: Source of Foreign Direct Investment

Host country	Japan	United States	Western Europe	Other Asian economies	Other
	SOURCE (PERCENT)				
NIEs:					
Hong Kong (1989)	54.2	2.3	21.5	9.8	12.2
Singapore (1989)	45.6	19.6	35.7	0.0	0.9
South Korea (1988)	48.9	26.8	18.0	2.7	3.5
Taiwan (1988)	37.6	13.6	8.2	18.0	22.5
EAEs:					
China (1988)	16.1	7.4	6.1	69.8	0.6
India (1988)	7.3	40.5	41.1	2.6	8.5
Indonesia (1990)	25.6	1.8	12.2	31.4	29.0
Malaysia (1990)	23.9	3.2	9.3	54.6	9.0

SOURCE: United Nations, Transnational Corporations and Management Division, Department of Economic and Social Development, *World Investment Directory 1992: Volume 1, Asia and the Pacific* (New York: 1992).

23 Much of this discussion on investment patterns in Asia draws on information presented in USITC (1993).

Competitiveness 2

The Office of Technology Assessment (1991) has defined competitiveness as ". . . the degree to which a nation can, under free and fair market conditions, produce goods and services that meet the test of international markets while simultaneously maintaining or expanding the real incomes of its citizens."[24] Asian competitiveness is examined within this framework, beginning with a look at the region's recent experience in exporting to the United States, followed by an examination of the internal economic impacts of Asia's growing share of the global market.

COMPETITIVENESS IN THE MARKETPLACE

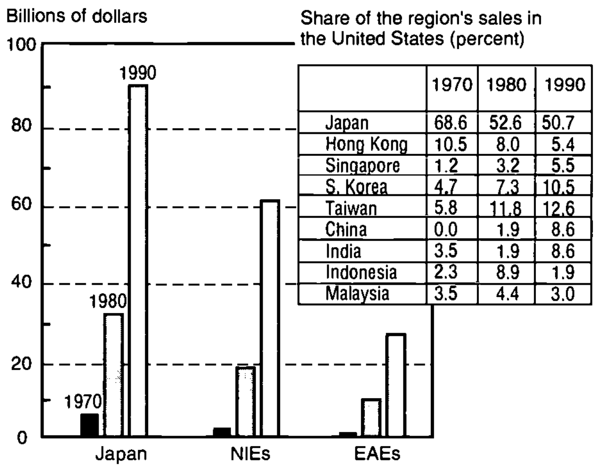
Over the past two decades Asian exports have grown dramatically in volume and sophistication. Once thought of as suppliers of cheap manufactures, the economies of the Asian region, one by one, have elevated their technical capabilities – becoming, in the process, suppliers of some of the most advanced products available anywhere. In the United States, arguably the single most important and demanding market in the world, the region's successes are obvious and varied, reaching across a full spectrum of goods and services. (See figure 13 and text table 5.) Asian products enjoy market acceptance in fundamental industries such as steel and electronics and in myriad products that incorporate outputs of these industries including motor vehicles, semiconductors, and VCRs.

All Manufactured Products.

In the U.S. market, Asian economies registered sales of manufactured goods averaging $180 billion annually during a recent 3-year period (1989-91) and maintained an average trade balance with the United States of nearly $78 billion. (See figure 14 and appendix table 19.) Merchandise imports from Asia represent approximately 7 percent of total U.S. imports.

[24] For further discussion of international competiveness, see Competitiveness Policy Council (1993) and OTA 1991.

FIGURE 13: U.S. Imports From the Asian Region



	1970	1980	1990
Japan	68.6	52.6	50.7
Hong Kong	10.5	8.0	5.4
Singapore	1.2	3.2	5.5
S. Korea	4.7	7.3	10.5
Taiwan	5.8	11.8	12.6
China	0.0	1.9	8.6
India	3.5	1.9	8.6
Indonesia	2.3	8.9	1.9
Malaysia	3.5	4.4	3.0

NOTE: Data include U.S. imports of both products and services.
SOURCE: Text table 5.

TEXT TABLE 5: Total U.S. Imports From the Asian Region (All Products and Services)

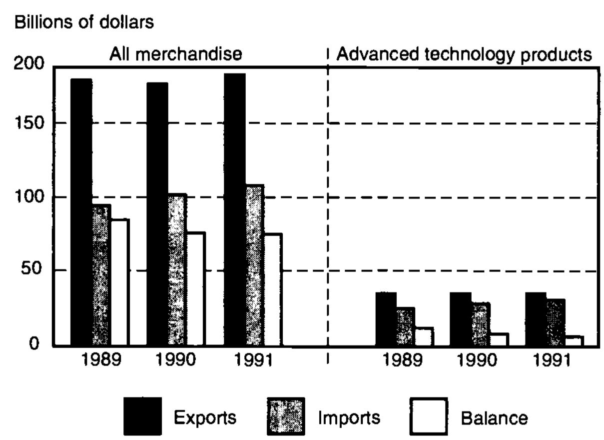
Country	1970	1980	1990
	BILLIONS OF DOLLARS		
Total Asian region....	8.6	58.7	176.9
Japan.............	5.9	30.9	89.7
NIEs..............	1.9	17.8	60.2
Hong Kong	0.9	4.7	9.6
Singapore	0.1	1.9	9.8
South Korea	0.4	4.3	18.5
Taiwan...........	0.5	6.9	22.3
EAEs	0.8	10.0	27.0
China	0.0	1.1	15.2
India	0.3	1.1	3.2
Indonesia	0.2	5.2	3.3
Malaysia	0.3	2.6	5.3

SOURCE: Bureau of the Census, Foreign Trade Division, unpublished tabulations.

Japan accounts for over half of the region's merchandise sales here, and the four NIEs collectively account for about one-third. While Japan and the NIEs showed flat or slightly declining sales during the 1989-91 period, China and Malaysia both increased their U.S. sales of manufactures (by 58 and 29 percent, respectively).

China has made tremendous gains in its ability to produce goods that meet international standards. During 1989-91, China's exports to the United States exceeded those of the other three EAEs combined as well as those of two of the Asian NIEs (Hong Kong and Singapore). And, in 1991, U.S. imports from China were greater than from South Korea. Footwear, clothing, and toys are among the leading products imported from China. (See USITC 1992.)

FIGURE 14: Asian Merchandise Trade With the United States



NOTE: Trade data are presented from Asia's perspective; e.g., exports from Asia to the United States, etc.
SOURCE: Appendix tables 14 and 19.

High-Tech Products.

The market competitiveness of the region's technological advances when embodied in new products and processes provides an important evaluation of the economic productivity of a nation's science and technology system. The Asian region has become an important supplier of high-tech products to the United States – the source of more than half of all such products purchased from abroad. Such success in selling high-tech products to a demanding market such as the United States indicates a highly productive science and technology system.

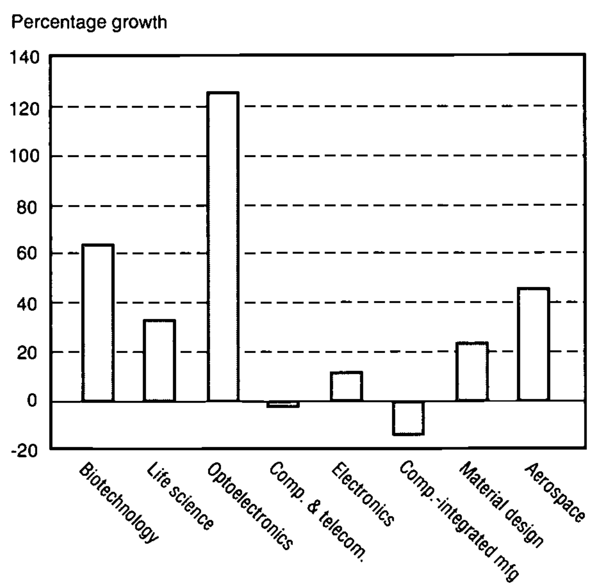
Asian sales of high-tech products (merchandise that incorporates advanced technologies) to the United States averaged nearly $34 billion annually, and exceeded Asian purchases of like-classified products from the United States each year between 1989 and 1991. (See figure 14 and appendix table 14.) Computers, telecommunication equipment, and electronics account for 80 percent of the region's high-tech sales in the United States and approximately 95 percent of the NIEs' high-tech sales. (See text table 6 and appendix table 14.)

TEXT TABLE 6: Composition of Asian High-Tech Sales in the United States, by Product Field: 1991

Product field	Japan	Newly industrialized economies: Hong Kong	Singapore	S. Korea	Taiwan	Emerging Asian economies: China	India	Indonesia	Malaysia
		MILLIONS OF DOLLARS							
All high-tech fields	19,793.4	1,047.6	5,952.8	3,357.4	3,441.2	355.5	15.2	89.4	2,332.0
		PERCENT							
Biotechnology	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
Life science	4.5	1.8	1.3	0.2	0.5	4.1	7.6	0.3	0.0
Optoelectronics	8.1	0.9	0.8	1.1	1.8	4.9	0.6	0.0	1.2
Computers and telecommunications	58.6	69.4	76.4	41.0	74.8	82.4	39.2	63.1	32.4
Electronics	17.0	27.1	19.2	52.8	19.4	0.6	14.2	29.2	65.6
Computer-integrated manufacturing	6.4	0.1	0.2	0.3	0.9	0.3	2.7	0.0	0.0
Material design	2.3	0.8	0.7	1.0	2.3	0.2	15.1	0.1	0.7
Aerospace	3.1	0.1	1.4	3.5	0.3	7.2	19.3	7.3	0.0
Weapons	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.0
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SOURCE: Appendix table 14.

FIGURE 15: Growth in Asian Exports of High-Tech Products to the United States: 1989-91

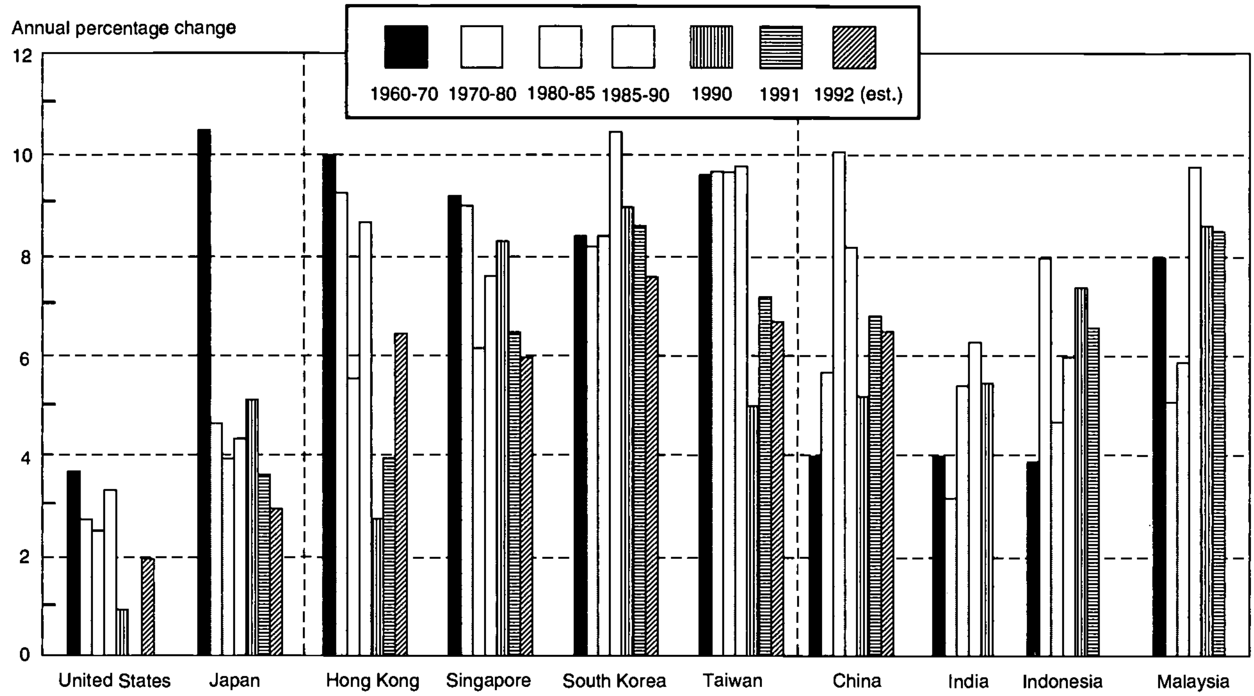


NOTE: Asian exports are estimated from U.S. imports from the nine Asian economies.

SOURCE: Appendix table 14.

The fastest growing product area for the region and also for Japan over this period was optoelectronic products. Japan's biotech products, although a very small share of Japan's technology sales in the United States, also found an increasingly receptive U.S. market. (See figure 15.) Among the other Asian economies, the technology products that experienced the most growth in U.S. sales varied. Two of the NIEs—Singapore and Taiwan—showed high U.S. sales growth in advanced materials products. Aerospace was a key growth technology area for two EAEs (India and Malaysia) as well as for South Korea. For China and Indonesia, growth in U.S. sales of computers and telecommunication products led all other technology product areas, while for Hong Kong, electronics experienced the fastest growing sales in the United States over the period.

FIGURE 16: Growth in Real Gross Domestic Product



NOTE: Growth is measured as percentage change in gross domestic product.
SOURCE: Appendix table 20.

Economic Gains

Asian industries' apparent success in the U.S. market provides convincing evidence that Asian products meet the challenge of the international marketplace. But have the region's citizens shared in this market success? To what extent has the market success discussed above helped to maintain or expand real income for Asia's people? This section examines evidence of an improved standard of living in the region using information on patterns of economic growth and earnings of manufacturing workers.

Economic Growth.

The economies that comprise the Asian region have enjoyed a pattern of sustained growth over the past three decades.[25] The newly industrialized economies grew at twice the rate of the Japanese economy during the 1970s and 1980s (their collective average annual rate was 9.3-percent growth versus 4.7 for Japan). South Korea and Taiwan led the NIEs in growth throughout most of this time period. (See appendix table 20.)

The emerging Asian economies grew more slowly than the NIEs during the 20-year span from 1970 to 1990, but their rate was still generally faster than Japan's. The Indonesian and Malaysian economies grew at an impressive pace during the seventies, and China led all EAEs during the eighties. In the 1990s, China and Malaysia ranked with South Korea and Taiwan as the fastest growing economies in the region. (See figure 16.) In comparison, the U.S. real gross domestic product (GDP) grew at a 2.8-percent annual rate during the 1970s and a 2.6-percent rate during the 1980s.

GDP growth, when normalized by the wide-ranging size of populations in the region, is highest for Hong Kong; it overtook Japan's per capita GDP in 1986. (See figure 17 and appendix table 21.) Singapore also records a relatively high per capita GDP.

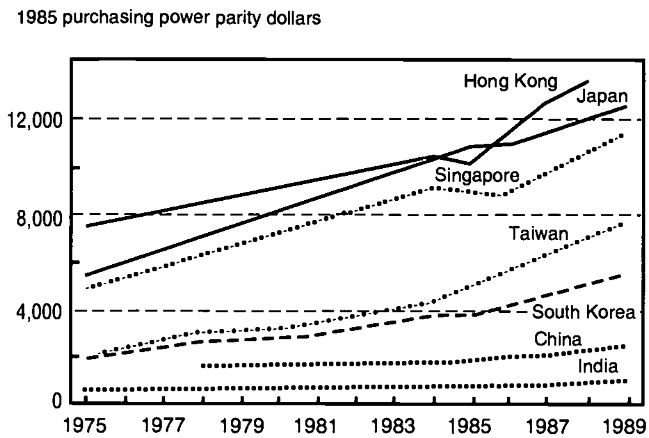
Labor Compensation.

Trends in compensation to Asia's manufacturing workers provide two separate insights on the region's competitiveness position. First, they highlight the

[25] Growth is measured as increases in real gross domestic product (GDP) based on 1985 U.S. dollars.

sizable cost advantage enjoyed by Asian corporations resulting from what are still significantly lower labor costs when compared with Asia's global competitors in the United States and Europe.[26] Second, the sharp rise in labor costs over the 1975-90 period suggests that Asia's manufacturing workers are beginning to share in the economic rewards of the market successes achieved over the last two decades.

FIGURE 17: Real Gross Domestic Product Per Capita



NOTE: Data for Indonesia and Malaysia were not available.
SOURCE: Appendix table 21.

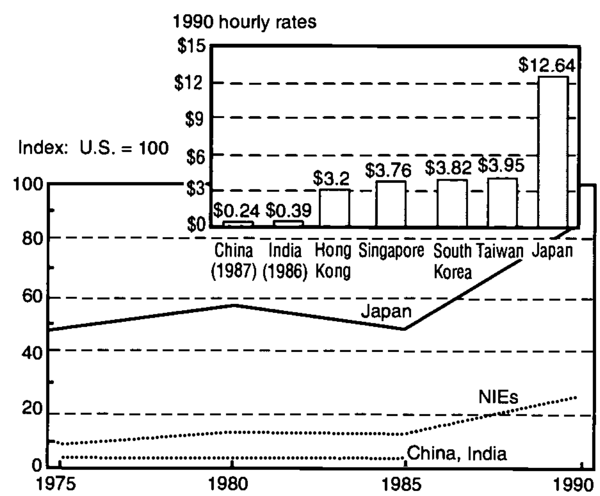
Within the Asian region, compensation paid (earnings and benefits) to workers varies widely.[27] (See figure 18 and appendix tables 22 and 23.) In 1990, Japan's manufacturing workers earned approximately three times that paid to workers in the NIEs. Japanese workers' earnings nearly doubled since 1985 and are now very near that earned by U.S. workers.

Manufacturing workers in NIEs saw their wages and benefits increase somewhat faster than did their Japanese counterparts. Since 1975, hourly compensation for the NIEs increased by a factor of seven compared to a fourfold increase in Japan.

Growth in compensation paid to workers in South Korea and Taiwan outpaced the growth in the other NIEs (Hong Kong and Singapore). Limited data reported for China and India yield a more erratic trend, but the labor compensation rates in these countries remain extremely low by regional and international standards. Indonesian and Malaysian labor costs fall between those of the NIEs and those of China – Malaysia is closer to the NIEs; Indonesia is closer to China. (See Schlossstein 1991, p. 312.)

In the near future, earnings for workers in the emerging Asian economies should follow the rapid growth experienced by the other nations in the region. As labor costs rise, Asian industry will incorporate more labor saving capital equipment and other manufacturing technology in their production processes, thereby encouraging further indigenous technology development.

FIGURE 18: Manufacturing Workers' Compensation Costs



SOURCE: Appendix tables 22 and 23.

[26] In Asia, only Japanese workers are compensated at a level comparable to workers in the United States and Europe.

[27] The compensation data presented here are designed to compare international labor costs and to gauge trends in worker income. The compensation and other pay measures were computed in national currency units and subsequently converted into U.S. dollars at prevailing commercial market currency exchange rates. These data do *not* account for differences in purchasing power and therefore cannot compare living standards for workers in these countries.

Prospects for the Future 3

What part will Asia play in high-technology development and sales as we move into the 21st century? Overall, the region's large and continuing investments in both science and engineering education and R&D can be a base from which to advance its position in many high-tech areas. (See NSF 1993.) By individual economy, however, the answer will differ depending on each economy's past, current, and continuing investments in relevant resources and infrastructure.

This section presents an assessment of future national competitiveness in high-tech industries for Asia's four newly industrialized and four emerging economies. This competitiveness is gauged through scores on the following leading indicators:

- **National orientation**[28]–evidence that a nation is taking directed action to achieve technological competitiveness. These actions might be explicit and/or implicit national strategies involving cooperation between the public and private sectors.
- **Socioeconomic infrastructure**–the social and economic institutions that support and maintain the physical, human, organizational, and economic resources essential to the functioning of a modern, technology-based industrial nation. Evidence of this type of infrastructure might be dynamic capital markets, upward trends in capital formation, rising levels of foreign investment, and national investments in education.
- **Technological infrastructure**–the social and economic institutions that contribute directly to a nation's capacity to develop, produce, and market new technology. Evidence of a supportive technological infrastructure might include the existence of a system for the protection of intellectual property rights, the extent to which R&D activities relate to industrial application, a nation's competency in high-tech manufacturing, and a nation's capability to produce qualified scientists and engineers from the general population.

[28] This indicator was called "national commitment" in *Science & Engineering Indicators* – 1993; here it is referred to by the term used by its originators.

- **Productive capacity** – the physical and human resources devoted to manufacturing products, and the efficiency with which those resources are used. A nation's productive capacity for future high-tech production can be assessed by examining its current level of high-tech production, including the quality and productivity of its labor force, the presence of skilled labor, and the existence of innovative management practices.

These four indicators were designed (see box) to identify countries that have the potential to become more important exporters of high-technology products over the next 15 years. An analysis of these indicators as applied to the eight Asian economies under consideration follows.

National Orientation

The national orientation indicator attempts to identify those nations whose business, government, and cultural orientation encourage high-technology development. This indicator was constructed using information from a survey of international experts and published data. The survey asked the experts to rate national strategies that promote high-tech development, social influences favoring technological change, and entrepreneurial spirit. Published data were used to rate each nation's risk factor for foreign investment over the next 5 years. (See Frost and Sullivan 1993.)

Singapore outscored the other Asian NIEs on each of the components that comprise this indicator. (See figure 19.) The national orientation ratings for Taiwan and South Korea are nearly equal, although each country's composite score is built on different strengths. Taiwan edged out South Korea on the composite score, as the published data rated Taiwan a better risk for foreign investment than South Korea and experts surveyed gave the edge to Taiwan in "entrepreneurial spirit." On the other hand, experts felt that, compared to Taiwan, South Korea had a more explicit government strategy to promote the production of high-tech goods for foreign consumption and had basic societal characteristics (cultural, religious, and/or industrial) that more closely associate technology with

New Leading Indicators of National Technological Competitiveness

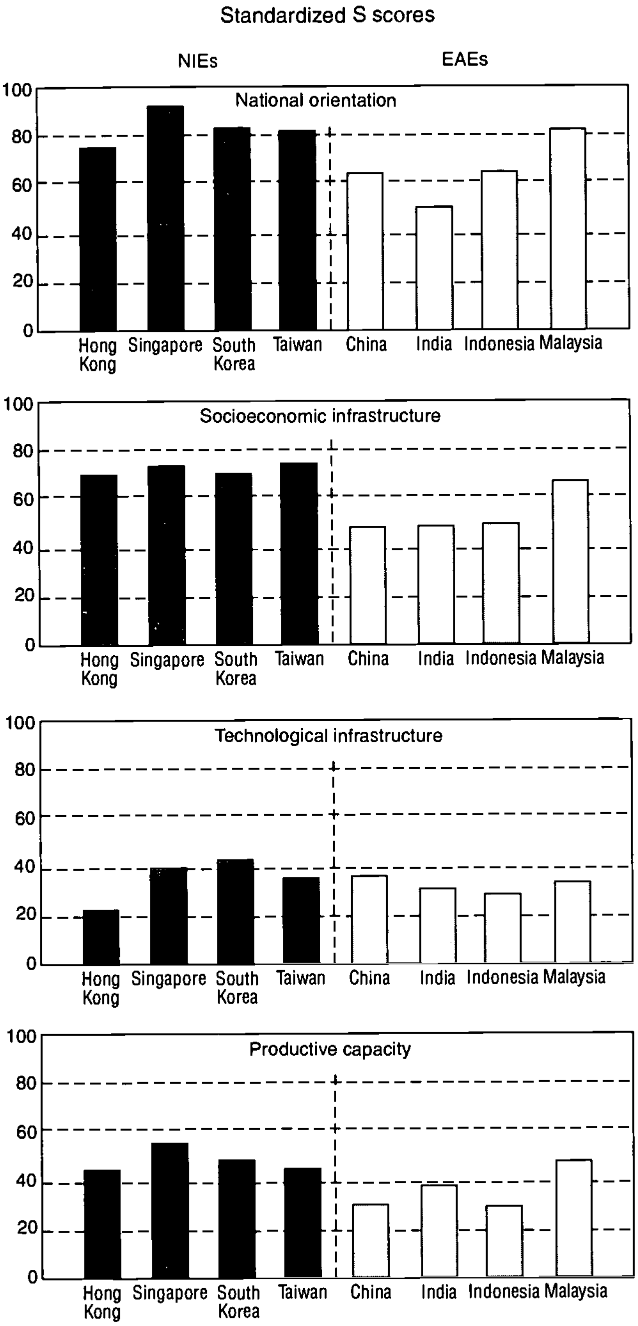
How can a country's future technological competitiveness be determined? An ongoing series of research projects, begun in the mid-1980s, is aimed at answering this question by developing new indicators of national technological competitiveness. This NSF-supported research is being performed in three phases at the Georgia Institute of Technology.

In the study's first phase, the researchers created a conceptual model involving a set of composite indicators that could be used to assess current and future national competitiveness in technology-based product markets. They operationalized the model by combining, for each indicator, various quantitative data with expert-derived measures. To obtain the expert input required, the researchers designed a survey instrument consisting of 14 closed-ended questions. Corresponding to the three phases of the research, surveys were sent to samples of country experts during 1987, 1990, and 1993; these experts were selected based on their knowledge of the technology policies and socioeconomic conditions in the countries studied. Generally, the survey items discriminated well among countries, and the mean standard deviation of responses to individual questions within countries was less than one on a five-point scale. (See Porter and Roessner 1991 for details of survey and indicator construction and Roessner, Porter, and Xu 1992 for information on the validity and reliability testing the indicators have undergone.)

In the first phase, 20 countries were studied. In the second phase, overall country coverage was expanded to 27 and alternative formulations of the indicators were explored. The third phase of the research effort is currently under way; this phase involves further model refinement and testing.

While the conclusions drawn from these indicators should be considered preliminary, they are consistent with trends reported here and elsewhere (see, for example, NSF 1993). These indicators were also used by the Office of Technology Assessment to examine Mexico's technological prospects (OTA 1992).

FIGURE 19: Leading Indicators of Technological Competitiveness



NOTE: Scores were normalized to median values of zero based on raw scores calculated for 28 countries included in the project.

SOURCE: Appendix table 24.

desirable social development. Hong Kong's composite rating for the national orientation indicator trailed that of the other three NIEs. Although it, like Taiwan, received high ratings for "entrepreneurial spirit," the uncertainty created by its pending merge with China affected its scores on the variables related to risk investment and experts' judgments of cultural and social attitudes toward technology.

Three of the four emerging Asian economies (China, India, and Indonesia) scored quite low on this indicator. Their scores were diminished by experts' comparatively low judgments of their cultural and social attitudes toward new technology and entrepreneurship. India had the lowest overall score of these three EAEs, primarily because it was rated a riskier prospect for foreign investment and was perceived as having less deliberate government strategy to promote high-tech industries.

Malaysia is pulling ahead of the other EAEs in its national orientation toward achieving future technological competitiveness. Across the full range of variables considered, Malaysia's scores were consistently and significantly higher than the other EAEs' and were well within the range of scores accorded to the more advanced Asian NIEs.

Socioeconomic Infrastructure

This indicator assesses the underlying physical, financial, and human resources needed to support modern, technology-based economies. It was built from published data on percentages of population in secondary school and in higher education[29] and survey data evaluating the mobility of capital and the extent to which foreign businesses are encouraged to invest and/or do business in that country.

The data show a fairly clear separation between the NIEs and EAEs. (See figure 19.) Singapore again leads the Asian NIEs: its score reflects high expert ratings for variables comparing mobility of capital and the encouragement of foreign investment. Singapore's small size and national plan for technology-based growth certainly contribute to its high scores. Hong Kong had the next highest overall score on this indicator and showed strength in these same two variables. Taiwan's and South Korea's overall indicator scores trailed those of Singapore and Hong Kong, especially in the two expert-derived variables. However, they posted strong scores in the single variable that compares track records for general and higher education.

[29] The Harbison-Myers Skills Index (which measures the percentage of population attaining secondary and higher educations) was used for these assessments. (See The World Bank, *World Development Report 1992*, Oxford University Press, 1993.)

Among the EAEs, Malaysia's socioeconomic infrastructure was rated highest. Malaysia's score was bolstered by a stronger showing in both published education data and the experts' opinions of the country's physical and financial resources. China had the lowest overall score; it was held back by lower ratings on the variables judging mobility of capital and encouragement of foreign-owned business and investment. In earlier surveys conducted during phases I and II of this research (see box), India's socioeconomic infrastructure rated slightly behind China's. India's new, higher scores probably reflect an improved operating environment for foreign business – the result of numerous reforms instituted by the Indian Government in 1992.

Technological Infrastructure

Five variables are used to develop this indicator, which evaluates the institutions and resources that contribute to a nation's capacity to develop, produce, and market new technology. This indicator was constructed using—

- published data on the number of scientists in R&D;
- published data on national purchases of electronic data processing equipment; and
- survey data that asked experts to rate the nation's capability to train citizens locally in academic science and engineering, the ability to make effective use of technical knowledge, and the linkages of R&D to industry.

South Korea received the highest composite score of all eight Asian economies, with relatively strong ratings on each of the variables. (See figure 19.) The lowest score was accorded to Hong Kong;[30] this may be because of Hong Kong's traditional reliance on entrepreneurial expertise over formally conducted R&D. In addition, its comparatively small population may have played some part in its low score since numbers of trained scientists and engineers and the size of the attendant R&D enterprise are compared with economies with much larger populations. Yet even though Singapore's population is smaller than Hong Kong's, Singapore's extensive national investments in information technology and its prominence in the region as a computer manufacturer more than compensated for any population bias. Singapore's technological infrastructure was rated nearly as high as South Korea's and better than Taiwan's.

Among the EAEs, China and Malaysia have the highest rated technological infrastructures. China scored well on each of the variables, but distanced itself from the other EAEs by virtue of its comparatively large purchases of computer equipment. Malaysia's high rating was based on its national mastery of high-tech production and the close relationship between its R&D activities and industrial enterprise. India's score rested on the strength of its large number of trained scientists and engineers and their many contributions to the science and technology knowledge base. Indonesia's large population did not save it from the lowest ranking among EAEs; it garnered low scores on each of the variables making up this indicator.

Productive Capacity

This indicator evaluates the strength of a nation's current, in-place manufacturing infrastructure as a baseline for assessing its capacity for future growth in high-tech activities. It factors in expert opinion on the availability of skilled labor, numbers of indigenous high-tech companies, and management capabilities in the country, combined with published data on current electronics production in each country.

Singapore's productive capacity scored the highest among the NIEs, elevated by the experts' high opinion of this country's pool of labor and management personnel. (See figure 19.) South Korea scored higher than both Taiwan and Hong Kong by virtue of its higher score on the variable measuring electronics manufacturing.[31]

Malaysia once again stood out among the EAEs – in fact, its score was closer to that of the NIEs than to any in the group of emerging Asian economies. India also scored quite high compared to the other countries in this group, supported by its comparatively large electronics manufacturing industry and–once again–by its tradition of training its students in science and engineering.

[30] Hong Kong's overall score is understated because no data are reported for this country on the number of scientists and engineers in R&D (UN Statistical Yearbook). This omission notwithstanding, compared to the other NIEs, Hong Kong scored poorly on the other four variables. This assessment of Hong Kong may change in the near future as the country's rule shifts from the United Kingdom to China in 1997: Hong Kong recently opened a new University of Science and Technology and an Industrial Technology Center. See *Business Week* (1992).

[31] This is consistent with trends discussed earlier about these economies' sales of advanced technology products in the United States.

Report Summary

Based on the various indicators of technological activity and competitiveness presented in this report, several Asian economies stand out and appear headed toward greater prominence as developers of technology and as more visible competitors in markets for high-tech products.

Among the group of Asian NIEs, Taiwan and South Korea are likely to increase their competitiveness in technology-related fields and product markets. This conclusion is based on both economies' strong patent activity in the United States in electronics and telecommunications, data showing both economies increasing their licensing of technological know-how, and data showing both economies' rapidly rising imports of U.S. products that incorporate advanced technologies. Other indicators highlight the technological infrastructure in place in both economies that should support further growth in high-tech industries. (Technological infrastructure is defined by the existence of a system of intellectual property rights, R&D activities closely connected to industrial applications, large number of qualified scientists and engineers, etc.)

The other two Asian NIEs, Singapore and Hong Kong, also show strong signs of technological strength and scored impressively on many of the indicators. However, both seem to be functioning on a somewhat narrower technological foundation than either Taiwan or South Korea. Singapore and Hong Kong have not shown the same level of patent activity or the same presence in global technology markets as have the other two NIEs. Their comparatively small populations have probably limited the impact of these economies across a broad spectrum of technological areas.

Among the group of Asian EAEs, Malaysia stands out based on the technology indicators presented and could develop into the next Asian "tiger." Like Taiwan and South Korea, Malaysia is purchasing increasing amounts of advanced technology products and continues to attract large amounts of foreign investment — much if it in the form of new high-tech manufacturing facilities. Even if these facilities are mostly platform (assembly) operations today, Malaysia's strong national orientation (defined by the existence of national strategies and an accepting environment for foreign investment), socioeconomic structure (evidence of functioning capital markets and rising levels of foreign investment and investments in education), and productive capacity (future capacity suggested through assessments of current level of high-tech production combined with evidence of skilled labor and innovative management) suggest that as Malaysia gains technological capabilities, more complex processing will likely follow. While it still has a long way to go before joining the ranks of the NIEs, Malaysia shows many signs of developing the resources it will need to compete in global technology markets.

India shows considerable strength in certain of the indicators but also shows weakness. India has a long tradition of educating highly qualified scientists and engineers and of excellence in basic research, yet it also continues to have one of the highest illiteracy rates in the region. This anomaly produced one of the lowest scores among the eight economies for the socioeconomic infrastructure indicator. Uneven acceptance of foreign products and investment have inhibited internal competition that otherwise might have motivated India to better capitalize on its engineering strengths. Some of India's regulations and policies related to foreign investment are slated to change, and this may improve the country's situation over the long run (See Economist 1991). Evidence of positive change occurring in India surfaced in the model of leading indicators: India's socioeconomic infrastructure received a higher expert rating in the 1993 survey than in that conducted in 1990.[32]

[32] See section 3 - Prospects for the Future.

China and Indonesia show many mixed signs in these indicators of technology development and competitiveness. Both show rising purchases of U.S. high-tech products and increased licensing of U.S. technical know-how. Yet compared with the other Asian economies, these economies do not show the same level of national orientation, technological infrastructure, and productive capacity that would project technological competitiveness in the near future.

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Appendix: Detailed Data Tables

List of Tables

Appendix table 1. Natural science and engineering bachelor's degrees as a share of total bachelor's degrees, in selected Asian countries and the United States: 1980 and 1990

Country	All bachelors degrees		NS&E degrees		NS&E share	
	1980	1990	1980	1990	1980	1990
	Number				Percent	
Total Asian region	1,441,880	1,712,648	481,825	528,954	33.4	30.9
Japan	378,666	400,103	97,473	106,508	25.7	26.6
Newly industrialized economies	87,841	214,868	31,071	69,247	35.4	32.2
Hong Kong	NA	NA	NA	NA	NA	NA
Singapore	2,645	6,000	861	2,498	32.6	41.6
South Korea	50,973	165,916	19,413	51,266	38.1	30.9
Taiwan	34,223	42,952	10,797	15,483	31.5	36.0
Emerging Asian economies	975,373	1,097,677	353,281	353,199	36.2	32.2
China [1]	365,787	308,930	222,105	162,648	60.7	52.6
India	599,795	750,000	126,154	175,774	21.0	23.4
Indonesia	9,791	38,747	5,022	14,777	51.3	38.1
Malaysia	NA	NA	NA	NA	NA	NA
United States	940,251	1,062,151	176,774	169,726	18.8	16.0

NA = not available

NS&E = natural science and engineering

[1] The earliest data available for China are for 1982.

SOURCES: National Science Foundation, Science Resources Studies Division, *Human Resources for Science and Technology: The Asian Region*, by Jean Johnson, NSF 93-303 (Washington, DC: 1993), table A-3; and *Science & Technology Indicators of Indonesia 1993, 1st edition* (Republic of Indonesia, Science and Technology for Industrial Development: 1993).

Appendix table 2. Research and development expenditures in Asian region: 1975-90

Year	Japan	Newly industrialized economies				Emerging Asian economies		
		Hong Kong	Singapore	South Korea	Taiwan	China	India	Indonesia
	Millions of 1987 purchasing power parity dollars							
1975	18,296	NA	NA	NA	NA	NA	1,702	NA
1976	19,048	NA	NA	378	NA	NA	1,704	NA
1977	19,677	NA	28	577	NA	NA	1,857	NA
1978	20,959	NA	34	663	388	NA	2,220	NA
1979	23,031	NA	39	632	539	NA	2,302	NA
1980	25,382	NA	42	620	494	NA	2,460	NA
1981	28,054	NA	48	734	685	NA	2,759	NA
1982	30,093	NA	63	1,072	681	NA	3,293	NA
1983	32,888	NA	84	1,388	760	NA	3,476	NA
1984	35,830	NA	116	1,790	880	NA	4,172	NA
1985	39,992	NA	141	2,383	990	NA	4,513	NA
1986	40,692	NA	174	3,057	1,083	NA	4,982	NA
1987	43,712	NA	208	3,638	1,381	NA	5,377	NA
1988	47,106	NA	230	4,294	1,629	NA	5,828	NA
1989	51,718	NA	258	4,726	1,974	NA	6,037	NA
1990	55,943	NA	292	5,045	2,476	21,465	6,090	NA
	Percentage of gross domestic product							
1975	1.8	NA	NA	NA	NA	NA	0.5	NA
1976	1.8	NA	NA	0.4	NA	NA	0.4	NA
1977	1.8	NA	0.2	0.6	NA	NA	0.5	NA
1978	1.8	NA	0.3	0.6	0.6	NA	0.5	NA
1979	1.9	NA	0.3	0.6	0.8	NA	0.6	NA
1980	2.0	NA	0.3	0.6	0.7	NA	0.6	NA
1981	2.1	NA	0.3	0.6	0.9	NA	0.6	NA
1982	2.2	NA	0.3	0.8	0.9	NA	0.7	NA
1983	2.4	NA	0.4	1.0	0.9	NA	0.7	NA
1984	2.5	NA	0.5	1.1	1.0	NA	0.8	NA
1985	2.6	NA	0.7	1.4	1.0	NA	0.8	NA
1986	2.6	NA	0.8	1.6	1.0	NA	0.8	NA
1987	2.7	NA	0.9	1.7	1.1	NA	0.9	NA
1988	2.7	NA	0.9	1.8	1.3	NA	0.8	NA
1989	2.9	0.4	0.9	1.9	1.4	0.4	0.8	NA
1990	2.9	NA	0.9	1.9	1.7	0.7	0.8	NA

NA = not available

SOURCE: National Science Foundation, Science Resources Studies Division, *Human Resources for Science and Technology: The Asian Region*, by Jean Johnson, NSF 93-303 (Washington, DC: 1993), table A-16.

Appendix table 3. Patent applications filed and patents granted: 1985-90

Reporting country	Patent applications filed by			Patents granted to		
	Residents	Nonresidents	Total	Residents	Nonresidents	Total
			1985			
Total Asian region	297,221	56,222	353,443	49,142	15,957	65,099
Japan	274,398	30,997	305,395	42,323	7,777	50,100
Newly industrialized economies	17,776	18,239	36,015	6,345	6,796	13,141
Hong Kong	16	955	971	14	1,016	1,030
Singapore	4	1,003	1,007	2	414	416
South Korea	2,702	7,465	10,167	349	1,919	2,268
Taiwan	15,054	8,816	23,870	5,980	3,447	9,427
China	4,065	4,493	8,558	42	2	44
India	982	2,493	3,475	432	1,382	1,814
United States	67,673	48,950	112,623	39,427	30,949	70,376
			1988			
Total Asian region	337,448	60,333	397,781	56,560	18,810	75,370
Japan	308,775	26,984	335,759	47,912	7,388	55,300
Newly industrialized economies	22,860	25,973	48,833	7,170	8,421	15,591
Hong Kong	12	1,056	1,068	9	1,061	1,070
Singapore	NA	NA	NA	NA	NA	NA
South Korea	5,696	12,558	18,254	575	1,591	2,166
Taiwan	17,152	12,359	29,511	6,586	5,769	12,355
China	4,780	4,872	9,652	617	408	1,025
India	1,033	2,504	3,537	861	2,593	3,454
United States	75,192	64,633	139,825	40,415	35,697	76,112
			1989			
Total Asian region	348,105	64,977	413,082	67,864	25,010	92,874
Japan	317,353	27,787	345,140	54,743	8,558	63,301
Newly industrialized economies	24,955	29,680	54,635	11,601	13,683	25,284
Hong Kong	15	886	901	19	1,011	1,030
Singapore	3	835	838	4	1,060	1,064
South Korea	7,020	13,773	20,793	1,181	2,744	3,925
Taiwan	17,917	14,186	32,103	10,397	8,868	19,265
China	4,749	4,910	9,659	1,083	1,220	2,303
India	1,048	2,600	3,648	437	1,549	1,986
United States	82,370	70,380	152,750	50,102	43,247	93,349
			1990			
Total Asian region	363,170	60,913	424,083	64,366	29,100	93,466
Japan	332,952	27,752	360,704	50,370	9,031	59,401
Newly industrialized economies	29,071	30,488	59,559	13,690	18,764	32,454
Hong Kong	21	1,060	1,081	23	1,072	1,095
Singapore	4	1,024	1,028	5	1,233	1,238
South Korea	9,082	14,025	23,107	2,554	4,966	7,520
Taiwan	19,964	14,379	34,343	11,108	11,493	22,601
China	NA	NA	NA	NA	NA	NA
India	1,147	2,673	3,820	306	1,305	1,611
United States	90,643	73,915	164,558	47,306	40,987	88,293

NA = not available

NOTE: Indonesia and Malaysia report to the World Intellectual Property Organization only the number of patent applications filed.

SOURCES: World Intellectual Property Organization, *Industrial Property Statistics* (Geneva, Switzerland: 1985-90); data for Taiwan provided by the Taiwan Coordination Council for North American Affairs, Washington, DC.

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Appendix table 4. U.S. patents granted: 1963-91

Region/country	1963-70	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Total Asian region..........	10,887	4,058	5,187	5,000	5,941	6,414	6,625	6,304	6,993	5,325	7,233	8,532
Japan............................	10,642	4,006	5,140	4,935	5,871	6,350	6,539	6,217	6,912	5,250	7,124	8,387
NIEs..............................	75	25	18	28	22	47	58	70	64	56	103	134
Hong Kong..................	59	19	7	15	9	10	20	9	21	13	27	33
Singapore....................	4	4	4	7	6	1	3	3	2	0	3	4
South Korea................	12	2	7	5	7	13	7	6	12	5	8	17
Taiwan........................	0	0	0	1	0	23	28	52	29	38	65	80
EAEs..............................	170	27	29	37	48	17	28	17	17	19	6	11
China..........................	38	15	8	10	22	1	6	1	0	2	1	3
India............................	83	10	19	21	17	13	17	13	14	14	4	6
Indonesia....................	43	2	2	6	8	0	2	0	2	1	1	1
Malaysia......................	6	0	0	0	1	3	3	3	1	2	0	1

Region/country	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Total
Total Asian region..........	8,279	8,919	11,282	13,005	13,518	17,047	16,806	21,004	20,573	22,366	231,298
Japan............................	8,149	8,792	11,109	12,743	13,198	16,538	16,140	20,116	19,477	20,916	224,551
NIEs..............................	123	110	156	247	286	472	601	816	1,020	1,363	5,894
Hong Kong..................	18	14	24	25	30	34	41	47	52	49	576
Singapore....................	3	5	4	9	3	11	6	18	12	15	127
South Korea................	14	26	30	39	45	84	97	159	225	401	1221
Taiwan........................	88	65	98	174	208	343	457	592	731	898	3970
EAEs..............................	7	17	17	15	34	37	65	72	76	87	853
China..........................	0	1	2	1	9	23	47	52	47	51	340
India............................	4	14	12	10	18	12	14	14	23	22	374
Indonesia....................	2	0	1	1	3	0	2	4	3	2	86
Malaysia......................	1	2	2	3	4	2	2	2	3	12	53

NIEs = newly industrialized economies

EAEs = emerging Asian economies

SOURCE: Office of Technology Assessment and Forecast, Patent and Trademark Office, "Patenting Trends in the United States/Country Report, 1963-91" (Washington, DC: Department of Commerce, September 1992).

Appendix table 5. Patent classes most emphasized by inventors from Japan patenting in the United States: 1980 and 1990

Patent class	Class number	Activity Index	
		1980	1990
Photography	354	4.606	3.470
Photocopying	355	2.776	3.408
Dynamic Information Storage or Retrieval	369	3.298	3.276
Static Information Storage and Retrieval	365	1.243	2.832
Radiation Imagery Chemistry -- Process, Composition or Products	430	3.332	2.709
Dynamic Magnetic Information Storage or Retrieval	360	3.235	2.648
Typewriting Machines	400	1.388	2.601
Recorders	346	2.306	2.573
Pictorial Communication; Television	358	2.578	2.510
Image Analysis	382	2.082	2.254
Active Solid State Devices, E.G., Transistors, Solid State Diodes	357	2.061	2.213
Internal-Combustion Engines	123	3.106	2.123
Music	84	2.468	2.059
Motor Vehicles	180	1.091	2.032
Machine Elements and Mechanisms	74	1.338	1.893
Electricity, Motive Power Systems	318	1.754	1.886
Clutches and Power-Stop Control	192	1.614	1.883
Metal Treatment	148	2.568	1.861
Coating Apparatus	118	1.506	1.801
Error Detection/Correction and Fault Detection/Recovery	371	1.617	1.782
Electrical Generator or Motor Structure	310	1.515	1.767
Telecommunications	455	3.170	1.582
Semiconductor Device Manufacturing Process	437	1.423	1.569
Sheet Feeding or Delivering	271	1.407	1.567
Electrical Computers and Data Processing Systems	364	1.268	1.547

NOTES: the Activity Index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1990.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1990," report prepared for the National Science Foundation (Washington, DC: July 1991).

Appendix table 6. Patent classes most emphasized by inventors from Hong Kong patenting in the United States: 1980 and 1990

Patent class	Class Number	Activity Index	
		1980	1990
Electrical Generator Or Motor Structure	310	0.000	19.739
Amusement Devices, Toys	446	40.471	19.471
Illumination	362	0.000	18.915
Cutlery	30	0.000	15.152
Foods And Beverages: Apparatus	99	0.000	9.870
Electric Power Conversion Systems	363	0.000	9.355
Closure Fasteners	292	0.000	9.078
Chemistry, Electrical Current Producing Apparatus, Product and Process	429	0.000	8.244
Beds	5	0.000	7.796
Amusement Devices, Games	273	9.744	6.035
Pictorial Communication; Television	358	0.000	4.973
Electrical Connectors	439	11.713	4.657
Special Receptacle Or Package	206	0.000	3.221
Part Of The Class 520 Series -- Synthetic Resins Or Natural Rubber	528	0.000	3.009
Electric Heating	219	0.000	2.927
Part Of The Class 520 Series -- Synthetic Resins Or Natural Rubber	525	0.000	2.842
Photocopying	355	0.000	2.727
Electricity, Measuring And Testing	324	0.000	2.525
Metal Working	29	0.000	2.453
Measuring And Testing	73	0.000	1.822
Stock Material Or Miscellaneous Articles	428	0.000	1.122
Amusement And Exercising Devices	272	0.000	0.000
Metal Treatment	148	0.000	0.000
Plastic And Nonmetallic Article Shaping Or Treating	264	0.000	0.000
Electrical Audio Signal Processing And Systems	381	0.000	0.000

NOTES: The Activity Index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1990.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1990," report prepared for the National Science Foundation (Washington, DC: July 1991).

Appendix table 7. Patent classes most emphasized by inventors from Singapore patenting in the United States: 1980 and 1990

Patent class	Class number	Activity Index	
		1980	1990
Amplifiers	330	0.000	35.189
Telecommunications	455	0.000	30.002
Pipe Joints Or Couplings	285	0.000	29.188
Chemistry, Electrical Current Producing Apparatus, Product or Process	429	0.000	28.852
Electrical Audio Signal Processing And Systems	381	0.000	24.690
Recorders	346	0.000	14.941
Fluid Handling	137	0.000	11.189
Part Of The Class 520 Series -- Synthetic Resins Or Natural Rubber	528	0.000	10.532
Metal Working	29	94.960	8.587
Electrical Connectors	439	0.000	8.150
Communications, Electrical	340	0.000	8.115
Amusement And Exercising Devices	272	0.000	0.000
Brushing, Scrubbing And General Cleaning	15	0.000	0.000
Drug, Bio-Affecting And Body Treating Compositions	424	0.000	0.000
Electricity, Circuit Makers And Breakers	200	0.000	0.000
Compositions	252	0.000	0.000
Heat Exchange	165	0.000	0.000
Liquid Purification Or Separation	210	0.000	0.000
Part Of The Class 532-570 Series -- Organic Compounds	548	0.000	0.000
Internal-Combustion Engines	123	0.000	0.000
Prosthesis (I.E., Artificial Body Members), Parts Or Aid	623	0.000	0.000
Surgery	604	0.000	0.000
Metal Treatment	148	0.000	0.000
Photocopying	355	0.000	0.000
Pictorial Communication; Television	358	0.000	0.000

NOTES: The Activity Index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1990.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1990," report prepared for the National Science Foundation (Washington, DC: July 1991).

Appendix table 8. Patent classes most emphasized by inventors from South Korea patenting in the United States: 1980 and 1990

Patent class	Class number	Activity Index	
		1980	1990
Semiconductor Device Manufacturing Process	437	0.000	13.751
Electrical Transmission Or Interconnection Systems	307	0.000	12.874
Heating Systems	237	0.000	13.439
Electric Heating	219	0.000	5.997
Dynamic Magnetic Information Storage Or Retrieval	360	0.000	5.880
Part Of The Class 520 Series -- Synthetic Resins Or Natural Rubber	523	0.000	5.298
Static Information Storage And Retrieval	365	0.000	4.942
Pictorial Communication; Television	358	0.000	4.670
Closure Fasteners	292	0.000	4.650
Telephonic Communications	379	0.000	4.563
Geometrical Instruments	33	0.000	4.432
Music	84	0.000	4.391
Telecommunications	455	0.000	4.391
Electricity, Motive Power Systems	318	0.000	3.723
Photography	354	0.000	3.578
Part Of The Class 532-570 Series -- Organic Compounds	548	0.000	3.510
Part Of The Class 532-570 Series -- Organic Compounds	562	0.000	2.728
Cleaning And Liquid Contact With Solids	134	0.000	2.714
Part Of The Class 520 Series -- Synthetic Resins Or Natural Rubber	521	0.000	2.701
Winding And Reeling	242	0.000	2.675
Amplifiers	330	0.000	2.575
Electrical Generator Or Motor Structure	310	0.000	2.528
Foods And Beverages: Apparatus	99	0.000	2.528
Glass Manufacturing	65	0.000	2.493
Amusement Devices, Toys	446	0.000	2.493

NOTES: The Activity Index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1990.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1990," report prepared for the National Science Foundation (Washington, DC: July 1991).

Appendix table 9. Patent classes most emphasized by inventors from Taiwan patenting in the United States: 1980 and 1990

Patent class	Class number	Activity Index	
		1980	1990
Closure Fasteners	292	0.000	10.034
Music	84	0.000	9.474
Stoves And Furnaces	126	0.000	6.193
Telephonic Communications	379	0.000	4.924
Special Receptacle Or Package	206	0.000	4.747
Amusement And Exercising Devices	272	0.000	4.649
Communications, Electrical	340	0.000	4.271
Semiconductor Device Manufacturing Process	437	0.000	4.239
Part Of The Class 532-570 Series -- Organic Compounds	562	0.000	3.924
Part Of The Class 520 Series -- Synthetic Resins or Natural Rubber	521	0.000	3.886
Electrical Transmission Or Interconnection Systems	307	0.000	3.704
Part Of The Class 532-570 Series -- Organic Compounds	544	0.000	3.653
Locks	70	0.000	3.620
Amusement Devices, Toys	446	131.530	3.587
Land Vehicle	280	0.000	3.467
Part Of The Class 532-570 Series -- Organic Compounds	560	0.000	3.373
Recorders	346	0.000	3.146
Joints and Connections	403	0.000	3.072
Dispensing	222	0.000	3.014
Chemistry, Hydrocarbons	585	0.000	3.003
Beds	5	0.000	2.872
Coated Data Generation Or Conversion	341	0.000	2.851
Electical Audio Signal Processing & Systems	381	0.000	2.599
Metal Treatment	148	0.000	2.590
Electricity, Electical Systems And Devices	361	0.000	2.528

NOTES: The Activity Index is the percentage of the patents in a class that are granted to investors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1990.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1990," report prepared for the National Science Foundation (Washington, DC: July 1991).

Appendix table 10. Patent classes most emphasized by inventors from China patenting in the United States: 1980 and 1990

Patent class	Class number	Activity index	
		1980	1990
Electricity, Conductors And Insulators	174	0.000	16.812
Part Of The Class 532-570 Series -- Organic Compounds	546	0.000	16.430
Part Of The Class 532-570 Series -- Organic Compounds	549	0.000	14.575
Mineral Oils: Processes And Products	208	0.000	12.421
Metal Treatment	148	0.000	11.813
Electricity, Circuit Makers And Breakers	200	0.000	11.261
Gas Separation	55	0.000	9.769
Geometrical Instruments	33	0.000	9.691
Classification Undetermined	1	0.000	9.413
Catalyst, Solid Sorbent, Or Support Therefore, Product	502	0.000	8.903
Electrical Generator Or Motor Structure	310	0.000	8.290
Chemistry: Molecular Biology And Microbiology	435	0.000	7.866
Electric Heating	219	0.000	4.918
Stock Material Or Miscellaneous Articles	428	0.000	3.771
Radiation Imagery Chemistry -- Process, Composition Or Products	430	0.000	3.111
Radiant Energy	250	0.000	2.901
Electrical Computers And Data Processing Systems	364	0.000	1.439
Amusement And Exercising Devices	272	0.000	0.000
Part Of The Class 532-570 Series -- Organic Compounds	548	0.000	0.000
Metal Working	29	0.000	0.000
Prothesis (I.E., Artificial Body Members), Parts Or Aid	623	0.000	0.000
Surgery	604	0.000	0.000
Measuring And Testing	73	0.000	0.000
Photocopying	355	0.000	0.000
Electrical Audio Signal Processing And Systems	381	0.000	0.000

NOTES: The Activity Index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1990.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1990," report prepared for the National Science Foundation (Washington, DC: July 1991).

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Appendix table 11. Patent classes most emphasized by inventors from India patenting in the United States: 1980 and 1990

Patent class	Class number	Activity Index	
		1980	1990
Part Of The Class 520 Series -- Synthetic Resins Or Natural Rubber	525	0.000	29.843
Catalyst, Solid Sorbent, Or Support Therefore, Product	502	0.000	27.822
Solid Material Comminution Or Disintegration	241	0.000	25.441
Chemistry, Hydrocarbons	585	0.000	21.393
Mineral Oils: Processes And Products	208	0.000	19.409
Internal-Combustion Engines	123	0.000	5.011
Pictorial Communication; Television	358	0.000	4.351
Drug, Bio-Affecting And Body Treating Compositions	514	0.000	2.447
Amusement And Exercising Devices	272	0.000	0.000
Electric Lamp And Discharge Devices	313	0.000	0.000
Communication, Electrical: Acoustic Wave Systems And Devices	367	0.000	0.000
Liquid Purification Or Separation	210	0.000	0.000
Brushing, Scrubbing And General Cleaning	15	0.000	0.000
Drug, Bio-Affecting And Body Treating Compositions	424	37.787	0.000
Electricity, Circuit Makers And Breakers	200	0.000	0.000
Compositions	252	0.000	0.000
Heat Exchange	165	0.000	0.000
Electrical Connectors	439	0.000	0.000
Part Of The Class 532-570 Series -- Organic Compounds	548	0.000	0.000
Metal Working	29	0.000	0.000
Prothesis(I.E., Artificial Body Members), Parts Or Aid	623	0.000	0.000
Surgery	604	0.000	0.000
Metal Treatment	148	0.000	0.000
Photocopying	355	0.000	0.000
Electrical Audio Signal Processing And Systems	381	0.000	0.000

NOTES: The Activity Index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1990.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1990," report prepared for the National Science Foundation (Washington, DC: July 1991).

Appendix table 12. Number of U.S. patents granted to inventors from Asia, by field: 1980-90

Region/country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
						Computers						
Total Asian region	255.2	320.7	438.7	487.4	610.9	845.8	868.4	1,018.4	1,045.6	1,383.1	1,260.2	8,534.4
Japan	253.2	317.9	436.9	484.9	609.9	843.3	863.7	1,011.3	1,038.1	1,368.5	1,239.4	8,467.2
NIEs	2.0	2.8	1.8	2.5	1.0	2.5	4.5	5.6	7.5	14.6	18.8	63.5
Hong Kong	0.0	2.3	0.5	0.5	1.0	1.5	1.0	1.0	1.0	1.0	1.0	10.8
Singapore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.0	1.3
South Korea	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.3	3.8	6.3	8.0	21.4
Taiwan	2.0	0.5	1.3	1.0	0.0	1.0	3.5	2.0	2.7	7.3	8.8	30.0
EAEs	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.5	0.0	0.0	2.0	3.7
China	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	1.5	3.0
India	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.5	0.7
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
United States	773.3	766.2	815.0	880.7	1,036.8	1,027.6	888.3	860.4	849.7	1,170.9	1,311.9	10,380.9
						Industrial machinery						
Total Asian region	346.8	397.1	416.5	379.0	534.4	714.7	681.8	789.5	835.4	934.4	833.9	6,863.4
Japan	337.2	391.7	409.6	376.2	527.6	701.3	664.5	757.7	796.8	891.5	789.4	6,643.4
NIEs	9.6	5.4	6.6	2.8	5.5	13.1	16.8	29.3	33.3	41.0	41.9	205.3
Hong Kong	1.0	0.0	0.0	1.0	1.2	2.3	1.7	2.0	1.5	0.3	0.3	11.4
Singapore	0.5	0.5	0.2	0.0	0.0	0.0	0.5	1.2	0.0	1.2	0.0	4.1
South Korea	1.2	0.0	0.0	0.0	1.0	1.3	3.1	7.0	9.7	9.5	14.5	47.2
Taiwan	6.9	4.9	6.4	1.8	3.3	9.5	11.5	19.1	22.1	30.0	27.1	142.6
EAEs	0.0	0.0	0.3	0.0	1.3	0.3	0.5	2.5	5.3	1.9	2.6	14.7
China	0.0	0.0	0.0	0.0	0.3	0.0	0.5	2.5	5.2	0.8	2.3	11.7
India	0.0	0.0	0.3	0.0	1.0	0.3	0.0	0.0	0.1	1.0	0.3	2.9
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
United States	1,379.1	1,406.9	1,188.5	1,123.1	1,381.3	1,531.4	1,407.2	1,511.0	1,431.1	1,663.2	1,456.1	15,478.9
						Radio and television						
Total Asian region	218.4	190.0	198.2	200.5	236.2	288.9	311.2	420.9	372.7	495.0	438.5	3,370.6
Japan	216.4	189.0	197.2	199.0	236.0	288.3	307.7	416.1	364.9	480.4	422.7	3,317.9
NIEs	2.0	1.0	1.0	1.5	0.0	0.6	3.5	4.8	7.3	14.1	15.3	51.0
Hong Kong	1.0	0.5	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.0	3.5	6.5
Singapore	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	1.3	1.9
South Korea	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.8	6.0	10.0	8.5	29.8
Taiwan	1.0	0.5	1.0	1.5	0.0	0.0	2.5	0.0	1.3	3.1	2.0	12.8
EAEs	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.5	0.5	0.5	1.7
China	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.5	0.5	0.0	1.2
India	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
United States	236.2	243.8	260.8	293.8	266.8	349.9	323.8	367.9	305.2	319.0	294.3	3,261.6

Appendix table 12. Number of U.S. patents granted to inventors from Asia, by field: 1980-90

Region/country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
					Electronic components and communications equipment							
Total Asian region	852.4	983.6	1,081.0	1,175.5	1,398.1	1,846.0	1,981.6	3,039.1	2,950.8	3,973.9	3,827.6	23,109.1
Japan	844.4	968.8	1,065.8	1,165.2	1,387.4	1,824.1	1,967.1	3,001.9	2,884.8	3,864.4	3,671.6	22,645.4
NIEs	7.1	14.3	15.2	9.8	9.5	21.6	14.0	36.1	61.0	105.2	149.9	443.3
Hong Kong	2.3	5.5	3.3	2.8	2.5	1.5	1.5	3.5	3.3	5.5	4.8	36.3
Singapore	1.3	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.8	4.5	4.3	11.6
South Korea	0.0	0.0	4.0	0.5	2.5	4.0	2.0	8.3	13.5	33.3	64.2	132.3
Taiwan	3.5	8.8	7.9	6.5	4.5	15.5	10.2	24.3	43.4	61.9	76.6	263.1
EAEs	0.9	0.5	0.0	0.5	1.2	0.3	0.5	1.1	5.0	4.3	6.1	20.4
China	0.0	0.0	0.0	0.5	0.2	0.3	0.0	1.0	4.0	3.0	3.5	12.5
India	0.9	0.5	0.0	0.0	1.0	0.0	0.5	0.0	0.0	1.0	2.5	6.4
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	0.3	0.1	1.5
United States	2,847.0	2,787.9	2,746.4	2,759.9	3,166.9	3,605.1	3,844.8	4,813.3	4,108.4	5,157.8	4,808.9	40,646.4
					Motor vehicles and equipment							
Total Asian region	208.2	215.8	248.3	299.5	424.6	475.0	539.7	690.9	644.1	652.4	675.2	5,073.9
Japan	206.5	212.2	247.0	296.9	423.3	469.8	532.7	678.9	629.9	638.7	650.8	4,986.8
NIEs	1.2	3.6	1.0	2.6	1.0	5.2	6.5	11.0	11.2	12.9	22.6	78.9
Hong Kong	0.0	0.1	0.0	0.0	0.2	0.3	0.0	0.0	0.3	1.0	1.0	2.9
Singapore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Korea	0.0	1.0	0.0	0.3	0.0	0.6	2.8	3.2	0.9	2.3	5.6	16.8
Taiwan	1.2	2.5	1.0	2.3	0.8	4.3	3.7	7.8	10.0	9.6	16.0	59.2
EAEs	0.5	0.0	0.3	0.0	0.3	0.0	0.5	1.0	3.0	0.8	1.8	8.2
China	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	0.8	1.5	6.8
India	0.0	0.0	0.3	0.0	0.3	0.0	0.5	0.0	0.0	0.0	0.3	1.4
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
United States	401.4	427.1	354.9	394.0	402.9	444.6	402.7	447.5	440.6	530.8	488.3	4,734.8

Appendix table 12. Number of U.S. patents granted to inventors from Asia, by field: 1980-90

Region/country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
							Aircraft and parts					
Total Asian region	132.4	130.7	123.0	141.7	237.7	254.8	248.2	292.8	268.6	286.7	309.3	2,426.0
Japan	131.7	129.6	122.3	139.6	236.4	253.1	247.2	288.2	263.9	278.8	305.1	2,395.8
NIEs	0.7	1.1	0.4	1.1	0.7	1.7	1.0	4.6	3.4	7.1	3.4	25.3
Hong Kong	0.0	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	1.1
Singapore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Korea	0.0	0.0	0.0	0.3	0.0	0.6	0.3	1.2	0.9	0.3	1.1	4.8
Taiwan	0.7	1.0	0.4	0.8	0.7	0.8	0.7	3.4	2.2	6.5	2.3	19.4
EAEs	0.0	0.0	0.3	1.0	0.6	0.0	0.0	0.0	1.3	0.8	0.8	4.9
China	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.3	0.8	0.5	3.0
India	0.0	0.0	0.3	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	1.9
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
United States	237.3	273.1	178.0	222.8	286.5	281.2	232.7	285.1	273.1	318.0	291.7	2,879.5

NIEs = newly industrialized economies

EAEs = emerging Asian economies

NOTE: Patents are fractionally allocated to different industries depending upon the number of product fields to which they are pertinent. See Office of Technology Assessment and Forecast, Patent and Trademark Office, "Review and Assessment of the OTAF Concordance Between the U.S. Patent Classification and the Standard Industrial Classification Systems: Final Report (Washington, DC: 1985) for further description of the methodologies employed in this classification system.

SOURCE: CHI Research, Inc., International Technology Indicators Database, CHI Project No. 8708-A (Haddon Heights, NJ: 1992).

Appendix table 13. Technological performance indicators for U.S. patents granted to inventors from Asia: 1990

Region/country	Number of U.S. patents granted (1980-90)	Current Impact Index	Technology cycle time	Science linkage	Technological strength
	All patents				
Total Asian region	146,101	1.246	7.512	0.226	182,086
Japan	141,984	1.260	7.300	0.230	178,900
NIEs	4,117	0.774	14.821	0.082	3,186
Hong Kong	364	1.090	12.700	0.240	397
Singapore	84	0.630	12.700	0.160	53
South Korea	747	0.690	10.700	0.160	515
Taiwan	2,922	0.760	16.200	0.040	2,221
EAEs	374	0.611	13.104	0.981	228
China	194	0.730	13.400	0.930	142
India	136	0.480	10.500	1.320	65
Indonesia	19	0.310	24.100	0.120	6
Malaysia	25	0.630	16.700	0.170	16
United States	324,027	1.100	10.400	0.680	356,430
	Computer				
Total Asian region	8,530.7	1.057	5.606	0.159	9,019
Japan	8,467.2	1.060	5.600	0.160	8,975
NIEs	63.5	0.690	6.342	0.078	44
Hong Kong	10.8	1.740	7.400	0.000	19
Singapore	1.3	0.850	10.400	0.000	1
South Korea	21.4	0.570	5.200	0.050	12
Taiwan	30.0	0.390	6.600	0.130	12
EAEs	3.7	0.827	7.668	0.055	3
China	3.0	1.020	8.500	0.000	3
India	0.7	0.000	4.100	0.290	0
Indonesia	0.0	0.000	0.000	0.000	0
Malaysia	0.0	0.000	0.000	0.000	0
United States	10,380.9	1.050	7.000	0.430	10,900
	Industrial machinery				
Total Asian region	6,848.7	1.250	10.563	0.049	8,564
Japan	6,643.4	1.260	10.400	0.050	8,371
NIEs	205.3	0.941	15.843	0.031	193
Hong Kong	11.4	1.320	17.100	0.020	15
Singapore	4.1	1.890	7.900	0.000	8
South Korea	47.2	1.040	8.200	0.010	49
Taiwan	142.6	0.850	18.500	0.040	121
EAEs	14.7	0.258	24.966	0.165	4
China	11.7	0.290	18.900	0.130	3
India	2.9	0.140	50.300	0.310	0
Indonesia	0.1	0.000	0.000	0.000	0
Malaysia	0.0	0.000	0.000	0.000	0
United States	15,478.9	1.090	13.300	0.170	16,872

Appendix table 13. Technological performance indicators for U.S. patents granted to inventors from Asia: 1990

Region/country	Number of U.S. patents granted (1980-90)	Current Impact Index	Technology cycle time	Science linkage	Technological strength
	Radio and television				
Total Asian region	3,368.9	1.082	5.108	0.139	3,644
Japan	3,317.9	1.090	5.100	0.140	3,617
NIEs	51.0	0.543	5.646	0.066	28
Hong Kong	6.5	0.790	4.400	0.000	5
Singapore	1.9	1.050	5.300	0.670	2
South Korea	29.8	0.390	4.800	0.070	12
Taiwan	12.8	0.700	8.300	0.000	9
EAEs	1.7	1.193	3.135	1.529	2
China	1.2	1.690	3.900	0.500	2
India	0.5	0.000	1.300	4.000	0
Indonesia	0.0	0.000	0.000	0.000	0
Malaysia	0.0	0.000	0.000	0.000	0
United States	3,261.6	1.020	6.900	0.570	3,327
	Electronic components and communications equipment				
Total Asian region	23,088.8	1.112	5.829	0.337	25,681
Japan	22,645.5	1.120	5.800	0.340	25,363
NIEs	443.3	0.717	7.293	0.180	318
Hong Kong	36.3	1.360	7.600	0.050	49
Singapore	11.6	0.320	5.100	0.120	4
South Korea	132.3	0.570	5.200	0.280	75
Taiwan	263.1	0.720	8.400	0.150	189
EAEs	20.4	1.207	7.510	0.892	25
China	12.5	0.940	8.100	1.180	12
India	6.4	1.900	5.400	0.500	12
Indonesia	0.0	0.000	0.000	0.000	0
Malaysia	1.5	0.470	11.600	0.170	1
United States	40,646.4	1.080	7.700	0.710	43,898
	Motor vehicles and equipment				
Total Asian region	5,065.5	1.445	6.940	0.010	7,322
Japan	4,986.6	1.460	6.800	0.010	7,280
NIEs	78.9	0.529	15.780	0.000	42
Hong Kong	2.9	1.900	15.100	0.000	6
Singapore	0.0	0.000	0.000	0.000	0
South Korea	16.8	1.240	11.600	0.000	21
Taiwan	59.2	0.260	17.000	0.000	15
EAEs	8.2	0.121	23.361	0.000	1
China	6.8	0.070	19.400	0.000	0
India	1.4	0.370	42.600	0.000	1
Indonesia	0.0	0.000	0.000	0.000	0
Malaysia	0.0	0.000	0.000	0.000	0
United States	4,734.8	0.910	13.000	0.040	4,309

Appendix table 13. Technological performance indicators for U.S. patents granted to inventors from Asia: 1990

Page 3 of 3

Region/country	Number of U.S. patents granted (1980-90)	Current Impact Index	Technology cycle time	Science linkage	Technological strength
			Aircraft and parts		
Total Asian region	2,421.1	1.489	6.704	0.010	3,605
Japan	2,395.8	1.500	6.600	0.010	3,594
NIEs	25.3	0.441	16.542	0.000	11
Hong Kong	1.1	0.900	10.700	0.000	1
Singapore	0.0	0.000	0.000	0.000	0
South Korea	4.8	0.380	13.200	0.000	2
Taiwan	19.4	0.430	17.700	0.000	8
EAEs	4.9	0.268	21.902	0.000	1
China	3.0	0.280	22.600	0.000	1
India	1.9	0.250	20.800	0.000	0
Indonesia	0.0	0.000	0.000	0.000	0
Malaysia	0.0	0.000	0.000	0.000	0
United States	2,879.5	0.890	14.100	0.070	2,563

NIEs = newly industrialized economies; EAEs = emerging Asian economies

NOTES: The technology performance indicators are weighted averages. The Current Impact Index is calculated from a weighted average of the citation frequency for a country's patents in a particular product field in each of the previous 5 years, divided by the corresponding citation frequency for all patents in the database. The expected value of this indicator is 1.0. Technology cycle time is defined as the median age of the patent references cited on the front page of a country's patents. Science linkage is the average number of references to scientific literature found on the front page of a country's patents. This indicator measures a country's activity in leading-edge technology and how close its new technology is to the scientific frontier. Overall technological strength is determined by multiplying the number of patents (column 1) by the Current Impact Index (column 2).

SOURCE: CHI Research, Inc., International Technology Indicators Database, CHI Project No. 8708-A (Haddon Heights, NJ: 1992).

Appendix table 14. Trade in advanced technology products between Asian countries and the United States: 1989-91

Region/country	U.S. exports to			U.S. imports from			Balance		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
	Millions of dollars								
	All advanced technology products								
Total Asian region	24,264.64	28,007.92	30,408.28	35,547.64	35,885.49	36,384.60	(11,283.01)	(7,877.57)	(5,976.31)
Japan	9,944.13	12,074.94	12,196.70	20,410.36	19,423.91	19,793.45	(10,466.23)	(7,348.97)	(7,596.75)
NIEs	10,606.48	11,527.19	13,466.95	13,245.82	14,365.72	13,799.04	(2,639.35)	(2,838.52)	(332.09)
Hong Kong	1,608.69	1,884.72	2,180.55	1,227.15	1,198.72	1,047.65	381.54	686.00	1,132.90
Singapore	3,277.43	3,304.57	3,748.29	4,916.55	5,785.01	5,952.76	(1,639.12)	(2,480.45)	(2,204.46)
South Korea	3,415.70	3,495.37	4,040.24	3,776.07	3,690.25	3,357.42	(360.37)	(194.88)	682.82
Taiwan	2,304.66	2,842.53	3,497.86	3,326.05	3,691.73	3,441.22	(1,021.39)	(849.20)	56.64
EAEs	3,714.03	4,405.78	4,744.63	1,891.46	2,095.86	2,792.10	1,822.57	2,309.92	1,952.53
China	1,083.67	1,234.60	1,700.61	94.58	161.44	355.49	989.09	1,073.16	1,345.12
India	399.08	272.48	210.77	11.13	9.57	15.18	387.95	262.91	195.59
Indonesia	397.39	527.34	245.04	6.42	19.86	89.44	390.97	507.49	155.59
Malaysia	1,833.89	2,371.36	2,588.21	1,779.33	1,905.00	2,331.99	54.56	466.36	256.22
	Biotechnology								
Total Asian region	186.91	198.06	198.66	1.28	1.55	2.11	185.63	196.51	196.54
Japan	166.88	178.52	176.60	0.25	1.35	1.88	166.63	177.17	174.72
NIEs	15.67	15.61	16.24	0.00	0.00	0.00	15.67	15.61	16.24
Hong Kong	4.43	3.84	4.10	0.00	0.00	0.00	4.43	3.84	4.10
Singapore	1.65	1.60	1.95	0.00	0.00	0.00	1.65	1.60	1.95
South Korea	2.23	3.43	2.54	0.00	0.00	0.00	2.23	3.43	2.54
Taiwan	7.36	6.74	7.64	0.00	0.00	0.00	7.36	6.74	7.64
EAEs	4.35	3.93	5.81	1.03	0.20	0.23	3.33	3.73	5.58
China	0.76	0.52	1.48	0.00	0.02	0.04	0.76	0.50	1.44
India	1.02	0.75	0.80	1.03	0.18	0.19	(0.01)	0.57	0.62
Indonesia	1.70	1.48	2.39	0.00	0.00	0.00	1.70	1.48	2.39
Malaysia	0.87	1.18	1.14	0.00	0.00	0.00	0.87	1.18	1.14

Appendix table 14. Trade in advanced technology products between Asian countries and the United States: 1989-91

Region/country	U.S. exports to			U.S. imports from			Balance		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
	Millions of dollars								
	Life science								
Total Asian region	1,140.25	1,243.70	1,362.36	768.57	867.04	1,027.02	371.68	376.66	335.33
Japan	652.52	690.12	726.22	651.62	746.59	887.93	0.90	(56.47)	(161.71)
NIEs	300.87	384.31	440.87	93.46	104.90	122.28	207.42	279.41	318.59
Hong Kong	45.16	50.77	73.00	21.67	19.80	18.64	23.49	30.97	54.36
Singapore	52.70	63.10	65.22	52.06	63.20	80.10	0.65	(0.09)	(14.87)
South Korea	120.43	168.43	207.02	8.31	8.60	7.31	112.12	159.83	199.71
Taiwan	82.58	102.02	95.62	11.42	13.31	16.23	71.16	88.71	79.39
EAEs	186.85	169.27	195.27	23.49	15.55	16.82	163.36	153.73	178.45
China	99.58	87.68	118.78	21.97	14.01	14.73	77.60	73.67	104.05
India	60.66	62.20	49.36	1.06	1.24	1.15	59.60	60.96	48.21
Indonesia	16.61	9.49	12.90	0.13	0.07	0.26	16.48	9.42	12.63
Malaysia	10.00	9.90	14.23	0.32	0.22	0.67	9.68	9.68	13.56
	Optoelectronics								
Total Asian region	121.72	155.52	208.41	793.36	968.03	1,802.38	(671.64)	(812.51)	(1,593.97)
Japan	61.77	110.08	141.51	655.48	798.28	1,603.98	(593.71)	(688.20)	(1,462.47)
NIEs	50.53	36.67	60.45	117.11	140.87	153.53	(66.58)	(104.21)	(93.09)
Hong Kong	6.84	7.42	11.28	2.02	2.88	9.20	4.83	4.54	2.08
Singapore	3.94	6.73	9.48	56.89	58.87	45.16	(52.95)	(52.14)	(35.68)
South Korea	9.84	10.90	23.59	37.46	32.91	37.44	(27.62)	(22.01)	(13.85)
Taiwan	29.91	11.62	16.10	20.75	46.22	61.73	9.16	(34.60)	(45.63)
EAEs	9.42	8.78	6.46	20.77	28.88	44.87	(11.35)	(20.10)	(38.41)
China	3.47	3.18	1.61	3.55	8.89	17.38	(0.08)	(5.70)	(15.77)
India	3.14	1.55	0.95	0.20	0.10	0.09	2.94	1.45	0.86
Indonesia	0.44	0.39	0.45	0.23	0.00	0.00	0.22	0.38	0.45
Malaysia	2.37	3.66	3.45	16.79	19.89	27.39	(14.42)	(16.23)	(23.95)

Appendix table 14. Trade in advanced technology products between Asian countries and the United States: 1989-91

Region/country	U.S. exports to			U.S. imports from			Balance		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
	Millions of dollars								
	Computers and telecommunications								
Total Asian region	7,285.70	8,053.71	7,868.42	23,446.47	23,728.54	21,931.70	(16,160.77)	(15,674.82)	(14,063.28)
Japan	3,809.90	4,232.55	4,203.34	13,770.05	13,055.94	11,596.64	(9,960.15)	(8,823.39)	(7,393.30)
NIEs	2,959.54	3,245.25	3,050.53	9,427.02	10,220.99	9,223.34	(6,467.48)	(6,975.75)	(6,172.82)
Hong Kong	504.93	452.16	514.04	983.72	889.63	726.59	(478.79)	(437.47)	(212.54)
Singapore	1,017.71	1,106.55	1,008.33	3,757.41	4,519.44	4,547.18	(2,739.70)	(3,412.90)	(3,538.86)
South Korea	750.66	826.96	830.41	2,034.73	1,876.42	1,375.06	(1,284.07)	(1,049.46)	(544.65)
Taiwan	686.24	859.58	697.74	2,651.17	2,935.50	2,574.51	(1,964.92)	(2,075.92)	(1,876.77)
EAEs	516.26	575.91	614.55	249.40	451.60	1,111.71	266.86	124.31	(497.16)
China	199.10	232.45	229.33	52.50	114.01	293.01	146.61	118.44	(63.69)
India	136.55	89.31	83.15	4.32	2.59	5.96	132.23	86.72	77.20
Indonesia	52.66	88.81	83.68	0.56	5.05	56.44	52.11	83.76	27.24
Malaysia	127.95	165.34	218.39	192.02	329.96	756.31	(64.08)	(164.61)	(537.92)
	Electronics								
Total Asian region	2,854.19	3,093.63	3,633.77	7,893.36	7,868.50	8,796.09	(5,039.18)	(4,774.88)	(5,162.32)
Japan	890.62	933.47	1,122.65	3,020.29	2,748.99	3,371.20	(2,129.68)	(1,815.52)	(2,248.55)
NIEs	1,542.88	1,726.52	2,149.43	3,311.41	3,564.69	3,865.62	(1,768.53)	(1,838.17)	(1,716.19)
Hong Kong	400.66	425.51	465.34	213.23	267.06	283.42	187.43	158.45	181.92
Singapore	495.26	555.20	622.32	918.80	1,052.46	1,140.83	(423.54)	(497.26)	(518.51)
South Korea	225.26	226.66	278.39	1,588.53	1,618.70	1,772.48	(1,363.28)	(1,392.04)	(1,494.09)
Taiwan	421.71	519.15	783.38	590.85	626.48	668.89	(169.14)	(107.32)	114.49
EAEs	420.69	433.63	361.69	1,561.66	1,554.82	1,559.26	(1,140.97)	(1,121.19)	(1,197.57)
China	22.74	23.99	22.72	0.92	1.10	2.22	21.81	22.88	20.50
India	42.71	43.96	28.79	2.14	1.99	2.16	40.57	41.97	26.63
Indonesia	1.83	1.85	7.93	5.02	13.53	26.09	(3.19)	(11.68)	(18.16)
Malaysia	353.41	363.84	302.26	1,553.58	1,538.20	1,528.79	(1,200.16)	(1,174.36)	(1,226.53)

Appendix table 14. Trade in advanced technology products between Asian countries and the United States: 1989-91

Region/country	U.S. exports to 1989	U.S. exports to 1990	U.S. exports to 1991	U.S. imports from 1989	U.S. imports from 1990	U.S. imports from 1991	Balance 1989	Balance 1990	Balance 1991
	Millions of dollars								
	Computer-integrated manufacturing								
Total Asian region	1,385.08	1,210.80	1,402.47	1,533.22	1,159.01	1,313.84	(148.14)	51.79	88.63
Japan	578.28	593.06	661.42	1,476.00	1,103.52	1,259.74	(897.72)	(510.46)	(598.32)
NIEs	651.07	459.73	573.70	56.09	53.50	51.57	594.97	406.22	522.13
Hong Kong	38.41	35.78	42.71	1.23	2.54	0.88	37.19	33.23	41.84
Singapore	99.80	100.48	94.09	10.83	10.10	10.58	88.97	90.38	83.52
South Korea	362.16	207.98	289.54	11.29	9.45	10.85	350.87	198.53	278.69
Taiwan	150.69	115.49	147.36	32.74	31.41	29.27	117.95	84.08	118.09
EAEs	155.73	158.02	167.35	1.12	1.99	2.53	154.61	156.03	164.82
China	74.97	60.80	89.05	0.70	1.07	1.19	74.26	59.73	87.85
India	30.09	35.60	18.05	0.18	0.25	0.41	29.91	35.34	17.63
Indonesia	5.84	4.26	5.37	0.00	0.00	0.00	5.84	4.25	5.37
Malaysia	44.84	57.37	54.88	0.24	0.67	0.92	44.60	56.70	53.96
	Material design								
Total Asian region	3,297.69	3,963.93	3,856.23	515.97	614.78	636.99	2,781.71	3,349.15	3,219.24
Japan	379.89	437.09	498.43	444.17	481.95	452.45	(64.28)	(44.86)	45.99
NIEs	1,716.90	2,178.23	2,016.50	53.54	112.93	164.21	1,663.36	2,065.30	1,852.29
Hong Kong	239.06	338.97	307.37	4.79	10.52	7.94	234.27	328.46	299.43
Singapore	516.77	660.49	690.11	8.93	24.89	43.65	507.84	635.60	646.46
South Korea	610.10	773.49	630.06	24.58	43.04	34.38	585.52	730.45	595.68
Taiwan	350.97	405.27	388.97	15.24	34.47	78.25	335.73	370.80	310.72
EAEs	1,200.90	1,348.61	1,341.30	18.26	19.90	20.34	1,182.63	1,328.71	1,320.97
China	14.45	8.44	4.19	0.06	0.65	0.54	14.39	7.80	3.65
India	12.35	1.92	1.49	1.90	2.85	2.30	10.44	(0.93)	(0.81)
Indonesia	5.32	12.23	6.54	0.00	0.34	0.08	5.32	11.89	6.46
Malaysia	1,168.79	1,326.02	1,329.09	16.30	16.06	17.42	1,152.49	1,309.96	1,311.67

Appendix table 14. Trade in advanced technology products between Asian countries and the United States: 1989-91

Region/country	U.S. exports to			U.S. imports from			Balance		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
	Millions of dollars								
	Aerospace								
Total Asian region	6,818.71	8,960.13	10,704.14	587.64	678.04	864.59	6,231.08	8,282.10	9,839.55
Japan	2,502.27	4,080.34	3,751.85	388.39	487.29	615.61	2,113.88	3,593.05	3,136.25
NIEs	3,134.58	3,205.97	4,945.37	184.46	167.82	213.44	2,950.12	3,038.15	4,731.93
Hong Kong	365.95	564.89	749.94	0.38	6.28	0.90	365.57	558.61	749.04
Singapore	1,077.62	786.55	1,219.17	111.62	56.06	85.04	966.00	730.49	1,134.13
South Korea	1,239.61	1,126.13	1,662.36	69.46	101.14	117.07	1,170.14	1,024.98	1,545.29
Taiwan	451.41	728.40	1,313.90	3.00	4.34	10.43	448.41	724.06	1,303.47
EAEs	1,181.87	1,673.82	2,006.91	14.79	22.92	35.54	1,167.07	1,650.90	1,971.37
China	645.56	801.06	1,205.16	14.01	21.69	25.55	631.56	779.37	1,179.61
India	101.79	26.97	20.33	0.29	0.36	2.92	101.49	26.61	17.41
Indonesia	311.74	406.85	120.25	0.49	0.87	6.57	311.26	405.98	113.68
Malaysia	122.77	438.95	661.17	0.00	0.00	0.49	122.77	438.94	660.68
	Weapons								
Total Asian region	191.04	198.05	241.13	6.77	0.00	8.46	184.28	198.05	232.67
Japan	104.24	91.54	100.64	3.08	0.00	2.62	101.15	91.54	98.02
NIEs	60.09	79.90	104.11	2.74	0.00	5.02	57.35	79.90	99.10
Hong Kong	2.19	4.27	11.44	0.13	0.00	0.09	2.06	4.27	11.36
Singapore	11.25	23.46	36.41	0.02	0.00	0.22	11.23	23.46	36.19
South Korea	19.98	40.66	38.30	1.71	0.00	2.80	18.27	40.66	35.50
Taiwan	26.67	11.50	17.96	0.89	0.00	1.91	25.79	11.50	16.05
EAEs	26.71	26.61	36.38	0.94	0.00	0.82	25.77	26.61	35.56
China	15.88	12.94	22.71	0.87	0.00	0.82	15.01	12.94	21.89
India	7.96	7.68	6.01	0.00	0.00	0.00	7.96	7.68	6.01
Indonesia	0.68	1.27	4.77	0.00	0.00	0.00	0.68	1.27	4.77
Malaysia	2.19	4.71	2.89	0.07	0.00	0.00	2.11	4.71	2.89

Appendix table 14. Trade in advanced technology products between Asian countries and the United States: 1989-91

Region/country	U.S. exports to			U.S. imports from			Balance		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
	Millions of dollars								
	Nuclear technology								
Total Asian region	983.36	930.37	932.70	1.02	0.00	1.42	982.34	930.37	931.28
Japan	797.77	728.17	814.04	1.02	0.00	1.40	796.75	728.17	812.64
NIEs	174.35	195.01	109.75	0.00	0.00	0.02	174.35	195.01	109.73
Hong Kong	1.07	1.10	1.33	0.00	0.00	0.00	1.07	1.10	1.33
Singapore	0.73	0.40	1.20	0.00	0.00	0.00	0.73	0.40	1.20
South Korea	75.44	110.75	78.03	0.00	0.00	0.02	75.44	110.75	78.01
Taiwan	97.11	82.76	29.19	0.00	0.00	0.00	97.11	82.76	29.19
EAEs	11.24	7.19	8.91	0.00	0.00	0.00	11.24	7.19	8.91
China	7.16	3.53	5.59	0.00	0.00	0.00	7.16	3.53	5.59
India	2.82	2.64	1.85	0.00	0.00	0.00	2.82	2.64	1.85
Indonesia	0.56	0.73	0.76	0.00	0.00	0.00	0.56	0.73	0.76
Malaysia	0.71	0.39	0.71	0.00	0.00	0.00	0.71	0.39	0.71

NOTE: The advanced technology product areas are defined as follows.

Biotechnology is the medical and industrial application of advanced scientific discoveries in genetics to the creation of new drugs, hormones and other therapeutic items for both agricultural and human use.

Life science is the application of scientific advances (other than biological) to medical science. Recent advances, such as nuclear resonance imaging, echocardiography, and novel chemistry coupled with new production techniques for the manufacture of drugs have led to many new products for the control or eradication of disease.

Optoelectronics encompasses electronic products and components that involve the emitting and/or detection of light. Examples of products included are optical scanners, optical disc players, solar cells, photo-sensitive semiconductors, and laser printers.

Computers and telecommunications focuses on products that are able to process increased volumes of information in shorter periods of time. Includes central processing units, all computers, and some peripheral units such as disk drive units and control units from the computer field, along with modems, facsimile machines and telephonic switching apparatus from the telecommunications field. Examples of other products included are radar apparatus and communications satellites.

Electronics concentrates on recent design advances in electronic components (with the exception of opto-electronic components) that result in improved performance and capacity and in many cases reduced size. Products included are integrated circuits, multi-layer printed circuit boards and surface-mounted components such as capacitors and resistors.

Computer-integrated manufacturing encompasses advances in robotics, numerically controlled machine tools, and similar products involving industrial automation that allow for greater flexibility to the manufacturing process and reduce the amount of human intervention. Includes robots, numerically controlled machine tools and semiconductor production and assembly machines.

Material design encompasses recent advances in the development of materials that allow for further development and application of other advanced technologies. Examples are semiconductor materials, optical fiber cable and video discs.

Aerospace encompasses most new military and civil helicopters, airplanes, and spacecraft (with the exception of communications satellites that are included under computers and telecommunications). Other products included are turbojet aircraft engines, flight simulators, and automatic pilots.

Weapons primarily encompasses products with military applications. Includes such products as guided missilies and parts, bombs, torpedoes, mines, missile and rocket launcers and some firearms.

Nuclear technology encompasses nuclear power production apparatus including nuclear reactors and parts, isotopic separation equipment, and fuel cartridges. Nuclear medical apparatus is included under life science.

SOURCE: Bureau of the Census, Foreign Trade Division, special tabulations.

Appendix table 15. Asian receipts and payments of royalties and license fees associated with affiliated and unaffiliated U.S. residents: 1987-91

[Millions of dollars]

Region/country	Receipts					Payments					Balance				
	1987	1988	1989	1990	1991	1987	1988	1989	1990	1991	1987	1988	1989	1990	1991
Total Asian region	336	400	465	571	714	2,211	2,939	3,375	3,871	4,401	(1,867)	(2,527)	(2,910)	(3,300)	(3,687)
Japan	322	398	459	562	695	1,950	2,454	2,673	2,990	3,419	(1,628)	(2,056)	(2,214)	(2,428)	(2,724)
NIEs	13	2	5	9	19	218	410	621	806	890	(205)	(408)	(616)	(797)	(871)
Hong Kong	2	1	5	5	5	43	64	118	132	155	(41)	(63)	(113)	(127)	(150)
Singapore	2	*	*	1	9	76	106	162	183	237	(74)	(106)	(162)	(182)	(228)
South Korea	6	D	D	D	5	61	164	226	351	346	(55)	(164)	(226)	(351)	(341)
Taiwan	3	1	*	3	*	38	76	115	140	152	(35)	(75)	(115)	(137)	(152)
EAEs	1	0	1	0	0	43	75	81	75	92	(34)	(63)	(80)	(75)	(92)
China	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
India	1	*	1	*	*	25	44	29	26	18	(24)	(44)	(28)	(26)	(18)
Indonesia	0	0	0	0	0	10	19	29	25	40	(10)	(19)	(29)	(25)	(40)
Malaysia	0	0	0	0	0	8	12	23	24	34	(*)	(*)	(23)	(24)	(34)

* = less than $500,000; D = withheld to avoid disclosing operations of individual companies

NIEs = newly industrialized economies

EAEs = emerging Asian economics

NOTE: Includes royalties and fees paid for use of industrial processes, media, franchise fees, etc.

SOURCES: Bureau of Economic Analysis, *Survey of Current Business*, Vol. 71, No. 9 (September 1991): pp. 75-78; and Vol. 72, No. 9 (September 1992): pp. 95-99.

Appendix table 16. Asian receipts and payments of royalties and license fees generated from the exchange and use of industrial processes with unaffiliated U.S. residents: 1987-91

[Millions of dollars]

Region/country	Receipts					Payments					Balance				
	1987	1988	1989	1990	1991	1987	1988	1989	1990	1991	1987	1988	1989	1990	1991
Total Asian region....	89	108	120	143	148	872	1,139	1,189	1,417	1,612	(783)	(1,031)	(1,069)	(1,274)	(1,464)
Japan.......	88	108	120	142	148	723	883	898	1,028	1,244	(635)	(775)	(778)	(886)	(1,096)
NIEs.......	1	0	0	1	0	89	172	199	330	312	(88)	(172)	(199)	(329)	(312)
Hong Kong.......	1	*	*	0	*	4	6	7	6	6	(3)	(6)	(7)	(6)	(6)
Singapore.......	*	0	0	0	0	30	13	3	19	21	(30)	(13)	(3)	(19)	(21)
South Korea.......	*	*	D	D	*	34	107	167	249	228	(34)	(107)	(167)	(249)	(228)
Taiwan.......	*	*	D	1	*	21	46	22	56	57	(21)	(46)	(22)	(55)	(57)
EAEs.......	0	0	0	0	0	60	84	92	59	56	(60)	(84)	(92)	(59)	(56)
China.......	*	*	*	*	*	37	39	51	25	20	(37)	(39)	(51)	(25)	(20)
India.......	*	*	*	*	*	18	40	31	21	14	(18)	(40)	(31)	(21)	(14)
Indonesia.......	0	0	0	0	0	5	5	8	11	20	(5)	(5)	(8)	(11)	(20)
Malaysia.......	0	0	0	0	0	*	*	2	2	2	*	*	(2)	(2)	(2)

* = less than $500,000; D = withheld to avoid disclosing operations of individual companies; NIEs = newly industrialized economies; EAEs = emerging Asian economies

NOTE: Industrial processes include patents and other proprietary inventions and technology.

SOURCES: Bureau of Economic Analysis, *Survey of Current Business*, Vol. 71, No. 9 (September 1991): pp. 75-78; and Vol. 72, No. 9 (September 1992): pp. 95-99.

Appendix table 17. Ownership of companies active in high-tech fields operating in the United States, by country of ownership: March 1992

Region/country	All fields	Auto-mation	Biotech-nology	Computer hardware	Advanced materials	Photonics & optics	Soft-ware	Telecom-munications	Electronic components
	Number of companies								
Total	30,919	3,413	974	4,541	2,302	1,673	7,095	2,424	5,328
Total Asian region	697	70	16	126	43	53	22	76	87
Japan	600	66	15	101	42	51	16	66	66
NIEs	91	2	1	25	1	2	4	10	21
Hong Kong	19	1	0	5	0	0	0	1	9
Singapore	15	0	0	4	0	0	2	0	1
South Korea	22	1	1	6	1	0	1	3	5
Taiwan	35	0	0	10	0	2	1	6	6
India	6	2	0	0	0	0	2	0	0
United States	27,412	3,066	868	4,212	1,957	1,471	6,887	2,182	4,726
	Percent of total	High-tech field percentage of national total							
Total Asian region	2.25	10.04	2.32	18.23	6.22	7.67	3.19	11.00	12.59
Japan	1.94	11.00	2.50	16.83	7.00	8.50	2.67	11.00	11.00
NIEs	0.29	2.20	1.10	27.47	1.10	2.20	4.40	10.99	23.08
Hong Kong	0.06	5.26	*	26.32	*	*	*	5.26	47.37
Singapore	0.05	*	*	26.67	*	*	13.33	0.00	6.67
South Korea	0.07	4.55	4.55	27.27	4.55	*	4.55	13.64	22.73
Taiwan	0.11	*	*	28.57	*	5.71	2.86	17.14	17.14
India	0.02	33.33	*	*	*	*	33.33	*	0.00
United States	88.66	11.18	3.17	15.37	7.14	5.37	25.12	7.96	17.24

* = less than 0.005 percent; NIEs = newly industrialized economies

NOTES: China, Indonesia, and Malaysia were not reported as owners of any of the companies in the database.
Companies considered active in particular technology fields must develop or manufacture a product within the scope of the CorpTech high-tech codes.

SOURCE: Derived from the CorpTech database, Rev. 6.0, Corporate Technology Information Services, Inc. (Wellesley Hills, MA: March 1992).

74

Appendix table 18. Foreign direct investment in the Asian region: 1980-90

[Millions of dollars]

Host region/country	1980-85 (average)	1986	1987	1988	1989	1990
Total Asian region	4,995	6,437	11,954	12,212	12,585	16,880
Japan	325	230	1,170	(520)	(1,060)	1,760
Newly industrialized economies	2,155	3,467	7,450	8,152	7,650	7,636
Hong Kong	542	996	3,298	2,675	1,076	783
Singapore	1,330	1,710	2,836	3,647	4,212	4,808
South Korea	98	435	601	871	758	715
Taiwan	185	326	715	959	1,604	1,330
Emerging Asian economies	2,515	2,740	3,334	4,580	5,995	7,484
China	718	1,875	2,314	3,194	3,393	3,489
India	62	118	212	91	252	129
Indonesia	227	258	385	576	682	964
Malaysia	1,508	489	423	719	1,668	2,902

SOURCE: United Nations, Transnational Corporations and Management Division, Department of Economic and Social Development, *World Investment Report 1992: Transnational Corporations as Engines of Growth* (New York: 1992).

Appendix table 19. Total merchandise trade between Asian economies and the United States: 1989-91

[Millions of dollars]

Region/country	U.S. exports to			U.S. imports from			Balance		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
Total Asian region	95,253	101,928	107,885	179,904	177,304	182,421	(84,651)	(75,376)	(74,536)
Japan	44,494	48,580	48,147	93,553	89,684	91,583	(49,059)	(41,105)	(43,436)
Newly industrialized economies	38,429	40,734	45,658	62,774	60,573	59,324	(24,345)	(19,839)	(13,666)
Hong Kong	6,291	6,817	8,140	9,722	9,622	9,286	(3,431)	(2,805)	(1,146)
Singapore	7,345	8,023	8,808	9,003	9,800	9,976	(1,658)	(1,778)	(1,169)
South Korea	13,459	14,404	15,518	19,737	18,485	17,025	(6,278)	(4,081)	(1,506)
Taiwan	11,335	11,491	13,191	24,313	22,666	23,036	(12,978)	(11,175)	(9,845)
Emerging Asian economies	12,330	12,615	14,081	23,577	27,047	31,515	(11,247)	(14,433)	(17,434)
China	5,755	4,806	6,287	11,990	15,237	18,976	(6,235)	(10,431)	(12,689)
India	2,458	2,486	2,003	3,315	3,197	3,197	(857)	(711)	(1,195)
Indonesia	1,247	1,897	1,892	3,529	3,341	3,241	(2,282)	(1,444)	(1,349)
Malaysia	2,870	3,425	3,900	4,744	5,272	6,102	(1,874)	(1,847)	(2,202)

SOURCE: Bureau of the Census, Foreign Trade Division, special tabulations.

Appendix table 20. Real growth rates of Asian economies: 1960-92

[Average annual percentage change in gross domestic product]

Region/country	1960-70 (average)	1970-80 (average)	1980-85 (average)	1985-90 (average)	1990	1991	1992 (est.)
Japan	10.5	4.7	4.0	4.4	5.2	3.7	3.0
Newly industrialized economies							
Hong Kong	10.0	9.3	5.6	8.8	2.8	4.0	n.a.
Singapore	9.2	9.0	6.2	7.6	8.3	6.5	6.0
South Korea	8.4	8.2	8.4	10.5	9.0	8.6	7.6
Taiwan	9.6	9.7	9.7	9.8	5.0	7.2	6.7
Emerging Asian economies							
China	4.0	5.7	10.1	8.2	5.2	6.8	6.5
India	4.0	3.2	5.4	6.3	5.5	NA	NA
Indonesia	3.9	8.0	4.7	6.0	7.4	6.6	NA
Malaysia	NA	8.0	5.1	5.9	9.8	8.6	8.5
United States	3.8	2.8	2.6	3.4	1.0	-0.5	2.0

SOURCES: Ippei Yamazawa, "On Pacific Economic Integration," *The Economic Journal*, 102 (November 1992): pp. 1519-29, table 1; Indian data are from International Monetary Fund, IMF Statistics Department, *International Financial Statistics Yearbook, Vol. XLV* (Washington, DC: 1992).

Appendix table 21. Real gross domestic product per capita: 1975-90

[Millions of 1985 purchasing power parity dollars]

Region/country	1975	1978	1980	1984	1985	1986	1987	1988	1989	1990
Japan	7,544	8,510	9,175	10,341	10,741	10,971	11,405	11,983	12,470	NA
Newly industrialized economies										
Hong Kong	5,457	7,178	8,394	10,323	10,176	11,156	12,601	13,459	NA	NA
Singapore	4,853	5,871	6,857	8,981	8,732	8,797	9,524	10,467	11,313	NA
South Korea	2,064	2,710	2,773	3,661	3,858	4,285	4,743	5,223	5,480	NA
Taiwan	2,026	2,938	3,070	4,248	4,533	5,357	6,183	6,742	7,600	NA
China	NA	1,596	1,665	1,711	1,845	1,913	1,989	2,197	2,372	2,473
India	543	598	584	661	689	706	711	764	848	NA

NA= not available

SOURCES: National Science Foundation, Science Resources Studies Division, *Human Resources for Science and Technology: The Asian Region,* by Jean Johnson, NSF 93-303 (Washington, DC: 1993); and NSF/SRS International Database on Human Resources, 1993.

Appendix table 22. Hourly compensation costs for production workers in manufacturing: 1975-90

[U.S. dollars]

Region/country	1975	1980	1984	1985	1986	1987	1988	1989	1990
Japan	3.05	5.61	6.34	6.43	9.31	10.83	12.8	12.63	12.64
Newly industrialized economies [1]	0.50	1.15	1.52	1.59	1.71	2.06	2.57	3.27	3.75
Hong Kong	0.76	1.51	1.58	1.73	1.88	2.09	2.40	2.79	3.20
Singapore	0.84	1.49	2.46	2.47	2.23	2.31	2.67	3.15	3.78
South Korea	0.33	0.97	1.22	1.25	1.34	1.65	2.30	3.29	3.82
Taiwan	0.40	1.00	1.42	1.50	1.73	2.26	2.82	3.53	3.95
China [2]	0.17	0.30	0.25	0.24	0.24	0.24	NA	NA	NA
India	0.19	0.44	0.42	0.35	0.39	NA	NA	NA	NA
United States	6.36	9.87	12.55	13.01	13.25	13.52	13.91	14.31	14.77
Europe (EC-12)	5.05	9.89	7.69	7.87	10.67	13.21	14.2	13.93	16.93

[1] Trade-weighted measure.

[2] China's data are for all employees.

NA = not available

NOTES: Hourly compensation is defined as all payments made directly to the worker, before payroll deductions of any kind, and employer insurance expenditures. The compensation and other pay measures are computed in national currency units and are converted into U.S. dollars at prevailing commercial market currency exchange rates which the U.S. Bureau of Labor Statistics considers considers the appropriate measure for comparing levels of employer labor costs.

SOURCES: Data for all countries except China are from Bureau of Labor Statistics, International Comparisons of Hourly Compensation Costs for Production Workers in Manufacturing, 1975-90, Report 817 (Washington, DC: November 1991); data for China are unpublished data from BLS (December 1990).

Appendix table 23. Indexes of hourly compensation costs for production workers in manufacturing: 1975-90

[Index: United States = 100]

Region/country	1975	1980	1984	1985	1986	1987	1988	1989	1990
Japan	48	57	51	49	70	80	92	88	86
Newly industrialized economies [1]	8	12	12	12	13	15	18	23	25
Hong Kong	12	15	13	13	14	15	17	19	22
Singapore	13	15	20	19	17	17	19	22	26
South Korea	5	10	10	10	10	12	17	23	26
Taiwan	6	10	11	12	13	17	20	25	27
China [2]	3	3	2	2	2	2	NA	NA	NA
India	3	4	3	3	3	NA	NA	NA	NA
Europe (EC-12)	79	100	61	60	81	98	102	97	115

[1] Trade-weighted measure.

[2] China's data are for all employees.

NA = not available

SOURCES: Data for all countries except China are from Bureau of Labor Statistics, International Comparisons of Hourly Compensation Costs for Production Workers in Manufacturing, 1975-90, Report 817 (Washington, DC: November 1991); data for China are unpublished data from BLS (December 1990).

Appendix table 24. Leading indicators of technological competitiveness

[Standardized S scores]

Region/country	National orientation	Socioeconomic infrastructure	Technological infrastructure	Productive capacity
Japan	85.3	72.7	83.7	92.7
Newly industrialized economies:				
Hong Kong [1]	74.4	69.6	23.0	43.0
Singapore	92.7	73.3	40.5	54.6
South Korea	81.9	69.6	42.6	46.4
Taiwan	81.1	74.5	37.4	43.1
Emerging Asian economies:				
China	62.3	46.4	38.6	33.2
India	52.4	46.4	33.0	38.6
Indonesia	62.5	49.5	25.3	24.8
Malaysia	81.1	63.7	34.3	47.5
United States	69.9	84.0	87.5	89.8

[1] Data on the number of scientists and engineers engaged in research and experimental development were not available for Hong Kong; consequently, its score on the technological infrastructure indicator is based on incomplete data.

NOTES: S score and indicator calculations--

Raw data were transformed into scales of 0-100 for each for each indicator component and then averaged to generate comparable indicators with a 0-100 range. For survey items, 100 represents the highest response category for each question; for statistical data, 100 typically represents the value attained by the country with the largest value among the 28 countries included in the study.

National orientation (NO). Evidence that a nation is taking directed action to achieve technological competitiveness. These actions could take place in the business, government, or cultural sectors, or any combination of the three.
Indicator formulation: 'NO = Q1 + (Q2 + Q3)/2 + Q4 + F1V93. Each term carries equal weight.
Data used: Published data rating each country's investment risk (F1V93), source: Frost and Sullivan 5-year investment risk index for July 1, 1993)), and survey data assessing each country's national strategy to promote high-tech development (Q1), social influences favoring technological change (Q2 and Q3), and entrepreneurial spirit (Q4).

Socioeconomic infrastructure (SE). This indicator assesses the social and economic institutions that support and maintain the physical, human, organizational, and economic resources essential to the functioning of a modern, technology-based industrial nation.
Indicator formulation: 'SE = Q5+ Q10 + HMHS89. Each term carries equal weight.
Data used: Published data on the percentage of students enrolled in secondary and tertiary education (HMHS89), source: Harbison-Myers Skills Index for 1989)); and survey data assessing each country's efforts to attract foreign investment (Q10) and the mobility of capital (Q5).

Technological infrastructure. This indicator assesses the institutions and resources that contribute to a nation"s capacity to develop, produce, and market new technology.
Indicator formulation: TI = (Q7 + Q8)/2 +Q9 + Q11 + EDP93 + S&E. Each term carries equal weight.
Data used: Published data on the number of scientist and engineers (S&E) involved in research (S&E), source: UN Statistical Yearbook)) and national purchases of electronic data processing equipment (EDP93), source: Elsevier Yearbook of World Electronics Data 1993)); and survey data assessing linkages of R&D to industry (Q9), output of indigenous academic science and engineering (Q7and Q8), and ability to make effective use of technological knowledge (Q11).

Productive capacity (PC). This indicator assesses the phsical and human resources devoted to manufacturing products, and the efficiency with which those resources are employed.
Indicator formulation: PC = Q6 + Q12 + Q13 + A2693. Each term carries equal weight.
Data used: Published data on electronics production for 1993 (A2693), source: Elsevier Yearbook of World Electronics Data 1993)) and survey data assessing the supply and quality of skilled labor (Q6), capability of the indigenous management (Q13), and the existence of indigenous suppliers of components for technology intensive products (Q12).

SOURCES: Reports prepared for the National Science Foundation under Project Number 9219337 by J. David Roessner and Alan L. Porter, Georgia Institute of Technology (Atlanta, GA).

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