Asia's Rising Science and Technology Strength

Comparative Indicators for Asia, the European Union, and the United States

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

National Science Foundation

May 2007

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INTRODUCTION

Science and technology (S&T) are changing the world in profound ways. Governments, having recognized the contributions of S&T to economic growth and societal well-being, are thinking strategically about their innovation systems and acting to make these systems more effective and efficient in an increasingly interdependent and competitive world. Policies that seek to strengthen countries' education infrastructure, the institutions that carry out research and development (R&D), and the innovation environment have become commonplace.

The major development over the past decade or more has been the rapid emergence of Asian[1] economies outside Japan as increasingly strong players in the world's S&T system, with South Korea and Taiwan being joined by Singapore, Malaysia, Thailand, and others. Although the world has experienced ubiquitous market- and policy-driven expansion of S&T capabilities, nowhere has this been as rapid and dramatic as in Asia.

The largest and fastest-growing actor is China, whose government has declared education and S&T to be the strategic engines of sustainable economic development. China has already become an important player in high-technology markets, has attracted the world's major corporations, and was a major recipient of foreign direct investment in 2004.

Fragmentary data on India suggest that it, too, is seeking rapid technological development. India is focusing on knowledge-intensive service sectors and biotechnology.

Numerous indicators point to Asian growth outside of Japan. In high-technology manufacturing, the European and Japanese world shares are eroding, while the United States continues to maintain its position. In high-technology exports, however, all three leading economic regions/countries—the European Union (EU), the United States, and Japan—are losing market share to other Asian economies, and the U.S. high-technology trade balance has recently turned negative by several measures.

Closer to the science base, multinational firms are moving R&D functions and laboratories to Asian locations. In doing so, they seek not only lower costs but also solid access to markets and well-trained personnel. Asian governments also are boosting their R&D investments.

According to figures published by the Organisation for Economic Co-operation and Development (OECD), by 2003 China had become the third largest R&D-performing country, behind only the United States and Japan, in part reflecting the growth of R&D performed by foreign-owned firms based in China. Although data uncertainties make the actual magnitude of China's R&D spending subject to interpretation, the rapidity of China's emergence as a major S&T player is unprecedented in recent memory. In recent years, China managed to boost the percentage of its gross domestic product (GDP) spent on R&D—a commonly used measure of research intensity—even as its GDP expanded at near double-digit rates.

In basic scientific research, China has yet to approach parity with major science-producing nations; its academic research budget remains below 10% of its total R&D spending. However, its scientists and engineers are collaborating broadly with their counterparts across the globe and in Asia, and their international patenting and publishing activities, although modest, are on accelerating upward trajectories similar to those observed in the past decade for other high-technology indicators in China.

Well-trained labor forces are expanding rapidly in developing and newly developed countries. The number of people in the world with a post-high-school education has nearly tripled since 1980, with the fastest growth occurring in Asia, including a doubling of both China's and India's percentages. Along with Europe, Asia made especially rapid strides in the graduation of new degree holders in engineering and the natural sciences, and these two regions are producing the bulk of doctorate holders in these fields.

The story, then, is of the emergence of Asia as a powerful S&T region in its own right, whose rise is producing changes in the international S&T order and is, to some extent, beginning to displace some traditional powers.

This report provides a range of standard indicators of S&T infrastructure and performance to highlight the growth of Asia's S&T enterprise. Where possible, it provides comparable information for Asia (Japan, China, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and

[1]Asia, other than Japan, here consists of China, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. The selection was, for the most part, based on the pragmatic consideration of limited data availability and the general level of S&T activity as evidenced by the specific types of data at hand. For specific indicators, data may be available for a more limited number of locations, as noted.

Thailand), the EU,[2] and the United States. Japan is also shown separately, as are other major Asian economies, for specific indicators. The aim is to give the reader a quick glance across a broad set of S&T indicators, with trends or multiple data points wherever possible.

The indicators cover:

- Education and advanced training
- Science and engineering (S&E) workforce and mobility
- R&D expenditures and foreign direct investment
- Scientific publications, collaboration, and citations
- Patents
- High-technology manufacturing and exports, services, and trade in technical know-how.

Each indicator is introduced with a brief description accompanied by several bulleted observations. The bullets present key points illustrated by the data and occasionally provide added information. Figures provide both global and regional comparisons. The global data compare Asia (often with Japan broken out), the EU, and the United States. The regional view displays Japan and (for selected indicators) other large Asian economies. Sometimes, an additional view provides data for Asia excluding Japan. Tables with selected data are also included (see footnote 1).

The reader is reminded again that the limited definition of Asia used in this report reflects only the major Asian S&T-producing economies. However, these economies are likely to represent a large share of total Asian S&T capabilities, infrastructure, and activity.

Some of the Asian data discussed in this report are not strictly comparable, and some may not fully conform to international statistical standards. Nevertheless, for any given country/economy, one can observe reasonably consistent activity across a range of indicators. Accordingly, the reader is advised to focus on the overall patterns and trends, rather than seeking precise point-to-point comparisons.

[2] Unless otherwise specified, EU-15 refers to the 15-member Union before its major enlargement: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom. For some series, the data refer to the EU–25 after enlargement, adding Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia.

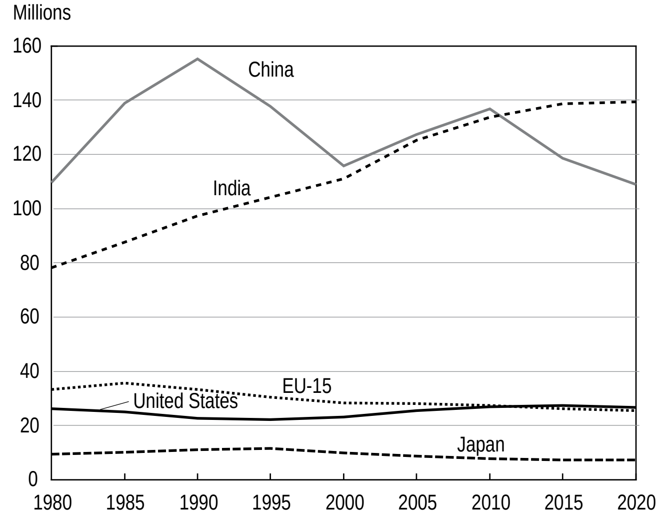
Education

College-Age Population Trends

The size of the college-age cohort of individuals 18–23 years old is an indication of the potential pool of candidates to obtain a higher education. Potential college students, even older ones, are increasingly important in a knowledge-based economy.

- Asia's college-age cohort is far larger than those of the EU and the United States. To illustrate: the combined total of only three Asian countries—China, India, and Japan—is projected to be five times as large as the combined EU and U.S. total from 2000 to 2020 (figure 1; table 1).
- China's One Child policy and various political upheavals produced a college-age cohort that oscillated enormously over two decades, swinging from 110 million in 1980 to 155 million in 1990 and then back to 116 million by 2000. After rebounding to 137 million in 2010, it is projected to decline further to 109 million in 2020.
- Meanwhile, India's college-age cohort grew continuously from 78 million in 1980 toward a projected 139 million in 2020.
- Japan's college-age cohort is expected to decline from just under 12 million in 1995 to just over a projected 7 million in 2020.
- The college-age cohort in the EU decreased from about 16 million in 1980 to 13 million in 2000 and is projected to be basically flat through 2020.
- The U.S. college-age population has trended slightly upward since 1995 after declining from 26 million in 1980 to a low of 22 million.

FIGURE 1. Population ages 18–23 years, by selected country and region: 1980–2020



EU = European Union

SOURCES: Department of Economic and Social Affairs, Population Division, United Nations Secretariat, World Population Prospects: The 2004 Revision Population Database, http://esa.un.org/unpp/; and World Urbanization Prospects: The 2003 Revision Population Database, http://www.un.org/esa/population/publications/wup2003/2003wup.htm, accessed 11 December 2006.

TABLE 1. Trends in population ages 18–23 years, by selected country and region: 1980–2020
(Thousands)

Year	Asia	China	India	Japan	EU-15	United States
1980	197,178	109,543	78,143	9,492	33,229	26,234
1985	236,430	138,793	87,573	10,064	35,524	25,123
1990	263,761	155,323	97,347	11,091	33,342	22,591
1995	253,551	137,816	104,166	11,569	30,346	22,070
2000	236,610	115,681	111,059	9,870	28,213	23,197
2005	261,132	127,270	125,183	8,679	28,010	25,385
2010	278,172	136,786	133,723	7,663	27,355	27,004
2015	264,494	118,562	138,668	7,264	26,152	27,273
2020	255,601	108,958	139,344	7,299	25,545	26,745

EU = European Union

NOTE: Asia includes China, India, and Japan

SOURCES: Department of Economic and Social Affairs of the United Nations Secretariat, Population Division, World Population Prospects: The 2004 Revision, http://esa.un.org/unpp/, accessed 14 December 2006; and World Urbanization Prospects: The 2003 Revision, http://www.un.org/esa/population/publications/wup2003/, accessed 14 December 2006.

Higher Education Degree Ratios

The ratio of higher education degrees earned to the size of the college-age population is a measure of the breadth of successful participation in postsecondary education, which in turn reflects government policies toward higher education availability and access. Over the past decades, the ratio of first university degrees to the college-age population (degree ratio) has increased in many locations.[3]

- In Asia, the degree ratio rose from about 3.8 per hundred in 1990 to 8.7 per 100 in 2002—a large increase in a short period, but the absolute level remains low (figure 2).

- Over the same period, the EU ratio rose from 11.1 per 100 to 30.7 per 100, bringing it nearly to the level of the United States. The U.S. degree ratio, for decades the highest in the world, rose modestly from 30.9 per 100 in 1990 to 33.9 per 100 in 2002.

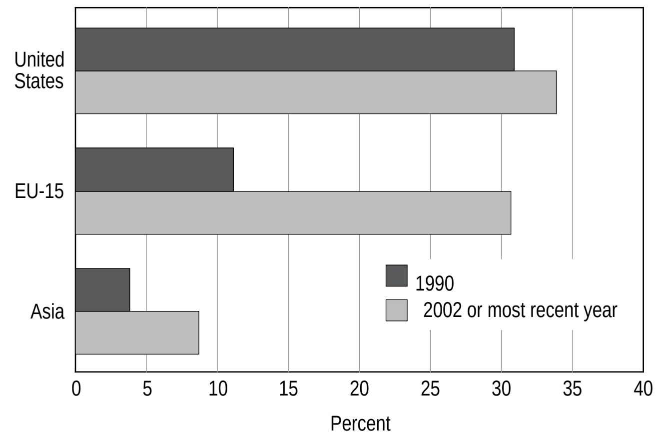
- Japan has a large higher education system and a declining population. It increased its degree ratio from 22.4 per 100 to 32.0 per 100 from 1990 to 2004, a degree ratio similar to the EU and the United States (figure 3).

- China's degree ratio stood at 1.2 per 100 in 1990 but jumped to 5.0 per 100 by 2003, on a par with India's 1990 level of 4.8 per 100 in 1990 (no comparable data have been available for India since 1990). Figure 3 also shows the heavy influence of China's numbers on the Asian average.

- In South Korea and especially in Taiwan, degree ratios rose steeply over the decade, equaling or surpassing the ratios of some major industrial nations and attesting to the emphasis in both countries on the importance of higher education for the workforces.

[3] All comparisons in this section are approximate. The 1990 ratio is based on the size of the cohort of individuals 22 years old; the 2002 ratio is based on individuals 24 years old, because directly comparable data are not readily available. Data are for most recent year; latest available data for China are for 2003, for Japan for 2004. Sources are *Science & Engineering Indicators 1993,* appendix table 2-1, and *Science & Engineering Indicators 2006,* appendix table 2-37.

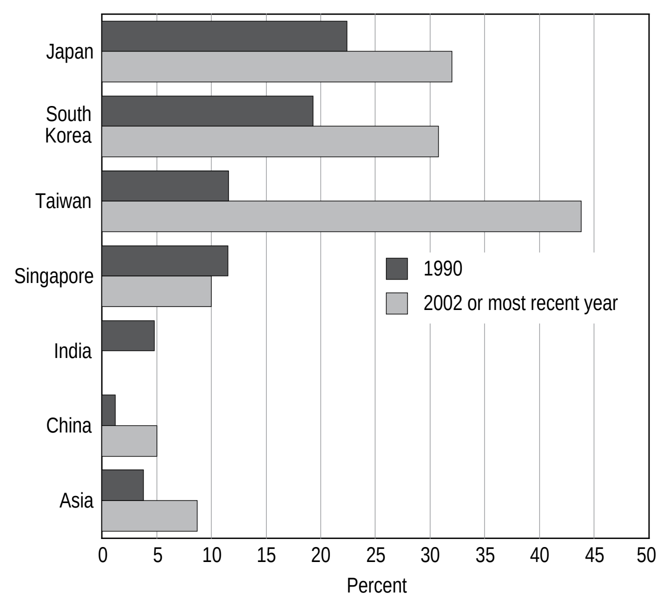
FIGURE 2. First university degrees per 100 24-year-olds, by selected region and country/economy: 1990 and 2002 or most recent year



EU = European Union

NOTES: Asia includes China, Japan, Singapore, South Korea, and Taiwan; data for China are for 2003, for Japan for 2004. For 1990, cohort is of 22-year-olds.
SOURCES: National Science Board, *Science and Engineering Indicators 1993*, NSB 931 (1993). Appendix table 2-1; *Science and Engineering Indicators 2006*, Volume 2, NSB 06-01A (2006), appendix table 2-37. National Science Foundation, Division of Science Resources Statistics, special tabulations from national and international sources.

FIGURE 3. First university degrees per 100 24-year-olds, by selected Asian country/economy: 1990–2002 or most recent year



NOTES: Asia includes China, Japan, Singapore, South Korea, and Taiwan; data for China are for 2003, for Japan for 2004. For 1990, cohort is of 22-year-olds.

SOURCES: National Science Board, *Science and Engineering Indicators* 1993, NSB 931 (1993). Appendix table 2-1; Science and Engineering Indicators 2006, Volume 2, NSB 06-01A (2006), appendix table 2-37. National Science Foundation, Division of Science Resources Statistics, special tabulations from national and international sources.

S&E Bachelor's Degrees

An S&E bachelor's degree represents achievement in a science or engineering field that allows junior professional-level entry into the S&E workforce or progression toward advanced S&E training. Only very broad estimates of bachelor's degrees conferred are possible, especially for Asia, because of data gaps and likely inconsistencies of classification.

- The number of S&E bachelor's degrees rose significantly in the 1990s in Asia (calculated without 1990 and 2002 data for India and the Philippines),[4] with China's output doubling from 1990 to 2002 and increases elsewhere ranging from 40% to over 200% (table 2).
- EU production of new S&E bachelor's degree holders rose similarly, nearly 80%. U.S. production increased by 26% from 1990 to 2002 (38% from 1990 to 2004).
- Especially stark differences were apparent in the production of engineering baccalaureates. Although Asian and EU engineering bachelor's degrees more than doubled,[5] U.S. engineering degrees declined 6%.
- Engineering bachelor's degree output in Asia was nearly double that in the EU and the United States combined in 1990, and Asia is pulling farther ahead.

[4] Degree data for Asia are from various years; the calculation omits India and Philippines, for which only 1990 data are available.

TABLE 2. Science and engineering bachelor's degrees and engineering baccalaureates by selected region and country/economy: 1990 or closest year and 2002 or most recent year available

Region and	1990 or closest year		2002 or most recent year	
country/economy	S&E	Engineering	S&E	Engineering
Asia	898,000	311,400	1,209,200	590,800
China	268,400	115,900	533,600	351,500
India	205,000	29,000	NA	NA
Indonesia	30,700	9,800	97,100	20,600
Japan	187,900	81,400	351,300	98,400
Malaysia	3,400	900	4,800	900
Philippines	71,100	29,400	NA	NA
Singapore	3,700	1,200	5,600	1,700
South Korea	79,300	28,100	113,100	64,900
Taiwan	24,400	9,000	72,500	41,900
Thailand	24,200	6,800	31,200	10,900
EU-15	284,300	92,700	506,100	198,300
United States	329,100	64,700	415,600	60,600

NA = not available
EU = European Union
S&E = science and engineering

NOTES: Data for bachelor's degrees use International Standard Classification of Education (ISCED) 97, level 5A. Most recent data for Indonesia are for 1997; for Singapore and Thailand, 1995. EU data are for 2003, U.S. data for 2004.

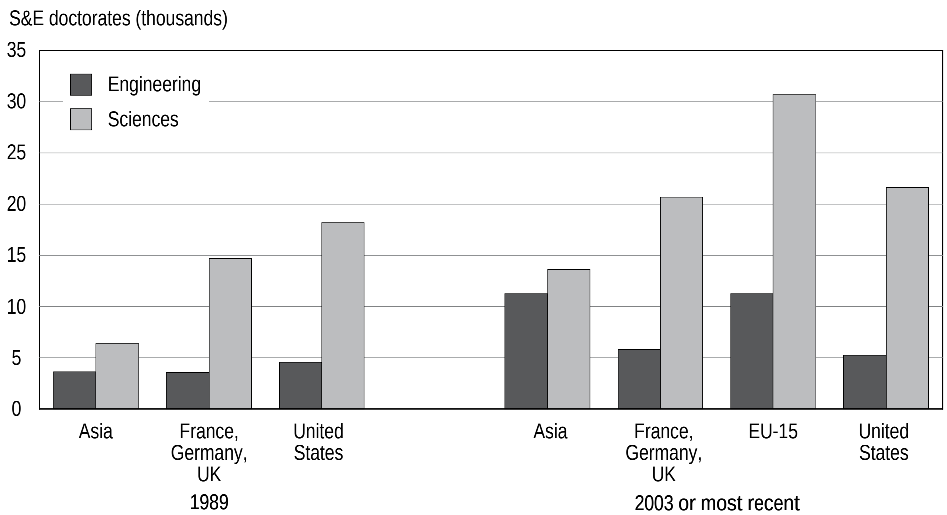
SOURCES: United Nations Educational, Scientific and Cultural Organization (UNESCO), *UNESCO Statistical Yearbook* (various years); UNESCO Institute for Statistics database, http://www.unesco.org, accessed 14 December 2006, special tabulations; Organisation for Economic Co-operation and Development (OECD), *Education at a Glance* (various years); OECD Education Database, http://www1.oecd.org/scripts/cde/members/EDU_UOEAuthenticate.asp, accessed 14 December 2006; China—National Bureau of Statistics of China, *China Statistical Yearbook* (2004); India—Department of Science and Technology, *Research and Development Statistics 1996–97* (1999); Japan—Ministry of Education, Science, and Culture, *Monbusho Survey of Education* (various years); Taiwan—Ministry of Education, *Educational Statistics of the Republic of China* (various years); and United States—National Science Foundation, Division of Science Resources Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://caspar.nsf.gov, accessed 14 December 2006.

S&E Doctoral Degrees

Doctoral degree conferrals signify achievement at a high level of training and indicate the availability of human capital with the capacity to generate original knowledge and innovations through advanced research.

- After increasing the number of new S&E doctorates during the 1990s, Asia[5] produced almost as many S&E doctorates in 2001 (24,900) as the United States in 2001 to 2003 (26,000–27,000)[6] but fewer than the EU (40,000–42,000 annually for 2001 to 2003) (figure 4).
- However, Asia produced more doctoral degrees in engineering in 2001 (11,200) than all of its doctoral S&E output in 1989 (10,000). This was similar to the 2001 EU total (10,300) and was double that year's U.S. total of 5,500.
- In 2001, China, expanding from a base of about 1,000 in 1989, conferred more than 8,000 S&E doctoral degrees, compared with 7,400 in Japan and an estimated 5,400 in India—the two closest Asian runners-up (figure 5). By 2003, China graduated 12,200 new S&E doctorates (table 3).
- Among Asian S&E doctoral degree recipients in 2001, those with engineering doctorates constituted about 45% of the total, compared with 26% for the EU and about 20% in the United States (figure 4; table 3).
- Asian universities award relatively small numbers of doctorates in the social and behavioral sciences: about 7% of all S&E doctorates in 2002, compared with 18% for the EU and 27% for the United States.

FIGURE 4. Science and engineering doctorate production by selected region and country: 1989 and 2003 or most recent year



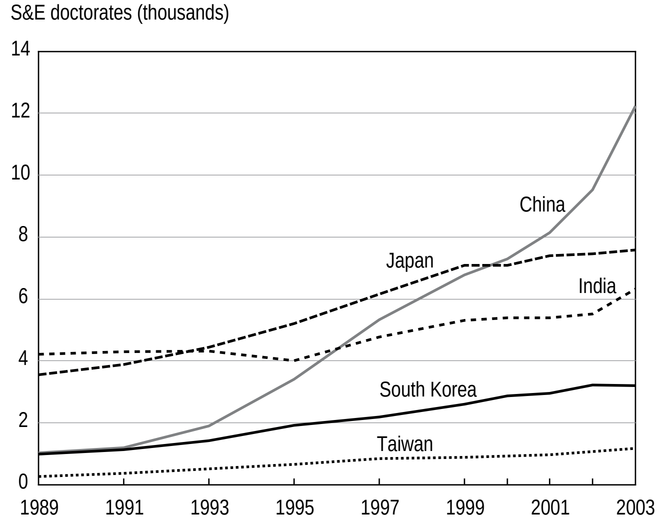
S&E = science and engineering; EU = European Union; UK = United Kingdom

NOTE: Asia includes China, India, Japan, South Korea, and Taiwan; 2001 is most recent year for Asia, 2002 for France and Germany, and 2003 for UK.

SOURCE: National Science Board, *Science and Engineering Indicators 2006*, Volume 2, NSB 06-01A (2006), appendix tables 2-40 and 2-42.

[5] Asia here includes China, India, Japan, South Korea, and Taiwan.
[6] Includes 9,600 doctoral S&E degrees conferred to foreign students on permanent and temporary visas.

FIGURE 5. Science and engineering doctorate production, by selected Asian country/economy: 1989–2003



S&E = science and engineering

NOTE: Data unavailable for even years during the 1990s.

SOURCES: National Science Board, *Science and Engineering Indicators 2006*, Volume 2, NSB 06-01A (2006), appendix table 2-43; and Ministry of Education of the People's Republic of China, Educational Statistics Yearbook (various years).

TABLE 3. Science and engineering doctorate production, by selected country/economy and region: 1989–2003 or most recent year

Field/year of doctorate	Asia	China	India	Japan	South Korea	Taiwan	EU-15	United States
All S&E								
1989	10,035	1,024	4,209	3,561	984	257	NA	22,706
1991	10,871	1,198	4,294	3,874	1,135	370	NA	25,061
1993	12,587	1,895	4,320	4,438	1,421	513	NA	26,640
1995	15,192	3,417	4,000	5,205	1,920	650	NA	27,864
1997	19,277	5,328	4,764	6,157	2,189	839	28,877	28,653
1999	22,676	6,778	5,317	7,082	2,607	892	36,269	27,339
2000	23,584	7,304	5,395	7,089	2,865	931	36,831	27,557
2001	24,874	8,153	5,394	7,401	2,956	970	40,151	27,160
2002	NA	9,523	5,527	7,461	3,225	1,069	40,026	26,226
2003	NA	12,238	6,318	7,581	3,192	1,167	41,939	26,891
Engineering								
1989	3,621	726	586	1,774	415	120	NA	4,543
1991	4,100	767	629	2,029	466	209	NA	5,214
1993	4,700	1,069	323	2,362	659	287	NA	5,698
1995	6,096	1,659	335	2,791	938	373	NA	6,008
1997	7,942	2,643	298	3,411	1,157	433	9,501	6,115
1999	9,964	3,269	696	3,934	1,583	482	9,672	5,330
2000	11,163	4,484	723	3,800	1,654	502	8,946	5,321
2001	11,242	4,341	778	3,964	1,638	521	10,328	5,502
2002	NA	5,252	734	3,955	1,899	587	10,145	5,071
2003	NA	6,573	779	3,921	1,868	656	11,263	5,265

EU = European Union
NA = not available
S&E = science and engineering

NOTES: Data for doctoral degrees use the International Standard Classification of Education (ISCED 97), level 6. S&E data do not include health fields. Asia includes China, India, Japan, South Korea, and Taiwan. Japanese data include thesis doctorates, called *ronbun hakase*, earned by employees in industry. Japan includes computer sciences in engineering.

SOURCES: National Science Board, *Science and Engineering Indicators 2006,* Volume 2, NSB 06-01A (2006), appendix tables 2-42 and 2-43; OECD Education database, http://www1.oecd.org/scripts/cde/members/EDU_UOEAuthenticate.asp, accessed 14 December 2006; and People's Republic of China Ministry of Education, Education Statistics Yearbook (various years).

Asian and EU Recipients of U.S. S&E Doctorates

Foreign participation in U.S. S&E doctoral education is an indicator of global flows of personnel and knowledge. The United States benefits from well-prepared and motivated foreign graduate students, the students benefit from advanced training, and countries of origin have the potential to benefit from the skills these students have acquired.

- From 1989 to 2003, foreign students earned nearly 40% of U.S. S&E doctorates, with Asian students representing about 55% of this group. Students from EU countries have totaled about 10% of all foreign doctorate recipients in the United States (figure 6).

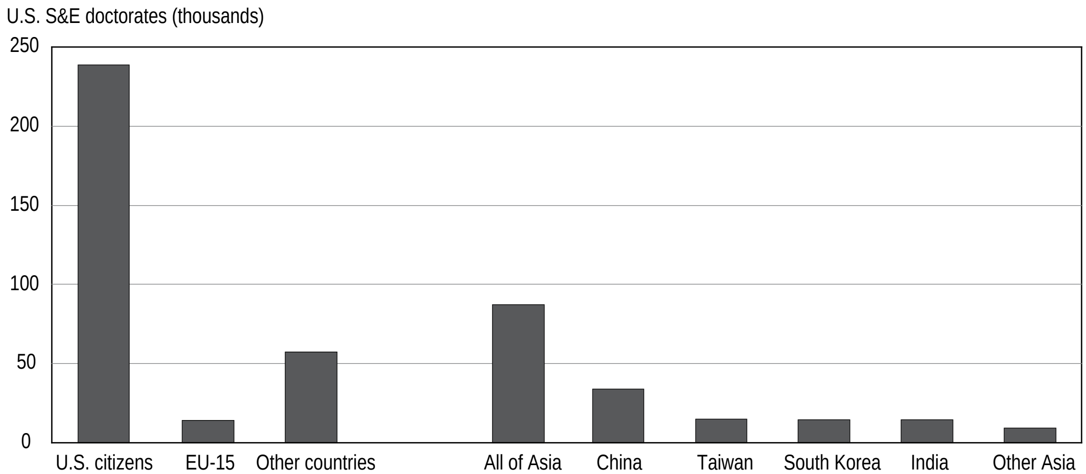
- The largest Asian sources were China with about 34,000 S&E doctorates from 1989 to 2003, Taiwan with 14,800, and South Korea and India with about 14,500 each. These four sources accounted for nearly 90% of all Asian recipients of U.S. S&E doctorates.

- The total number of U.S. S&E doctorates earned by Asian students rose through the mid-1990s and then reached a plateau or declined. (The numbers decreased for China, Taiwan, and India.) The number of EU students earning U.S. doctorates remained fairly steady, at around 1,000 per year (figure 7).

- Stay rates after degree conferral (the proportion of new foreign S&E doctorate holders planning to remain in the United States immediately upon degree conferral) have been rising for students from most Asian countries and the EU. For students from China and India, the stay rate has been 80% and higher since 1992. For all major Asian sources and the EU, over half of U.S. doctorate recipients stay in the United States (figure 8).

- Asian recipients of U.S. S&E doctorates are far more likely than EU students to earn an engineering doctorate: 35%–38% compared with 17%–21% of EU students. (The U.S. average is 13%–15%.)

FIGURE 6. Recipients of U.S. science and engineering doctorates, by selected region and country/economy: 1989–2003

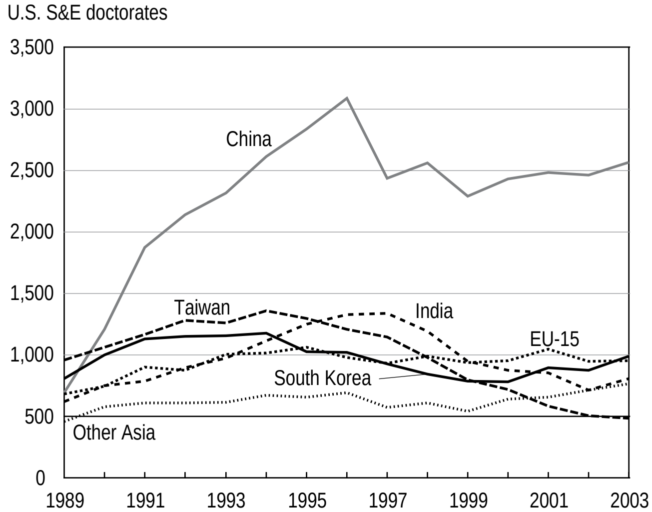


S&E = science and engineering; EU = European Union

NOTES: Foreign doctoral recipients include those with either permanent or temporary visa. European Union data include a few degrees to students from Norway and Switzerland. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. Other Asia includes Indonesia, Japan, Malaysia, Philippines, Singapore, and Thailand.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates (various years), Integrated Science and Engineering Resources Data System (WebCASPAR) database system, http://caspar.nsf.gov, special tabulations, accessed 11 December 2006.

FIGURE 7. U.S. science and engineering doctorates received by Asian and European Union students: 1989–2003

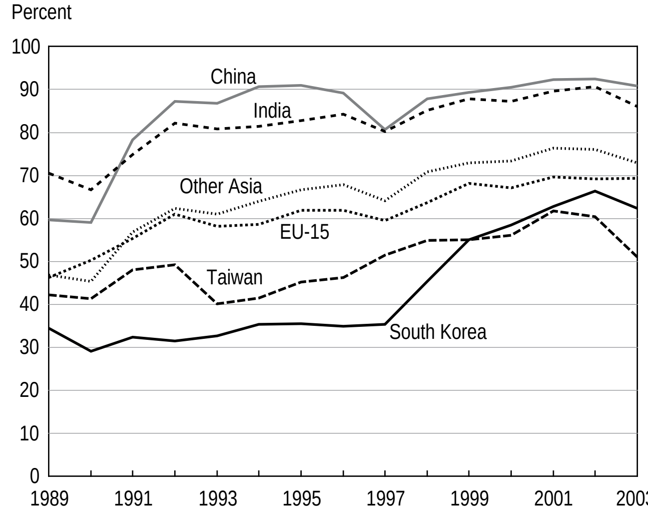


S&E = science and engineering; EU = European Union

NOTES: Other Asia includes Japan, Indonesia, Malaysia, Philippines, Singapore, and Thailand. Data include temporary and permanent visa holders.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates (various years), Integrated Science and Engineering Resources Data System (WebCASPAR) database system, http://caspar.nsf.gov, special tabulation, accessed 11 December 2006.

FIGURE 8. Stay rates of U.S. science and engineering doctorate recipients, by selected region and country/economy: 1989–2003



EU = European Union

NOTES: Stay rates are percentage of doctorate recipients with plans to stay in United States after degree conferral. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates (various years), Integrated Scinece and Engineering Resources Data System (WebCASPAR) database system, http://caspar.nsf.gov, special tabulations, accessed 11 December 2006.

EDUCATION LEVEL OF LABOR FORCE

For most Asian economies, detailed information is lacking on the educational distribution of the labor force. However, counts of the number of workers who have completed at least a tertiary level of education (roughly the equivalent of an associate degree or higher in the United States) are often available and can serve as an approximate indicator of the growth of a more skilled workforce.

- The number of people in the world who have completed a tertiary education rose from an estimated 139 million in 1990 to 193 million in 2000, at an average annual growth rate exceeding 3% (table 4).
- Between 1990 and 2000, all major Asian economies experienced significant growth in the tertiary-educated labor force, averaging 5% annually (closer to 6% without Japan), a rate similar to that of the EU. Growth for the United States was lower, just above 2%.
- As a result of this differential growth, 46% of all additions to the world's tertiary-educated labor force from 1990 to 2000 were contributed by Asia, compared with 16%–19% each by the EU, the United States, and all other countries (figure 9).
- In Asia, China added the most tertiary-educated workers from 1990 to 2000 with an increase of 8.4 million, accounting for one-third of the Asian total (and China's output of tertiary graduates has been accelerating since 2000). India was in second place with an increase of 5.7 million (figure 10; table 4).

TABLE 4. Estimated tertiary-educated workers, by selected region and country/economy: 1990 and 2000

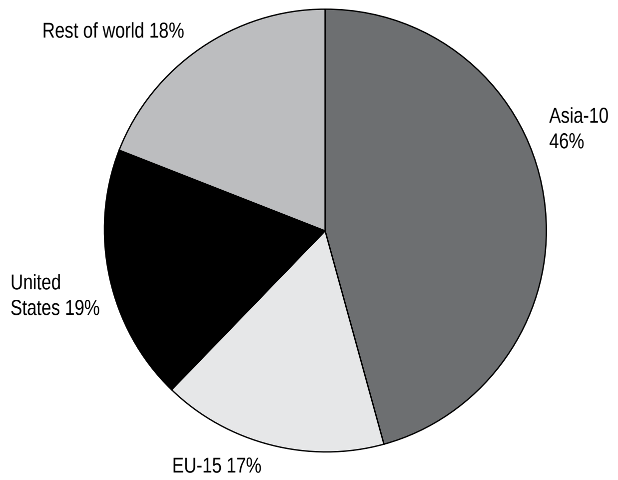
Region and country/economy	1990	2000	Increase	Average annual increase (%)
All countries/economies	139,000,000	193,000,000	54,000,000	3.3
Asia	38,742,000	63,429,000	24,687,000	5.1
China	11,731,000	20,139,000	8,408,000	5.6
India	9,221,000	14,962,000	5,741,000	5.0
Indonesia	235,000	736,000	501,000	12.1
Japan	9,274,000	12,537,000	3,263,000	3.1
Malaysia	210,000	418,000	208,000	7.1
Philippines	3,556,000	5,698,000	2,142,000	4.8
Singapore	33,000	86,000	53,000	10.1
South Korea	2,035,000	4,442,000	2,407,000	8.1
Taiwan	742,000	1,226,000	484,000	5.1
Thailand	1,705,000	3,185,000	1,480,000	6.4
EU-15	13,486,000	22,415,000	8,929,000	5.2
United States	42,650,000	52,772,000	10,122,000	2.2
Other	44,122,000	54,384,000	10,262,000	2.1

EU = European Union

NOTES: Tertiary-educated approximately equivalent to U.S. associate's degree or higher. Asia includes only the listed locations. All countries/economies total includes all countries/regions not specifically listed but included in Other.

SOURCE: R.J Barrow and J. Lee, *International Data on Educational Attainment,* CID Working Paper No. 42, Center for International Development (2000).

FIGURE 9. Increase in tertiary-educated workers, by region and country/economy: 1990–2000



EU = European Union

NOTES: Tertiary-educated approximately equivalent to U.S. associate's degree or higher. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: R.J Barrow and J. Lee, International Data on Educational Attainment. CID Working Paper No. 42. Center for International Development (2000).

FIGURE 10. Tertiary-educated workers in selected Asian countries/economies: 1990 and 2000

NOTE: Tertiary education approximately equivalent to a U.S. associate's degree or higher.

SOURCE: R.J. Barrow and J. Lee, International Data on Educational Attainment. CID Working Paper No. 42. Center for International Development (2000).

Asian- and EU-Born College-Educated Workers in U.S. S&E Occupations

There has been a rise in the number of individuals born in Asia who are employed in S&E occupations in the United States. These include both individuals educated abroad and those who received their degrees in the United States and chose to stay.

- Between 1990 and 2000, the number of individuals with college degrees (bachelor's or higher) born in Asia who were employed in S&E occupations in the United States rose from approximately 141,000 to 460,000; those born in EU countries increased from 45,000 to 75,000 (table 5).
- Although the number of U.S. natives employed in S&E occupations in the United States grew rapidly during the 1990s (40%), the increase was much larger for Asian-born individuals (more than 200%). EU-born individuals increased 67%.
- In 2000, 23% of individuals in U.S. S&E occupations were foreign born, and half of those foreign-born workers came from Asia.
- The most common countries of origin for foreign-born, college-educated individuals working in U.S. S&E occupations in 2000 were India (4.9%) and China (3.1%). The numerical increases since 1990 are remarkably large for both countries (figure 11; table 5).

TABLE 5. Workers in U.S. science and engineering occupations with bachelor's degree or higher, by place of birth: 1980, 1990, and 2000

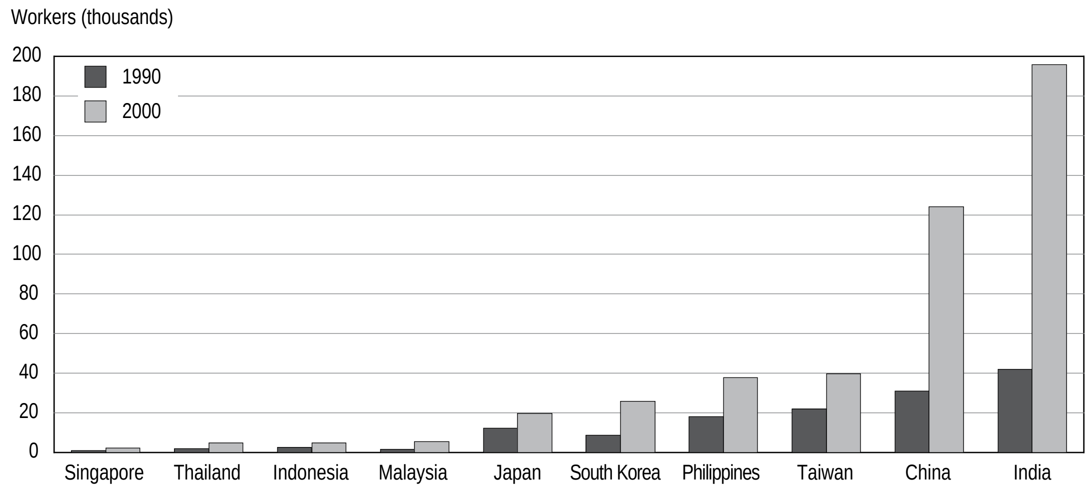
	1980		1990		2000	
Place of birth	Number	Percent	Number	Percent	Number	Percent
All countries/economies	1,549,200	100.0	2,550,000	100.0	3,967,500	100.0
United States	1,363,300	88.0	2,184,900	85.7	3,068,400	77.3
Foreign	185,900	12.0	365,100	14.3	899,100	22.7
EU-15	28,500	1.8	45,000	1.8	75,100	1.9
Asia	66,000	4.3	140,500	5.5	459,600	11.6
China	17,800	1.1	30,900	1.2	124,000	3.1
India	23,400	1.5	42,100	1.7	195,700	4.9
Indonesia	900	0.1	2,400	0.1	4,800	0.1
Japan	4,400	0.3	12,200	0.5	19,700	0.5
Malaysia	300	0.0	1,500	0.1	5,300	0.1
Philippines	9,300	0.6	18,000	0.7	37,900	1.0
Singapore	100	0.0	800	0.0	2,100	0.1
South Korea	3,200	0.2	8,700	0.3	25,800	0.7
Taiwan	5,700	0.4	21,900	0.9	39,600	1.0
Thailand	900	0.1	2,000	0.1	4,700	0.1
Other	91,400	5.9	179,600	7.0	364,400	9.2

EU = European Union

NOTES: Data exclude those in postsecondary teaching positions because 2000 census occupation codes do not allow categorization of postsecondary teachers by field. Other includes all countries not listed separately.

SOURCES: National Science Foundation tabulation of U.S. census data 1980, 1990, 2000; University of Minnesota, Minnesota Population Center, Integrated Public Use Microdata Series, http://www.ipums.org/usa, accessed 14 December 2006.

FIGURE 11. Asian-born workers in U.S. science and engineering occupations with bachelor's degree or higher, by selected country/economy: 1990 and 2000



NOTE: Data exclude those in postsecondary teaching positions because 2000 census occupation codes do not allow categorization of postsecondary teachers by field.

SOURCES: National Science Foundation tabulations of U.S. Census data 1980, 1990, 2000; and University of Minnesota, Minnesota Population Center, Integrated Public Use Microdata Series, http://ipums.org/usa, accessed 11 December 2006.

Asian- and EU-Born Doctorate Holders in U.S. S&E Occupations

Data on the place of birth of individuals with doctoral degrees employed in U.S. S&E occupations in 1990 and 2000 show that doctorate holders born in Asia are increasingly important to the United States.

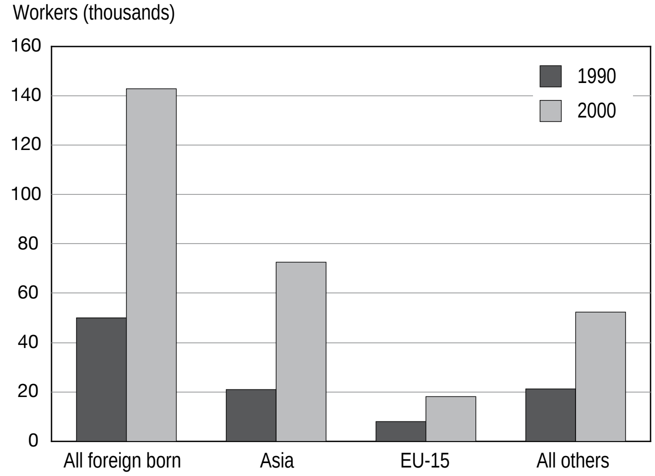
- Between 1990 and 2000, the number of foreign-born doctorate holders employed in U.S. S&E occupations rose from 50,000 to 143,000, with Asia accounting for over half of the total increase (figure 12; table 6).

- The steep increase in Chinese- and Indian-born doctorate holders in U.S. S&E occupations during the 1990s is remarkable, but the increase is also significant (tripling or near-tripling) for South Korea and Japan, countries whose doctorate holders traditionally have tended to return home after earning a U.S. doctorate (figure 13).

- Doctorate holders from the two largest Asian countries (China and India) constituted almost 14% of all doctorate holders in U.S. S&E occupations in 2000.

- China accounted for nearly 9% of all U.S. S&E doctorate holders in 2000, versus India's 5%. However, as of 2000, India remained the single largest source country for all degree levels combined (see table 5).

FIGURE 12. Foreign-born science and engineering doctorate holders in U.S. science and engineering occupations, by region: 1990 and 2000



EU = European Union

NOTES: Data exclude those in postsecondary teaching positions because 2000 census occupation codes do not allow categorization of postsecondary teachers by field. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCES: National Science Foundation tabulations of U.S. census data 1980, 1990, 2000; and University of Minnesota, Minnesota Population Center, Integrated Public Use Microdata Series, http://ipums.org/usa, accessed 11 December 2006.

TABLE 6. Doctorate holders in U.S. science and engineering occupations, by place of birth: 1990 and 2000

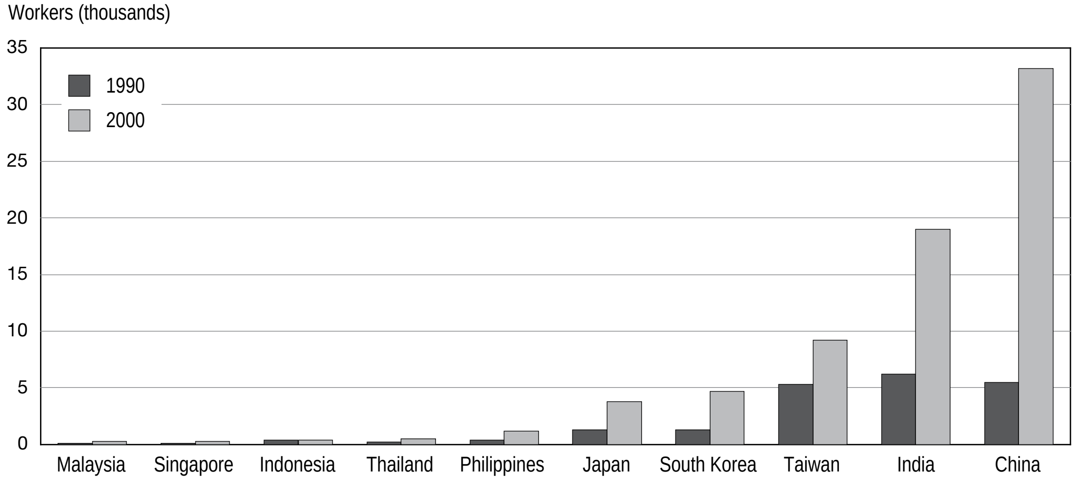
	1990		2000	
Place of birth	Number	Percent	Number	Percent
All countries/economies	209,000	100.0	383,000	100.0
United States	159,000	76.1	240,000	62.7
Foreign	50,000	23.9	143,000	37.3
EU-15	8,000	3.6	18,000	4.7
Asia	20,800	10.0	72,600	19.0
China	5,500	2.6	33,200	8.7
India	6,200	3.0	19,000	5.0
Indonesia	400	0.2	400	0.1
Japan	1,300	0.6	3,800	1.0
Malaysia	100	0.1	300	0.1
Philippines	400	0.2	1,200	0.3
Singapore	100	0.0	300	0.1
South Korea	1,300	0.6	4,700	1.2
Taiwan	5,300	2.6	9,200	2.4
Thailand	200	0.1	500	0.1
Other	21,200	10.3	52,400	13.7

EU = European Union

NOTES: Data exclude those in postsecondary teaching positions because 2000 census occupation codes do not allow categorization of postsecondary teachers by field. Other includes all countries not listed separately.

SOURCES: National Science Foundation tabulation of U.S. census data 1980, 1990, 2000; University of Minnesota, Minnesota Population Center, Integrated Public Use Microdata Series, http://www.ipums.org/usa, accessed 14 December 2006.

FIGURE 13. Asian-born science and engineering doctorate holders in U.S. science and engineering occupations, by selected country/economy: 1990 and 2000



NOTE: Data exclude those in postsecondary teaching positions because 2000 census occupation codes do not allow categorization of postsecondary teachers by field.

SOURCES: National Science Foundation tabulations of U.S. census data 1980, 1990, 2000; and University of Minnesota, Minnesota Population Center, Integrated Public Use Microdata Series, http://ipums.org/usa, accessed 11 December 2006.

Stay Rates for Asian and EU Recipients of U.S. S&E Doctorates

Foreign-born individuals who receive U.S. degrees and stay in the U.S. labor market[7] are a potential source of skills for their home countries but also an important source of highly skilled labor for the United States. Many stay in the United States well after receiving their degree.

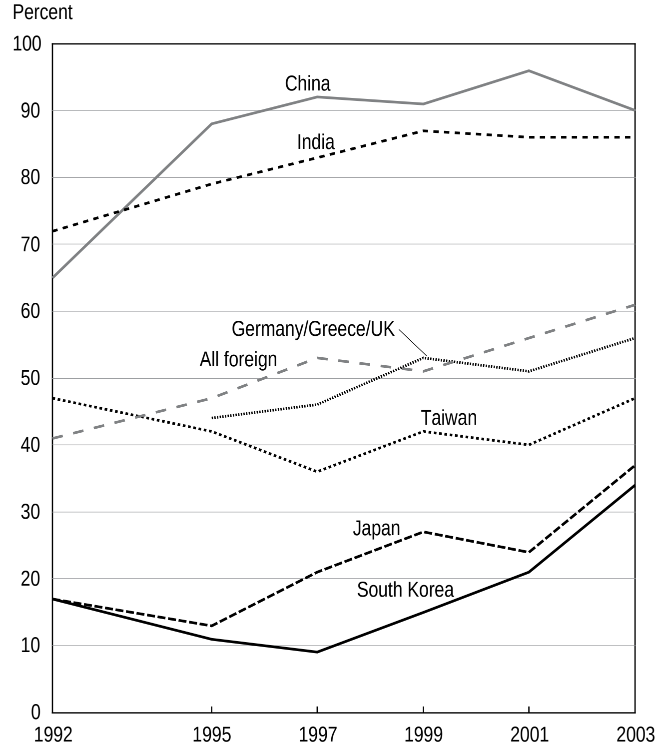
- Overall, in 2003, about 61% of those who were temporary visa holders when they received a U.S. S&E doctorate were working in the U.S. labor market 5 years after graduation. This rate has risen since 1992 (figure 14).

- U.S. stay rates differ greatly among Asian source countries and are especially high for Chinese and Indian doctorate holders.

- Japanese and South Korean doctorate recipients have historically had low stay rates, but both countries have seen strong increases since the mid-1990s.

- Students from the largest EU-sending countries—the United Kingdom, Germany, and Greece—have generally had stay rates just under the average for all foreign degree recipients.

FIGURE 14. Temporary-visa students who earned U.S. science and engineering doctorates and remained in the United States 4–5 years after degree, by country/economy: 1992–2003



UK = United Kingdom

SOURCE: National Science Foundation, Division of Science Resources Statistics (NSF/SRS), data provided by Michael Finn, Oak Ridge Institute for Science and Education, based on matching of NSF/SRS Survey of Earned Doctorates data to U.S. Social Security data.

[7] Michael Finn of the Oak Ridge Institute for Science and Education estimates U.S. stay rates of different graduation cohorts of temporary-visa doctorate recipients by matching each cohort with Social Security earning records (*Stay Rates of Foreign Doctorate Recipients From U.S. Universities,* 2003).

R&D Expenditures

Total R&D Expenditures

Many governments consider R&D to be a key to economic growth and social welfare. Gross expenditures on R&D are an indicator of overall potential for technological innovation.

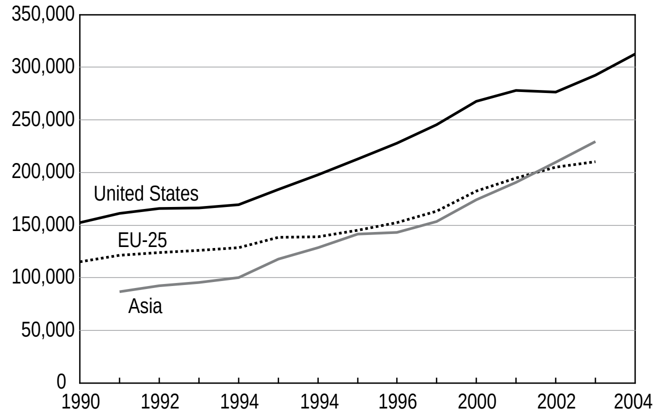
- The level of R&D activity in Asia[8] had surpassed that of the EU in 2002 and by 2003 was nearly 10% greater than the EU level. In 2003, the Asian R&D level was about 79% that of the United States (table 7; figure 15).

- From 1991 to 1995, R&D in Asia grew at a much faster annual rate (7.9%) than in the EU (3.4%) and in the United States (3.3%). After 1995, growth accelerated in Asia to an annual average of 8.7%, exceeding that of the EU (5.4%) and the 6.0% U.S. average (figure 16).

- China's annual rate of R&D growth from 1995 to 2003 (20%) exceeded that of all these other R&D

FIGURE 15. Gross expenditures on research and development, by selected region and country/economy: 1990–2004

Purchasing power parity (billions of dollars)



EU = European Union

NOTES: Purchasing power parity (PPP) is calculation of exchange rates based on relative costs of fixed basket of goods and services in different countries or regions. PPP exchange rates often differ from exchange rates set by financial markets. Asia includes China, Japan, Singapore, South Korea, and Taiwan.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2006).

TABLE 7. Gross expenditures on research and development, by selected region and country/economy: 1990–2004
(Millions of current purchasing power parity dollars)

Year	Asia	China	Japan	Singapore	South Korea	Taiwan	EU-25	United States
1990	NA	NA	62,865	NA	NA	NA	115,239	152,389
1991	86,763	12,495	66,942	NA	7,325	NA	121,281	161,388
1992	92,388	14,938	69,096	NA	8,354	NA	123,770	165,835
1993	95,675	16,658	69,107	NA	9,910	NA	125,964	166,147
1994	100,056	17,463	69,921	632	12,041	NA	128,860	169,613
1995	117,683	18,410	78,668	740	13,681	6,183	138,416	184,077
1996	128,818	20,340	85,470	985	15,282	6,742	139,159	197,792
1997	141,530	25,384	90,754	1,116	16,637	7,638	145,365	212,709
1998	143,086	27,939	90,508	1,358	14,789	8,493	152,509	228,109
1999	153,527	33,940	92,774	1,584	15,793	9,437	163,028	245,476
2000	174,008	44,771	98,850	1,810	18,395	10,182	182,567	267,768
2001	190,501	52,418	104,161	2,007	21,166	10,749	194,759	277,820
2002	209,936	65,154	108,248	2,202	22,247	12,085	205,263	276,260
2003	229,628	76,891	112,715	2,255	24,274	13,494	210,168	292,437
2004	NA	93,992	NA	2,678	NA	14,951	NA	312,535

NA = Not available
EU = European Union

NOTES: Purchasing power parity (PPP) is calculation of exchange rates based on relative costs of fixed basket of goods and services in different countries or regions. PPP exchange rates often differ from exchange rates set by financial markets. Asia includes China, Japan, Singapore, South Korea, and Taiwan for 1994-2003, but only China, Japan, and South Korea for 1991–1994. EU-25 is as estimated by Organisation for Economic Co-operation and Development (OECD) Secretariat. Japanese data for 1990–95 adjusted to more accurately reflect full-time-equivalent researcher labor costs. Detail may not add to total because of rounding.

SOURCE: OECD, *Main Science and Technology Indicators* (2006/1).

[8] Data for Asia are limited to Japan, China, Singapore, South Korea, and Taiwan. However, because R&D data are not available for Singapore and Taiwan until 1994/1995, the early 1990s growth rate for Asia represents only China, Japan, and South Korea. The 1990–95 data for Japan are adjusted to more accurately reflect full-time-equivalent researcher labor costs.

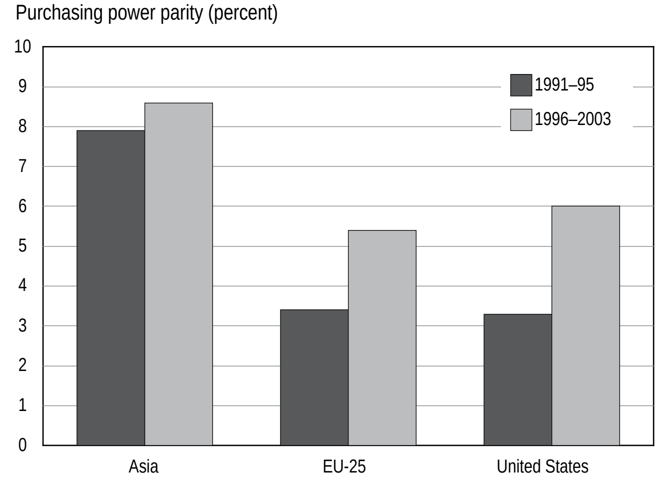
performers, followed by Singapore's at 15%. Growth in Taiwan averaged 10% and in South Korea 7% (figure 17).

- Only Japan's R&D growth from 1995 to 2003 was below that of the United States and the EU. At present growth rates, China's R&D expenditures appear to be rapidly approaching those of Japan, the world's second largest R&D-performing country.

- Obtaining internationally comparable estimates of R&D spending for a developing country like China is difficult,[9] and the estimated absolute level of R&D investment in China cannot be considered exact. However, there is no reason to doubt the rapidly accelerating investment trend indicated by the Chinese data.

[9] See "Comparing International R&D Expenditures" in National Science Board, 2006, *Science and Engineering Indicators 2006* (National Science Foundation, pp. 4-39).

FIGURE 16. Average annual growth rates of research and development expenditures, by selected region and country/economy: 1991–95 and 1996–2003

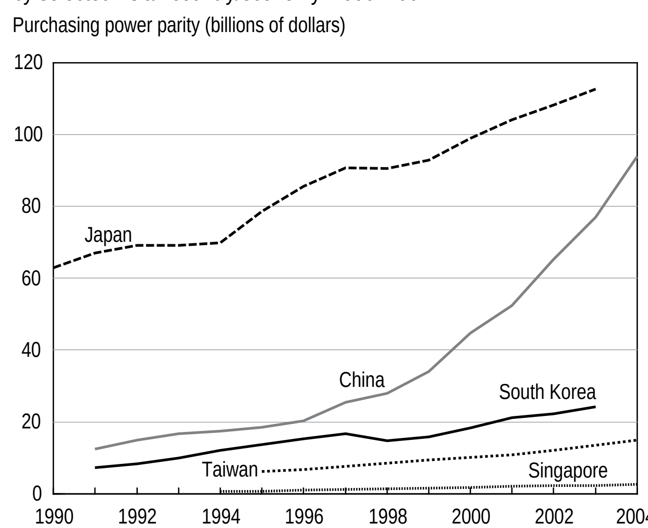


EU = European Union

NOTES: Purchasing power parity (PPP) is calculation of exchange rates based on relative costs of fixed basket of goods and services in different countries or regions. PPP exchange rates often differ from exchange rates set by financial markets. Asia includes China, Japan, Singapore, South Korea, and Taiwan.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2006).

FIGURE 17. Gross domestic expenditures on research and development, by selected Asian country/economy: 1990–2004



NOTES: Purchasing power parity (PPP) is calculation of exchange rates based on relative costs of fixed basket of goods and services in different countries or regions. PPP exchange rates often differ from exchange rates set by financial markets. Japanese data for 1990–95 adjusted to more accurately reflect full-time equivalent researcher labor costs.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2006).

R&D-to-GDP Ratio

This indicator shows the level of economic resources devoted to R&D activities compared with other economic activities, as measured by GDP. R&D-to-GDP ratios are broadly indicative of the capacity for innovative activity and technological change in overall economic activity.

- The ratio of R&D to GDP in Asia[10] has recently exceeded that in the EU, reaching 1.92 in 2003, when the EU ratio was 1.81. The ratio in the United States stood at 2.68 in 2003 (figure 18).

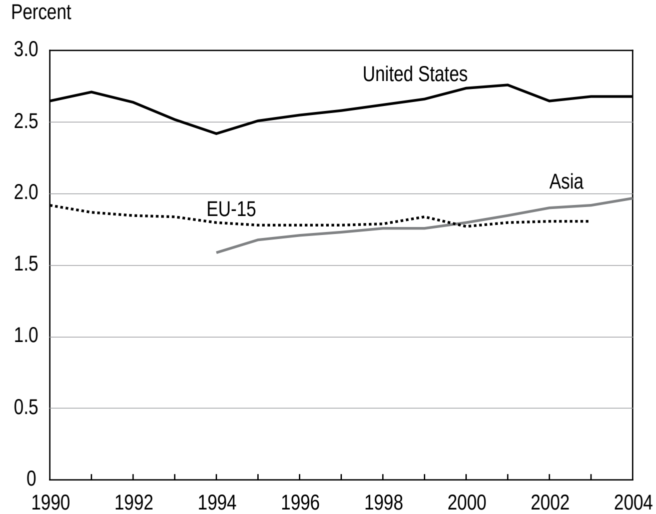
- Substantial differences in R&D-to-GDP ratios exist among the five Asian economies. In 2003, Japan and South Korea had the highest values: 3.15 and 2.63, respectively. The ratios were lower in Taiwan (2.45) and Singapore (2.13) (figure 19).

- Although China's R&D-to-GDP ratio was the lowest among the five Asian economies in 2003 (1.13), its ratio had the steepest increase since 1995 among these economies, closely followed by Singapore's, and showed further growth in 2004, to 1.23. When set against China's rapidly growing economy, the rise in the R&D-to-GDP ratio is remarkable.

- The ratios in Asia increased faster between 1995 and 2003 (in both absolute and relative terms) than the ratios in the United States and the EU.

[10] Data for Asia are limited to Japan, China, Singapore, South Korea, and Taiwan. The 1990–95 data for Japan are adjusted to more accurately reflect full-time-equivalent researcher labor costs.

FIGURE 18. Research and development share of gross domestic product, by selected region and country/economy: 1990–2004

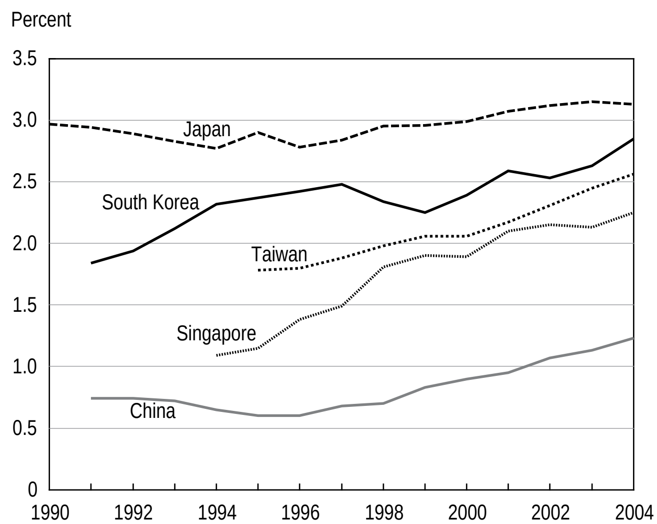


EU = European Union

NOTE: Asia includes China, Japan, Singapore, South Korea, and Taiwan.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2006).

FIGURE 19. Research and development share of gross domestic product, by selected Asian country/economy: 1990–2004



NOTE: Japanese data for 1990–95 adjusted to more accurately reflect full-time equivalent researcher labor costs.

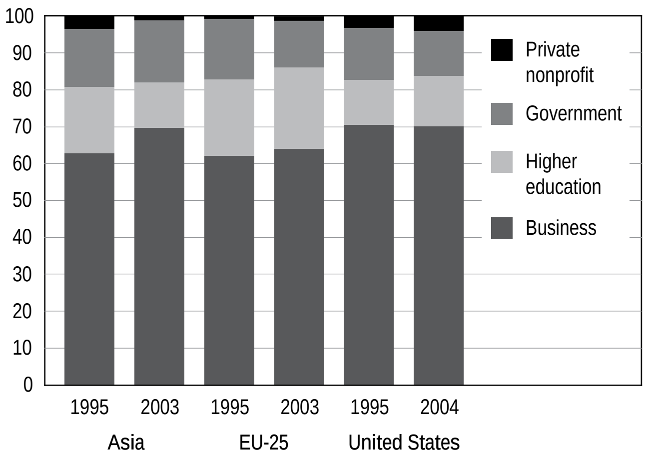
SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2006).

R&D Expenditures by Performing Sector

This indicator measures the relative prominence of different sectors, business, academic, government, and private nonprofit, in conducting R&D activities.

FIGURE 20. Research and development expenditures, by performing sector and selected region and country/economy: 1995 and 2003–04

Percent distribution



EU = European Union

NOTE: Asia includes China, Japan, Singapore, South Korea, and Taiwan.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2005).

- The business sector performed the majority of R&D in Asia,[11] the EU, and the United States. In 2003, the business sector's share in Asia (70%) was similar to that in the United States, but the sector's share in the EU (64%) was lower (figure 20).

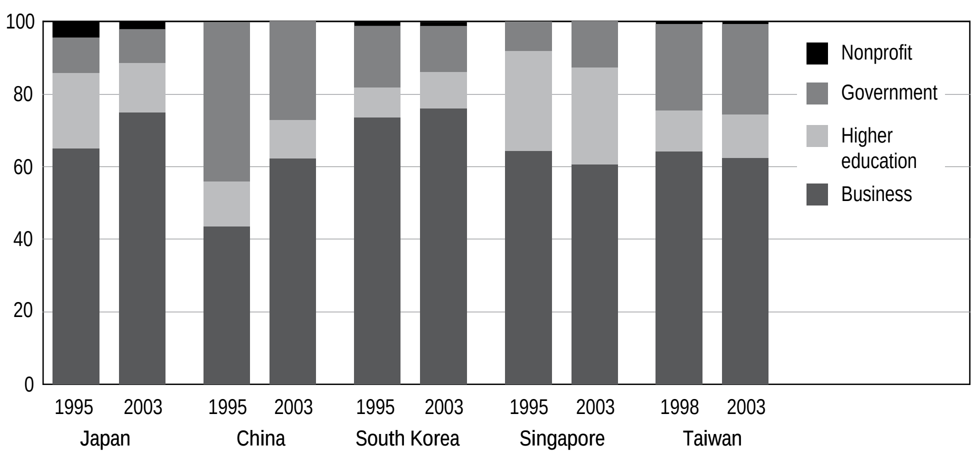
- From 1995 to 2003, the business sector share increased 7 percentage points in Asia, offset largely by a decline in the academic sector's share. In the EU, small increases in business and academic sector R&D shares were offset by a decline in the government share. The U.S pattern remained largely stable.

- Business sector growth was especially robust in China, where it reflected, in part, the restructuring of formerly state-owned enterprises and thus was accompanied by a sharp decline in the share of government-performed R&D (figure 21).

- Japan's business sector share of R&D also rose strongly, coupled with a decline in the academic share. In South Korea, business and academic R&D sector shares increased while that of government R&D declined. Singapore and Taiwan registered small declines in the business share of R&D.

FIGURE 21. Research and development expenditures, by performing sector and selected Asian country/economy: 1995 and 2003

Percent distribution



NOTE: Japanese data for 1995 adjusted to more accurately reflect full-time equivalent researcher labor costs.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2005).

[11] Data for Asia are limited to Japan, China, Singapore, South Korea, and Taiwan. The 1990–95 data for Japan are adjusted to more accurately reflect full-time-equivalent researcher labor costs.

U.S. Multinational Corporations' R&D in Asia and the EU

Foreign direct investment (FDI) is an indicator of globalization. It refers to the ownership by multinational corporations (MNCs) or their foreign affiliates of productive assets outside their home country. FDI can result from cross-border mergers and acquisitions, establishment of new facilities, and activities in existing facilities.[12]

- U.S.-based MNCs have nearly doubled the value of their overseas R&D activities through their foreign affiliates since the mid-1990s, from $11.9 billion in 1994 to $21.2 billion in 2002 (preliminary estimate). Although the bulk of this overseas R&D is performed in Europe, Asia[13] is becoming a key location (table 8).

- Asia absorbed $3.6 billion in R&D FDI in 2002, down slightly from $3.9 billion in 2001 but more than double its $1.5 billion in 1994. In contrast, the EU accounted for an estimated $12.1 billion, up from $8.3 billion in 1994.[14] However, the EU share of the total declined from about 70% in 1994 to 57% in 2002 (figure 22; table 8).

- Following consecutive annual declines in 1997 and 1998 that coincided with the Asian financial crisis, U.S. companies' R&D expenditures in Asia more than doubled from 1998 to 1999, from $1.3 billion to $2.9 billion, and reached $3.9 billion in 2001. However, investments in individual economies outside of Japan remained relatively modest through 2002 (figure 23; table 8).

TABLE 8. Research and development performed abroad by majority-owned foreign affiliates of U.S. multinational corporations, by host region and country/economy: 1994–2002
(Millions of current U.S. dollars)

Region and country/economy	1994	1995	1996	1997	1998	1999	2000	2001	2002
All countries/economies	11,877	12,582	14,039	14,593	14,664	18,144	20,457	19,702	21,151
Asia	1,538	1,569	1,651	1,482	1,298	2,923	3,587	3,908	3,552
China	58	68	63	117	118	533	D	D	D
Mainland	7	13	25	35	52	319	506	D	646
Hong Kong	51	55	38	82	66	214	D	289	D
India	5	5	9	22	23	20	D	26	80
Indonesia	5	9	6	5	4	1	2	3	3
Japan	1,130	1,286	1,333	1,089	962	1,523	1,630	1,507	1,433
Malaysia	27	21	23	32	30	161	218	D	D
Philippines	14	23	14	12	10	31	40	48	50
Singapore	167	63	88	73	62	426	551	755	589
South Korea	17	29	34	41	29	101	143	157	167
Taiwan	110	61	75	84	55	122	143	139	70
Thailand	3	5	5	5	4	7	13	18	22
EU	8,271	8,852	9,386	9,691	10,058	11,900	12,472	11,253	12,142
Other	2,068	2,161	3,002	3,420	3,308	3,321	4,398	4,541	5,457

D = suppressed to avoid disclosure of confidential information
EU = European Union

NOTES: Data are for nonbank overseas majority-owned affiliates of nonbank U.S. parent companies. Majority-owned affiliates are those in which combined ownership of all U.S. parents is more than 50%. Data include research and development (R&D) performed by affiliates, whether for themselves or others, and exclude R&D expenditures made by others for affiliates. European Union includes 12 countries for 1994 and 15 countries thereafter. Data for 2002 are preliminary estimates.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies (annual series), http://www.bea.gov/bea/di/di1usdop.htm, accessed 15 December 2006.

[12] Data in this section include the R&D activities of overseas affiliates of U.S. companies in which the parent company has a 50% or higher ownership share. Data are from the U.S. Bureau of Economic Analysis (BEA) Survey of U.S. Direct Investment Abroad. http://www.bea.gov/bea/di/di1usdop.htm

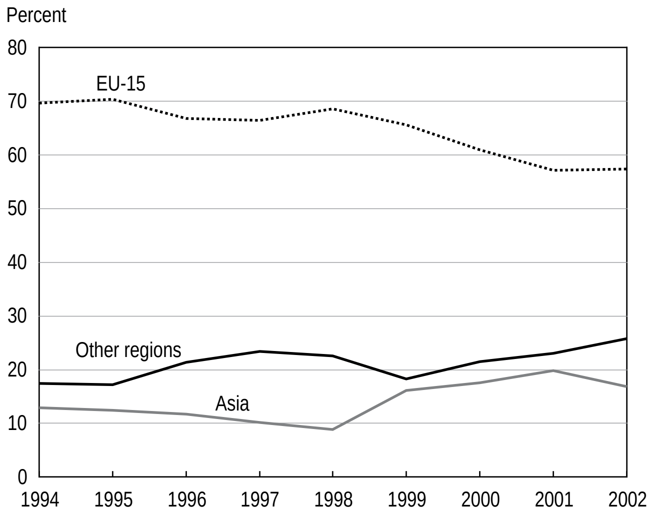
[13] Asian data include Hong Kong.

[14] EU data include 12 countries in 1994 and 15 thereafter.

- From 1998 to 2002, foreign affiliates of U.S. MNCs increased their R&D expenditures in Asia at an average annual rate of 28.6%, compared with 9.6% overall and 4.8% in the EU. Japan's share of Asia's total dropped from 74% to 40% over the period.

- Mainland China's R&D FDI growth for U.S.-based MNCs was particularly rapid, from $7 million in 1994 to $52 million in 1998 and $646 million in 2002. R&D FDI in India remained more modest in comparison, rising from $5 million in 1994 to $80 million in 2002.

FIGURE 22. Share of research and development expenditures of majority-owned foreign affiliates of U.S. multinational corporations, by host region: 1994–2002

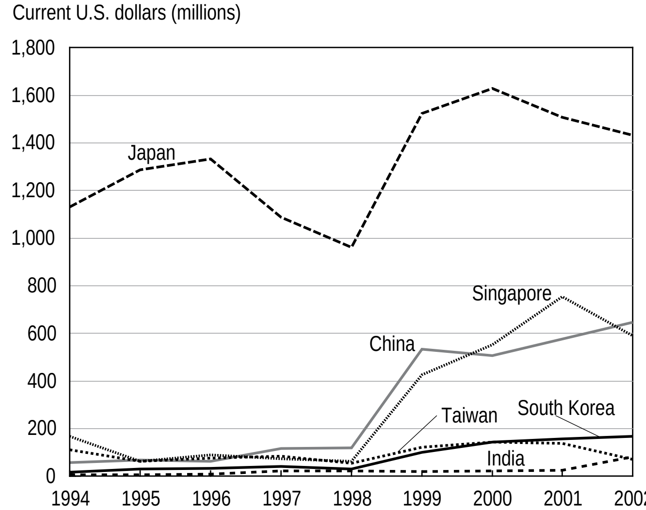


EU = European Union

NOTES: Data are for nonbank overseas majority-owned affiliates of nonbank U.S. parent companies. Majority-owned affiliates are those in which combined ownership of all U.S. parents is more than 50%. Data include research and development (R&D) performed by affiliates, whether for themselves or others, and exclude R&D expenditures made by others for affiliates. European Union includes 12 countries for 1994 and 15 countries thereafter. Asia includes China, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. Data for European Union and Asia for 2002 are preliminary estimates.

SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies (annual series), http://www.bea.gov/bea/di/di1usdop.htm, accessed 11 December 2006; and Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2005).

FIGURE 23. Research and development performed abroad by majority-owned foreign affiliates of U.S. multinational corporations, by selected host country/economy: 1994–2002



NOTES: Data are for nonbank overseas majority-owned affiliates of nonbank U.S. parent companies. Majority-owned affiliates are those in which combined ownership of all U.S. parents is more than 50%. Data include research and development (R&D) performed by affiliates, whether for themselves or others, and exclude R&D expenditures made by others for affiliates. Data for 2002 are preliminary estimates. 2001 data suppressed for China.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies (annual series), http://www.bea.gov/bea/di/di1usdop.htm, accessed 12 December 2006. Data for 2002 are preliminary estimates.

S&E Publications

S&E Article Output Volume

Researchers normally disseminate and validate their results by publishing articles in peer-reviewed journals. Authorship of such articles is crucial for career advancement in most fields. The number of articles attributed to countries in different fields of science provides information about the size and scope of a country's research portfolio and its research priorities relative to other countries.[15]

- The number of Asian-authored S&E articles, including those from Japan, grew from 51,000 in 1988 to 130,000 in 2003, approaching the EU's 1988 output level of 135,000. The EU output rose quite steadily during this period and has exceeded that of the United States since 1998. The number of U.S. articles has been essentially flat since 1992, with a modest increase in 2003 (figure 24).

- Japan and China accounted for about equal shares of the rise in Asia's article output from 1988 to 2003, adding 25,600 and 24,600 articles, respectively, for a combined 63% of total growth over the period.

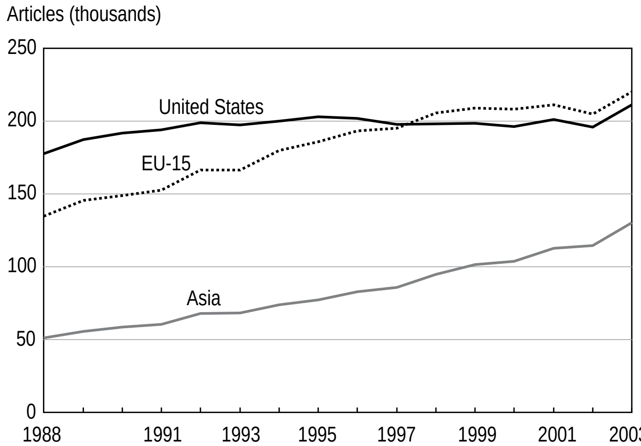
- South Korea and Taiwan together accounted for another 20,100 articles. The number of articles from India grew much less, from 8,900 to 12,800 (table 9).

- From 1988 to 2003, Asia's share of the world total S&E articles rose from 11% to 19%. The EU share rose from 29% in 1988 to 33% in 1997, after which it declined slightly. The U.S. share fell over the period from 38% to 30% (figure 25).

- Within Asia, although Japan's article output increased between 1988 and 2003, its share of total output in Asia declined, from 67% in 1988 to 46% in 2003. China's share more than doubled, reaching 22% in 2003, and South Korea's share went from 2% to 11%. India's share fell from 17% to 10% (figure 26).

[15] See "Technical Notes on Publication Indicators" at the end of the S&E Publications section.

FIGURE 24. Science and engineering articles, by selected region and country/economy: 1988–2003

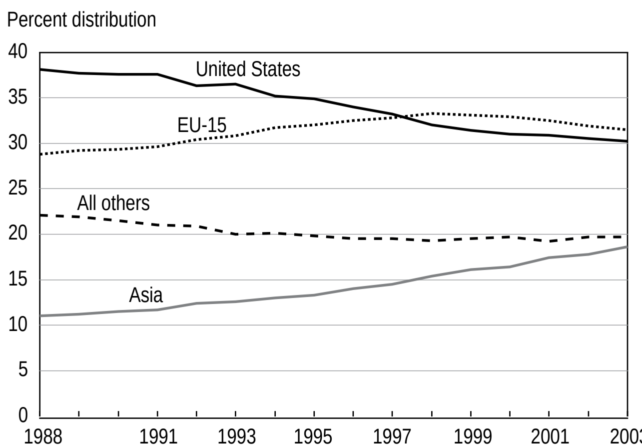


EU = European Union

NOTES: Articles assigned to region/country/economy on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on basis of proportion of its participating institutions. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/, accessed 12 December 2006; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

FIGURE 25. Global share of science and engineering articles, by region and country/economy: 1988–2003



EU = European Union

NOTES: Articles assigned to region/country/economy on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on basis of proportion of its participating institutions. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/, accessed 12 December 2006; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

TABLE 9. Science and engineering articles, by selected region and country/economy: 1988–2003

Year	All countries/ economies	Asia	Japan	China	Singapore	South Korea	Taiwan	India	Other Asia	EU-15	United States
1988	466,419	51,212	34,435	4,619	410	771	1,414	8,882	681	134,551	177,662
1989	497,102	55,748	36,569	5,411	517	1,035	1,724	9,744	748	145,337	187,224
1990	508,795	58,692	38,570	6,285	572	1,170	2,119	9,200	776	149,032	191,559
1991	515,530	60,540	39,590	6,186	599	1,361	2,492	9,517	795	152,761	194,015
1992	547,617	67,833	44,143	6,956	755	1,759	3,337	10,100	783	166,230	198,864
1993	540,491	68,260	43,339	7,566	854	2,184	3,693	9,763	861	166,540	197,397
1994	567,204	73,829	46,692	7,821	1,022	2,931	4,446	9,928	989	179,710	199,769
1995	580,809	77,286	47,603	9,261	1,184	3,806	4,846	9,591	995	185,842	202,887
1996	593,568	82,851	50,392	10,070	1,181	4,728	5,696	9,736	1,048	193,172	201,798
1997	594,467	86,045	50,171	12,530	1,338	5,636	5,878	9,419	1,074	195,060	197,531
1998	617,762	94,941	54,658	13,807	1,635	7,075	6,463	10,066	1,237	205,479	197,890
1999	632,059	101,538	56,134	16,197	1,984	8,386	6,838	10,589	1,410	209,006	198,524
2000	632,781	103,764	55,413	18,142	2,301	9,386	7,008	10,047	1,467	208,128	196,221
2001	649,795	112,781	57,420	20,978	2,603	11,037	8,082	11,076	1,586	211,177	200,870
2002	641,388	114,393	55,085	23,609	2,677	11,745	8,100	11,538	1,638	204,769	195,792
2003	698,726	130,114	60,067	29,186	3,122	13,746	9,270	12,774	1,949	220,002	211,233

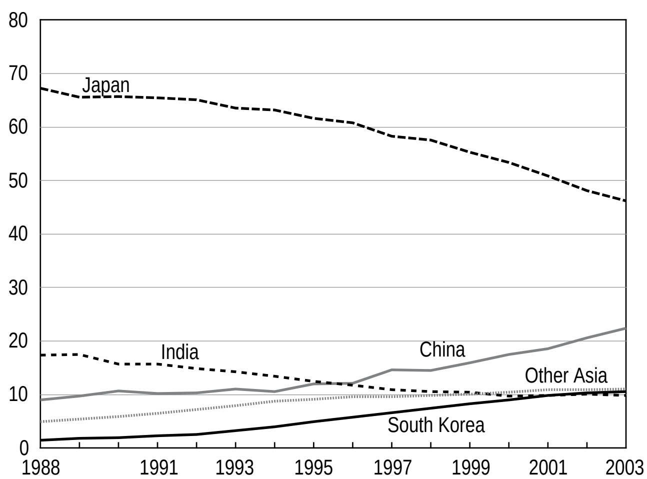
EU = European Union

NOTES: Articles assigned to region/country/economy on basis of institutional address(es) listed on article. For articles with collaborating institutions in multiple countries/economies, each country/economy receives credit on basis of proportion of its participating institutions. Asia includes China, India, Japan, Singapore, South Korea, Taiwan, and Other; Other Asia includes Indonesia, Malaysia, Philippines, and Thailand. Total includes all other countries not shown separately.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/; ipIQ, Inc., accessed 15 December 2006; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

FIGURE 26. Share of Asian science and engineering articles, by country/economy: 1988–2003

Percent distribution



NOTES: Articles assigned to country/economy on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on basis of proportion of its participating institutions. Other Asia includes Indonesia, Malaysia, Philippines, Singapore, Taiwan, and Thailand.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/, accessed 12 December 2006; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

S&E Article Portfolio

A country's S&E article portfolio reflects the relative emphasis placed on different fields (physical sciences, engineering/technology, life sciences, and social/behavioral sciences). It provides a nearly real-time archive of completed research activities.[16]

- The S&E article portfolio of Asia is more concentrated in the physical sciences and engineering/technology than are the portfolios of the EU and United States. In 2003, these fields accounted for 60% of Asian-authored articles, compared with 40% of EU articles and 30% of U.S. articles. Compared with Asia, both the EU and the United States have greater emphasis on life sciences (figure 27).

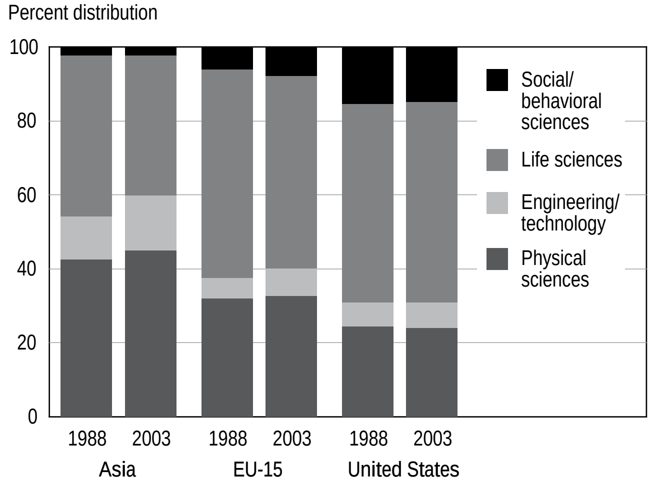
- Asia not only has a relatively smaller life sciences portfolio than the EU and the United States but also a smaller proportion of articles in the social/behavioral science fields.

- Since 1988, Asia's overall portfolio has shifted somewhat further toward engineering and the physical sciences, with similar but smaller shifts for the EU. Both patterns contrast with the stable U.S. portfolio composition (table 10).

- Within Asia, the S&E portfolio is marked by several distinct patterns: relative stability in India, Japan, and Taiwan; sharply declining life sciences proportions in China and Singapore because of growth in the physical sciences and engineering; and expanding life sciences in South Korea (figure 28).

[16] See "Technical Notes on Publication Indicators" at the end of the S&E Publications section.

FIGURE 27. Science and engineering article portfolio of Asia, European Union-15, and United States: 1988 and 2003



EU = European Union

NOTES: Social and behavioral sciences include social sciences, psychology, health sciences, and professional fields. Life sciences include clinical medicine, biomedical research, and biology. Biology includes agricultural sciences. Engineering/technology includes computer sciences. Physical sciences include chemistry, physics, and earth and space sciences. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/, accessed 12 December 2006; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

TABLE 10. Portfolio changes in science and engineering articles, by selected region and country/economy: 1988–2003
(Percentage point change)

Region and country/economy	Physical sciences and mathematics	Life sciences	Engineering/ technology	Social/ behavioral sciences
Asia	2.3	–5.6	3.3	0.0
China	1.6	–4.9	4.6	–1.3
India	2.4	–1.5	0.8	–1.7
Indonesia	4.9	–5.5	–0.6	1.1
Japan	–0.1	–1.0	1.0	0.1
Malaysia	10.8	–18.0	12.4	–5.2
Philippines	12.3	–13.9	1.6	0.0
Singapore	8.7	–19.2	15.4	–4.8
South Korea	–9.2	14.9	–4.2	–1.6
Taiwan	4.0	0.1	–4.1	–0.1
Thailand	12.9	–14.0	4.5	–3.3
EU-15	0.7	–4.4	2.0	1.7
United States	-0.3	0.4	0.3	–0.5

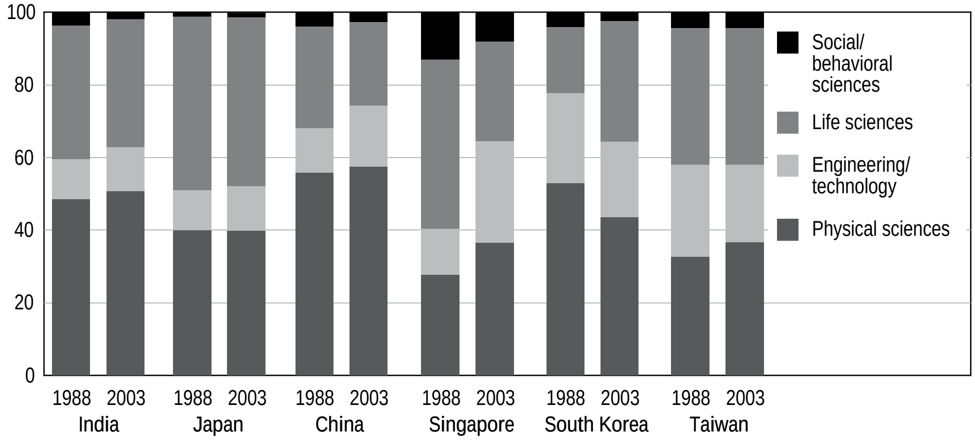
EU = European Union

NOTES: Fields classified by ipIQ, Inc. Computer sciences included in engineering/technology. Social and behavorial sciences are health sciences, psychology, social sciences, and professional fields.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index* http://www.isinet.com/products/citation/, accessed 15 December 2006; ipIQ, Inc.; and National Science Foundation, special tabulations.

FIGURE 28. Science and engineering article portfolio of selected Asian countries/economies: 1988 and 2003

Percent distribution



NOTES: Social and behavioral sciences include social sciences, psychology, health sciences, and professional fields. Life sciences include clinical medicine, biomedical research, and biology. Biology includes agricultural sciences. Engineering/technology includes computer sciences. Physical sciences include chemistry, physics, and earth and space sciences.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/, accessed 12 December 2006; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

Scientific Collaboration

Research collaboration has risen steeply in the past two decades, both within countries and across national borders. The collaborative ties revealed by article (institutional) coauthorships provide insight into increasingly shared knowledge production processes, often at a global level.[17]

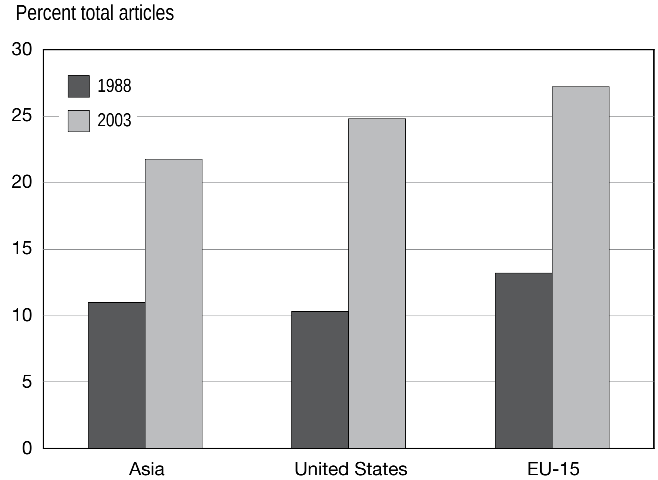
- Overall research collaboration, as indicated by the share of articles that are coauthored either domestically or internationally, has grown rapidly in Asia, the EU, and the United States. These collaborative articles now constitute more than 60% of all research articles.

- International research collaboration[18] as measured by coauthorship has generally increased faster than domestic collaboration.[19] Around 10% of publications by Asian and U.S. researchers were internationally coauthored in 1988; by 2003, the figure was 22% for Asia and 25% for the United States. International coauthorship was higher in the EU, rising from 13% in 1988 to 27% in 2003, which does not reflect the EU's successful efforts to stimulate collaboration within the Union (figure 29).

- India, Japan, and Taiwan had the lowest rates of international collaboration in Asia, about 21%–22% each in 2003. Several Asian countries with less fully developed S&T capacity (Indonesia, Philippines, Thailand) had rates of international collaboration exceeding 50% (table 11).

- In Asia,[20] the strongest growth is in articles involving coauthorships within Asia (almost 18% average annual growth from 1988–2003), suggesting growing intraregional collaboration. Growth in collaboration with researchers outside the region (11.3% annually) was also strong (figure 30).

FIGURE 29. International collaboration on science and engineering articles, by selected region and country/economy: 1988 and 2003



EU = European Union

NOTES: Collaboration is institution based. International articles are those with at least one collaborating institution from the indicated region (country for United States) and one institution from outside the region (or country). Each region (country for United States) receives one count for participation by its institutions. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCES: Thompson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/, accessed 12 December 2006; ipIQ, Inc; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

- Asian patterns of international collaboration have undergone large shifts in terms of the locations of foreign researchers with whom Asian researchers collaborate. From 1988 to 2003, the U.S. share of foreign participation in collaborative research declined substantially in all Asian economies except Singapore and Thailand, the intraregional share generally rose, and the EU share fell in most but not all Asian economies (table 12).

[17] See "Technical Notes on Publication Indicators" at the end of the S&E Publications section.
[18] Internationally coauthored articles are those having at least one institutional author outside the referenced region (country in the case of the United States); i.e., it excludes within-region collaboration unless specifically noted.
[19] See National Science Board. 2006. *Science and Engineering Indicators, 2006.* Arlington, VA. Volume 1, Figure 5-39.
[20] This bullet and figure refer to all types of Asian collaborations, including within-region coauthorships.

TABLE 11. Science and engineering articles that are internationally coauthored, by selected region and country/economy: 1988–2003
(Percent)

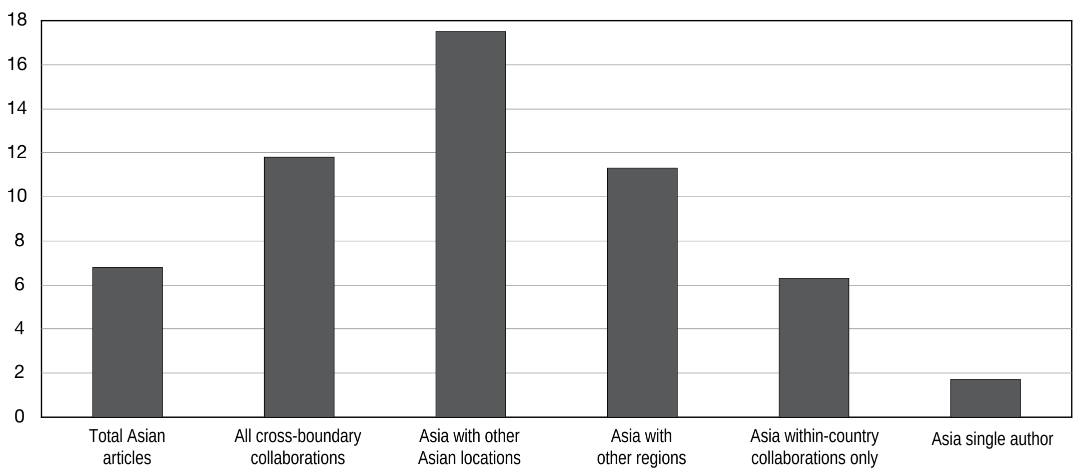
Region and country/economy	1988	1990	1992	1994	1996	1998	2000	2001	2002	2003
Asia	11.0	12.4	14.3	15.9	16.9	18.3	19.8	20.7	21.2	21.8
China	22.5	23.0	27.1	27.5	28.0	26.7	26.4	27.2	27.0	26.8
India	10.4	10.5	12.8	14.1	16.1	18.2	20.5	21.4	22.1	21.9
Indonesia	76.4	77.8	80.1	79.5	81.8	86.0	90.6	82.6	86.0	85.2
Japan	8.6	10.0	11.8	13.7	14.6	16.7	18.6	19.7	20.4	21.5
Malaysia	32.7	46.4	41.2	38.9	42.6	46.6	48.8	45.8	48.6	48.8
Philippines	48.5	61.0	60.9	62.0	64.9	65.7	75.5	72.2	70.7	73.7
Singapore	23.7	22.7	26.0	27.9	31.4	31.2	32.4	34.5	36.2	38.1
South Korea	27.4	28.2	30.5	28.7	26.8	25.4	24.1	25.7	26.4	28.0
Taiwan	19.2	19.0	18.0	17.5	17.5	16.9	19.7	20.8	20.6	20.8
Thailand	51.6	59.2	59.9	59.3	62.8	59.9	57.4	58.2	64.1	60.4
EU-15	13.2	14.7	17.3	18.9	20.6	22.3	24.3	25.5	26.6	27.2
United States	10.3	11.6	13.9	15.8	17.6	19.9	22.0	23.2	24.0	24.8

EU = European Union

NOTES: Collaboration is institution based. Internationally coauthored articles are those with at least one collaborating institution from the indicated region (country for the United States) and one institution from outside the region (or country). Each region (country for United States) receives one count for participation by its institutions; within-region collaborations are excluded.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index* http://www.isinet.com/products/citation/, accessed 15 December 2006; ipIQ, Inc.; and National Science Foundation, special tabulations.

FIGURE 30. Average annual growth rates of Asian science and engineering articles, by type of collaboration: 1988



NOTES: Collaboration is institution-based. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCES: Thompson ISI, *Science Citation Index and Social Sciences Citation Index*, http://www.isinet.products/citation/; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulation.

TABLE 12. Foreign participation in Asian science and engineering articles, by region and country/economy: 1988 and 2003
(Percent distribution)

Country/economy and year	All countries/ economies	United States	EU-15	Asia: Japan	Asia: China	Asia: Other	Australia	Canada	All other countries/economies
China									
1988	100.0	44.8	26.1	12.0	na	1.6	4.7	6.6	4.3
2003	100.0	33.1	26.2	14.4	na	10.4	5.2	4.9	5.8
India									
1988	100.0	34.5	38.5	4.5	0.4	1.1	2.3	8.0	10.6
2003	100.0	28.2	34.3	10.2	2.5	7.3	2.3	3.4	11.7
Indonesia									
1988	100.0	23.3	37.3	12.4	0.6	5.6	14.7	2.1	4.0
2003	100.0	17.8	28.5	24.5	1.6	9.5	10.1	2.0	5.8
Japan									
1988	100.0	49.5	25.5	na	4.1	5.7	1.9	5.6	7.7
2003	100.0	34.5	25.0	na	8.0	12.3	2.6	3.4	14.2
Malaysia									
1988	100.0	18.3	38.9	10.2	2.4	8.1	13.1	3.3	5.7
2003	100.0	10.8	22.7	11.3	13.2	21.3	6.8	1.8	12.0
Philippines									
1988	100.0	38.2	19.0	20.4	1.5	6.2	3.8	4.2	6.7
2003	100.0	25.7	17.0	20.2	5.5	12.3	4.3	1.5	13.5
Singapore									
1988	100.0	21.9	26.8	6.8	2.6	7.3	21.1	6.4	7.1
2003	100.0	28.5	17.9	4.6	20.4	8.5	9.1	5.1	6.0
South Korea									
1988	100.0	60.6	9.0	21.8	0.3	2.0	0.6	4.2	1.4
2003	100.0	47.8	11.7	18.6	5.3	3.6	1.6	2.6	8.8
Taiwan									
1988	100.0	71.9	6.3	11.5	1.8	1.8	0.5	4.7	1.6
2003	100.0	44.8	11.5	11.7	11.0	8.6	1.3	3.4	7.5
Thailand									
1988	100.0	29.5	31.8	17.3	0.2	4.9	8.4	3.0	4.9
2003	100.0	32.1	22.9	19.2	2.2	5.7	6.9	3.6	7.4

na = not applicable

EU = European Union

NOTES: Data reflect institutional coauthorship. They show region/country/economy's fractional share of indicated Asian country/economy's total internationally coauthored articles. Internationally coauthored articles have at least one author at institutional address in indicated country/economy and one author at foreign address. Detail may not add to total because of rounding. Articles counted on whole-count basis. Other Asia includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index* http://www.isinet.com/products/citation/, accessed 19 December 2006; ipIQ, Inc.; and National Science Foundation, special tabulations.

Citations of S&E Articles

Citations of S&E literature, aggregated by country/region of authorship, provide an indication of the relative prominence in world science of a given location's S&E literature.[21]

- Citation trends for articles authored in Asia, the EU, and the United States generally mirrored the trends in article production for these locations. Asia's citation volume more than doubled between 1992 and 2003 but continued to lag behind both the EU and the United States. Citations to the EU literature nearly doubled during the same period, and U.S. citations rose by one-third but flattened between 1999 and 2002 (figure 31).

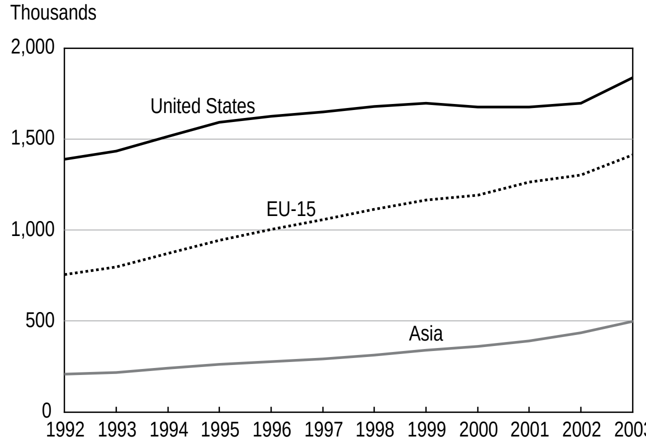
- Japan accounted for the overwhelming majority of Asian citations: 319,000 in 2003. However, at 64%, Japan's share of Asian citations was down from 84% in 1992, as citations rose for articles from East Asian economies, increasing from 5% to 13% for China (including Hong Kong), 1% to 8% for South Korea, and 2% to 6% for Taiwan (figure 32).

- Adjusted for article output, the relative volume of citations received by all Asian articles was fairly steady from 1992 to 2003, suggesting no major change in the prominence of overall Asian scientific output. However, China, India, Singapore, and South Korea had rising, though still low, ratios. The United States ratio held steady at a high level, while the EU ratio rose somewhat during the period (table 13).

- On average, Asian articles get cited with less frequency than would be expected based on article volume (ratio of 0.7 in 2003, 0.4 with in-country citations excluded); EU articles at about the expected frequency (1.0, 0.7 with in-country citations excluded), and U.S. articles more often than would be expected based on article volume (1.4, or 1.0 without in-country citations).

[21] See "Technical Notes on Publication Indicators" at the end of the S&E Publications section.

FIGURE 31. Citations of science and engineering articles, by selected region or country/economy of author's institution: 1992–2003

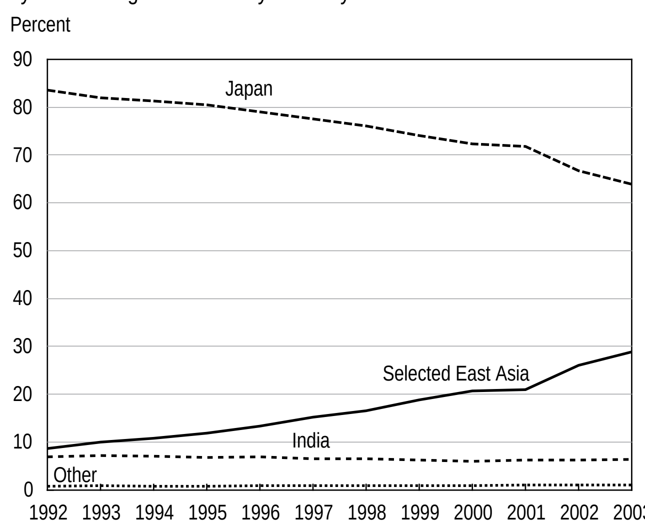


EU = European Union

NOTES: Citations on fractional-count basis, i.e., for articles with collaborating institutions from multiple regions/countries, each region/country receives fractional credit based on its proportion of cited articles. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCES: Thompson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/, accessed 12 December 2006; ipIQ, Inc; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

FIGURE 32. Citations of Asian science and engineering articles, by selected region and country/economy: 1992–2003



NOTES: Citations on fractional-count basis, i.e., for cited articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on basis of proportion of its participating institutions. Selected East Asia includes China, Singapore, South Korea, and Taiwan. "Other" includes Indonesia, Malaysia, Philippines, and Thailand.

SOURCES: Thompson ISI, *Science Citation Index* and *Social Sciences Citation Index*, http://www.isinet.com/products/citation/, accessed 12 December 2006; ipIQ, Inc; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

TABLE 13. Relative citation of science and engineering literature, by selected region and country/economy: 1992, 1997, and 2003
(Relative citation index)

Region and country/economy	1992		1997		2003	
	All countries/ economies	Country/economy's own lliterature excluded	All countries/ economies	Country/economy's own lliterature excluded	All countries/ economies	Country/economy's own lliterature excluded
Asia	0.690	0.430	0.652	0.414	0.692	0.429
China	0.332	0.231	0.387	0.247	0.519	0.304
India	0.280	0.150	0.317	0.196	0.439	0.284
Japan	0.870	0.570	0.805	0.539	0.832	0.575
Singapore	0.330	0.320	0.501	0.398	0.635	0.509
South Korea	0.410	0.290	0.480	0.323	0.620	0.439
Taiwan	0.490	0.320	0.481	0.321	0.563	0.401
EU-15	0.964	0.660	0.977	0.689	0.992	0.737
United States	1.369	1.000	1.353	1.016	1.363	1.026

EU = European Union

NOTES: Relative citation index is frequency of citation of region or country/economy's scientific literature relative to the number of its science and engineering articles. Citations assigned to geographic location by institutional address(es) listed on article and calculated on fractional-count basis, i.e., for cited articles with collaborating institutions from multiple regions or countries/economies, each receives fractional credit on basis of proportion of its participating institutions. Asia total includes countries not specifically listed.

SOURCES: Thomson ISI, *Science Citation Index* and *Social Sciences Citation Index* http://www.isinet.com/products/citation/, accessed 15 December 2006; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

PATENTS

U.S. PATENTS GRANTED TO ASIAN AND EU INVENTORS

Patenting activity is widely viewed as an indicator of a country's innovative capacity, but differences in national patent law complicate using this indicator to assess foreign countries' relative capacity. This difficulty can be mitigated by examining other countries' patenting in the United States, whose open economy tends to attract cutting-edge technologies from around the world.[22]

- Foreign inventors received about 81,100 U.S. patents in 2003, 48% of the total patents issued in the United States. Among foreign inventors, Asia, led by Japan's 35,500 patents, received 46,200; the EU countries received 26,700 (table 14; figure 33).

- From 1990 to 2003, the Asian share of U.S. patents rose from 23% to 27%, offsetting the EU decline from 20% to 16%. The U.S. share remained stable (table 14).

TABLE 14. U.S. patents granted, by region and country/economy of residence of first-named inventor: Selected years, 1990–2003

Region and country/economy	1990	1992	1994	1996	1998	1999	2000	2001	2002	2003
	Number of patents									
All countries/economies	90,365	97,444	101,676	109,645	147,518	153,486	157,495	166,037	167,334	169,028
United States	47,391	52,253	56,066	61,104	80,289	83,906	85,069	87,605	86,973	87,901
Asia	20,628	23,642	24,978	26,728	37,683	38,926	39,988	43,117	45,377	46,211
China	99	101	105	134	232	245	298	432	522	573
India	23	24	27	35	85	112	131	177	249	341
Indonesia	3	8	9	1	3	5	6	4	7	9
Japan	19,525	21,925	22,384	23,053	30,840	31,104	31,295	33,224	34,859	35,517
Malaysia	3	5	10	12	23	30	42	39	55	55
Philippines	4	7	1	4	8	11	2	12	14	22
Singapore	12	32	51	88	120	144	218	296	410	427
South Korea	225	538	943	1,493	3,259	3,562	3,314	3,538	3,786	3,944
Taiwan	732	1,001	1,443	1,897	3,100	3,693	4,667	5,371	5,431	5,298
Thailand	2	1	5	11	13	20	15	24	44	25
EU-15	17,640	16,989	15,912	16,719	22,704	23,498	24,968	27,048	26,960	26,660
Other	4,706	4,560	4,720	5,094	6,842	7,156	7,470	8,267	8,024	8,256
	Percent									
All countries/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	52.4	53.6	55.1	55.7	54.4	54.7	54.0	52.8	52.0	52.0
Asia	22.8	24.3	24.6	24.4	25.5	25.4	25.4	26.0	27.1	27.3
China	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
India	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan	21.6	22.5	22.0	21.0	20.9	20.3	19.9	20.0	20.8	21.0
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Philippines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Singapore	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3
South Korea	0.2	0.6	0.9	1.4	2.2	2.3	2.1	2.1	2.3	2.3
Taiwan	0.8	1.0	1.4	1.7	2.1	2.4	3.0	3.2	3.2	3.1
Thailand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU-15	19.5	17.4	15.6	15.2	15.4	15.3	15.9	16.3	16.1	15.8
Other	5.2	4.7	4.6	4.6	4.6	4.7	4.7	5.0	4.8	4.9

EU = European Union

NOTES: Increase from 1996 to 1998 reflects changed U.S. Patent and Trademark Office (PTO) processing procedures. Detail may not add to total because of rounding.

SOURCE: U.S. PTO, Office of Electronic Information Products, Patent Technology Monitoring Division, special tabulations.

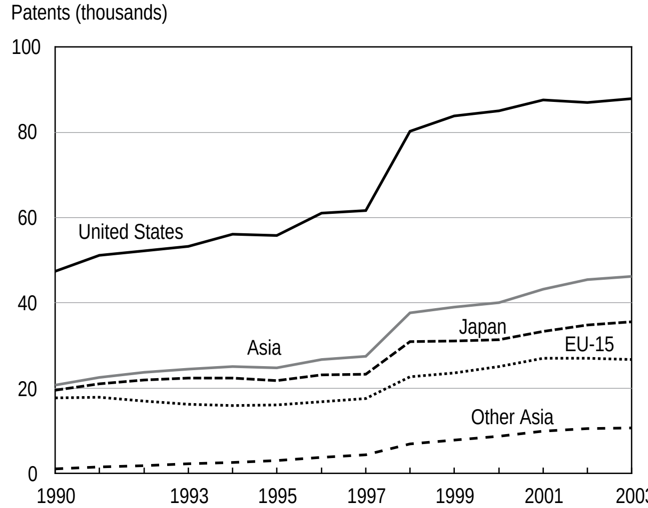
[22] Data examined are trends in number of U.S. patents granted and include only corporate-owned utility patents (i.e., patents for inventions). Country of origin reflects the residence of the inventor.

- Taiwan and South Korea have seen a particularly rapid increase in U.S. patents, moving them ahead of France and the United Kingdom. Along with Japan, they are among the leading sources of foreign inventions patented in the United States. In 2003, Taiwanese and South Korean inventors accounted for more than 25% of all foreign patents granted in the United States. China's patenting activity, while rising rapidly, remains relatively modest (figure 34).

- Patenting profiles of Asian economies show different portfolios of technological expertise. For example, Japanese inventors' patents in the United States focus on information processing, storage, and transmission; South Korean patents on television technologies and a broad array of computer technologies; and Taiwanese inventions on communications technologies, semiconductor manufacturing processes, and internal combustion engine technologies.

- Trends based on patent applications in the United States, a leading indicator of patents granted, are similar to those based on patent awards: Asian share gains from 1990 to 2003 offset European losses, while shares for U.S. and other inventors were stable. Within Asia, growth of Japan's U.S. patent applications slowed while those of other locations, notably Korea and Taiwan, rose.

FIGURE 33. U.S. patents granted, by region and country/economy of residence of inventor: 1990–2003

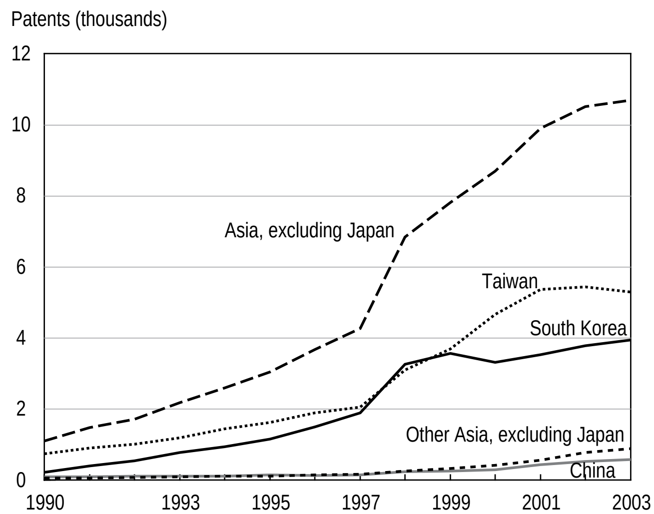


EU = European Union

NOTE: Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: U.S. Patent and Trademark Office, Office of Electronic Information Products, Patent Technology Monitoring Division, special tabulations.

FIGURE 34. U.S. patents granted to selected Asian countries/economies: 1990–2003



NOTES: "Asia, excluding Japan" includes China, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. "Other Asia, excluding Japan" includes Indonesia, Malaysia, Philippines, Singapore, Thailand, and India. 1997 increase reflects changed U.S. Patent and Trademark (PTO) processing procedures.

SOURCE: U.S. PTO, Office of Electronic Information Products, Patent Technology Monitoring Division, special tabulations.

Asia's High-Value Patents

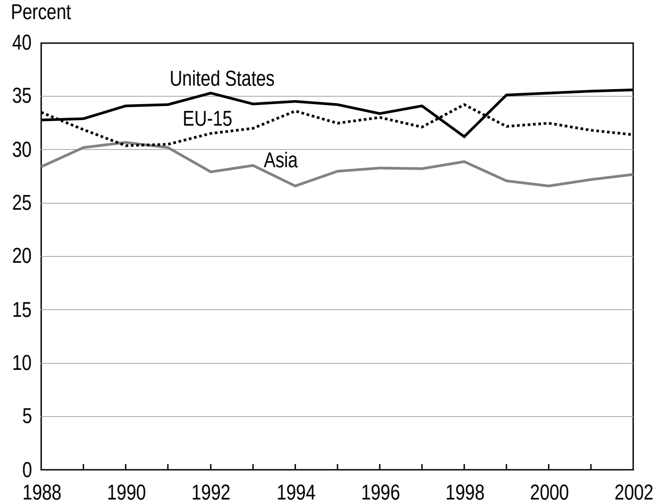
The expense of filing for patents in three different major markets (Japan, Europe, and the U.S.) means that, for the most part, only inventions deemed to be economically valuable will be patented in all three. The distribution of these "triadic patents" by the inventor country can provide insight into the location of important technological competencies.

- Counts of Asian triadic patents by residence of inventor and year of first filing show Asia generally trailing both the United States and the EU (figure 35; table 15).

- Japan accounts for nearly all of Asia's triadic patent families, with more limited but increasing activity by South Korea (table 15).

- In 2003, inventors residing in Japan produced approximately 72% and 82% of the number of triadic patents produced by U.S.- and EU-based inventors, respectively. Given Japan's much smaller population, its inventive productivity on a per capita basis is well in excess of the per capita productivity of the United States or the EU.

FIGURE 35. Triadic patent families, by region or country of residence of first-named inventor and year of first filing: 1988–2002



EU = European Union

NOTES: A triadic patent family is formed when patent applications for same invention are filed in Europe, Japan, and United States. Because of differing disclosure regulations during period examined, data for Europe and Japan are applications, and data for United States are patents granted. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. Data in 2001 and 2002 are estimated.

SOURCE: Organisation for Economic Co-operation and Development, World Intellectual Property Organization, accessed June 2006.

TABLE 15. Triadic patent families, by selected region and country/economy of residence of first-named inventor and year of first filing: Selected years, 1988–2002

Region and country/ economy	1988	1990	1992	1994	1995	1996	1997	1998	1999	2000	2001	2002
All countries/economies	30,662	32,717	29,918	32,189	35,388	38,655	41,035	41,419	46,614	49,698	51,263	51,502
United States	10,057	11,158	10,598	11,095	12,100	12,921	14,008	12,915	16,353	17,534	18,213	18,324
EU-15	10,279	9,939	9,414	10,801	11,517	12,750	13,181	14,156	15,014	16,154	16,313	16,167
Asia	8,728	10,049	8,346	8,566	9,924	10,961	11,571	11,964	12,628	13,231	13,958	14,277
China	17	23	26	32	42	38	51	67	95	125	168	177
India	10	12	5	6	11	15	23	31	32	52	69	78
Indonesia	0	1	0	0	0	1	2	2	2	2	2	2
Japan	8,661	9,931	8,150	8,263	9,487	10,490	11,025	11,257	11,844	12,355	12,937	13,195
Malaysia	2	2	5	0	4	5	3	5	5	5	5	5
Philippines	0	0	1	1	0	0	1	2	2	2	2	2
Singapore	3	4	18	22	26	34	29	46	68	79	90	85
South Korea	20	65	118	213	327	325	386	466	501	532	593	630
Taiwan	13	10	22	27	25	50	49	88	79	79	90	102
Thailand	2	1	0	2	2	3	3	2	2	2	2	2
Other	1,598	1,571	1,560	1,726	1,847	2,023	2,275	2,386	2,619	2,779	2,779	2,734

EU = European Union

NOTES: A triadic patent family is formed when patent applications for same invention are filed in Europe, Japan, and United States. Because of differing disclosure regulations during period examined, data for Europe and Japan are applications, and data for United States are patents granted. Asia includes only those listed, while All countries/economies includes countries/regions not specifically listed but included in Other. Detail may not add to total because of rounding. Data for 2001 and 2002 are preliminary.

SOURCE: Organisation for Economic Co-operation and Development, World Intellectual Property Organization, http://www.wipo.int, accessed 19 December 2006.

High-Technology Industries

High-Technology Manufacturing Industries

National economies benefit from high-technology industries that generate new products and processes, stimulate other business activity, increase productivity, and create high-wage jobs. The OECD defines five industrial sectors as high-technology:[23] aerospace, pharmaceuticals, computers and office machinery, communication equipment, and scientific (medical, precision, and optical) instruments. The following analysis is in terms of domestic value added, i.e., the total production value minus the value of foreign inputs.

- Asia performed more than one-third of the world's value-added production by high-technology manufacturing industries from 1990 to 1997, greater than the U.S. and EU shares. Thereafter, Asia's share fell below that of the United States as global demand soared for communication equipment and other information technology products produced in the United States, while growth of high-technology production became erratic and slowed in many East Asian economies (figure 36).

- Throughout the entire 1990–2003 period, Asia's high-technology value added has consistently exceeded that of the EU. Unlike the rising trend observed for Asia in 2002 and 2003, the EU's value added has essentially remained flat since about 2000 (table 16).

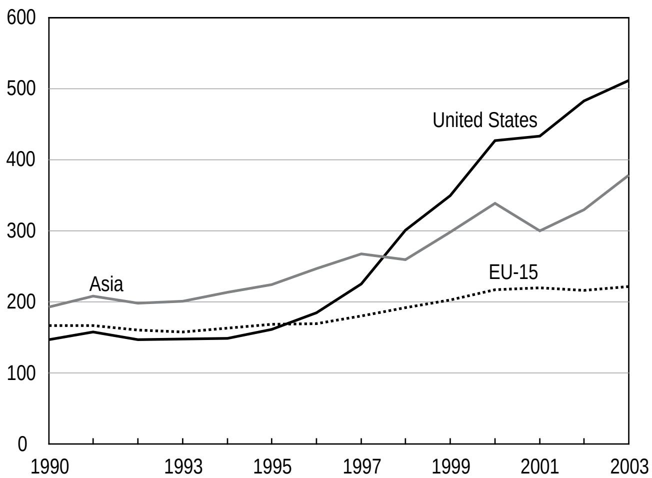
- Japan once accounted for the lion's share of high-technology value added in Asia, but its long-term output grew more slowly than that of other Asian economies and dropped sharply after 2000. Its share of Asia's total declined from 77% in 1990 to half in 2000 and 38% in 2003 (figure 37).

- China's high-technology value-added manufacturing expanded rapidly, especially since 1998, and in 2003 approached 80% of the magnitude of Japan's. South Korea also recorded rapid growth since 1998.

- High-technology industry value added activity has also grown rapidly in Taiwan, Singapore, and Malaysia since the late 1990s. Of the 10 Asian economies examined here, only Indonesia and Thailand showed little or no growth between 1993 and 2003 (figure 38).

FIGURE 36. Value added in high-technology manufacturing industries, by selected region and country/economy: 1990–2003

1997 U.S. dollars (millions)



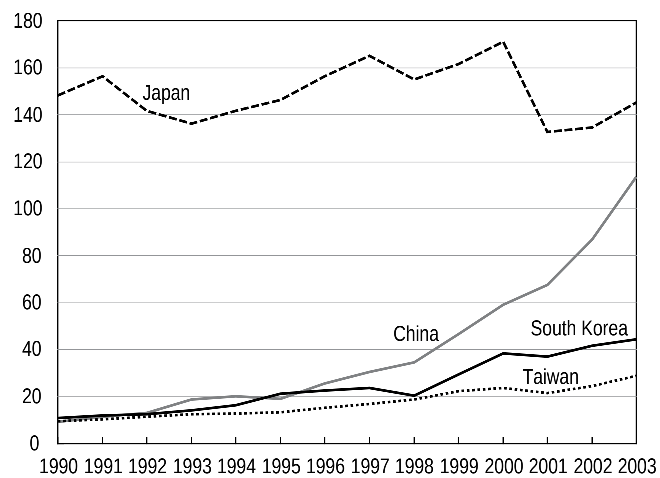
EU = European Union

NOTE: Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: Global Insight, Inc., World Industry Service database (2005), special tabulations.

FIGURE 37. Value added in high-technology manufacturing industries, by selected Asian country/economy: 1990–2003

1997 U.S. dollars (millions)



SOURCE: Global Insight, Inc., World Industry Service database (2005), special tabulations.

[23] Based on above-average ratios of research, development, and evaluation expenditures to total output.

TABLE 16. High-technology industry value added, by selected region and country/economy: Selected years, 1990–2003

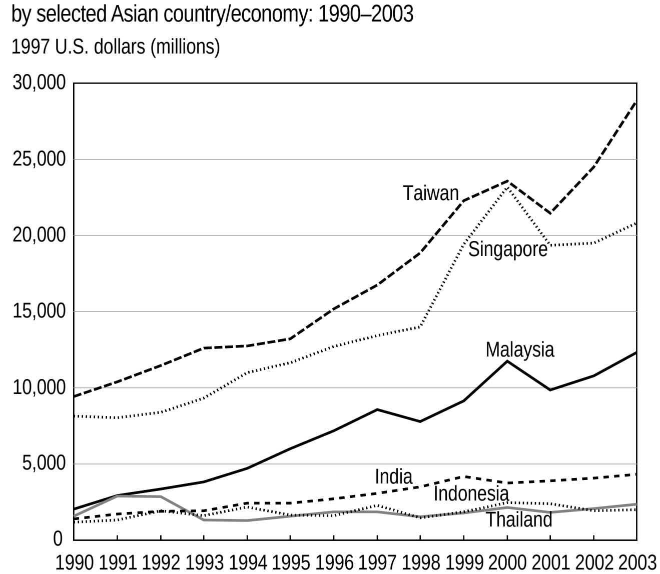
Region and country/ economy	1990	1992	1994	1996	1998	2000	2001	2002	2003
	Millions of 1997 dollars								
All countries/economies	596,138	589,086	609,396	683,404	838,653	1,078,421	1,046,942	1,120,520	1,203,332
United States	147,061	146,755	149,118	184,461	300,532	426,802	433,178	482,836	511,316
EU-15	166,633	160,664	163,209	169,558	191,797	216,724	219,762	216,396	222,000
Asia	193,032	197,846	213,656	247,165	259,256	338,797	299,965	329,983	378,080
China	9,224	13,157	20,139	25,596	34,532	59,042	67,596	86,770	113,497
India	1,401	1,891	2,416	2,722	3,516	3,734	3,886	4,076	4,310
Indonesia	1,161	1,915	2,185	1,617	1,460	2,451	2,400	1,931	1,998
Japan	148,350	141,549	141,804	156,459	155,110	170,993	132,786	134,610	145,208
Malaysia	2,025	3,342	4,719	7,200	7,772	11,769	9,877	10,795	12,329
Philippines	768	809	952	1,246	2,045	3,478	3,832	4,022	4,464
Singapore	8,150	8,413	10,989	12,715	14,022	23,206	19,353	19,524	20,814
South Korea	10,959	12,448	16,397	22,577	20,375	38,407	36,958	41,652	44,248
Taiwan	9,418	11,478	12,771	15,181	18,873	23,567	21,468	24,524	28,859
Thailand	1,576	2,844	1,283	1,853	1,552	2,149	1,810	2,079	2,354
	Share of world total (%)								
All countries/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	24.7	24.9	24.5	27.0	35.8	39.6	41.4	43.1	42.5
EU-15	28.0	27.3	26.8	24.8	22.9	20.1	21.0	19.3	18.4
Asia	32.4	33.6	35.1	36.2	30.9	31.4	28.7	29.4	31.4
China	1.5	2.2	3.3	3.7	4.1	5.5	6.5	7.7	9.4
India	0.2	0.3	0.4	0.4	0.4	0.3	0.4	0.4	0.4
Indonesia	0.2	0.3	0.4	0.2	0.2	0.2	0.2	0.2	0.2
Japan	24.9	24.0	23.3	22.9	18.5	15.9	12.7	12.0	12.1
Malaysia	0.3	0.6	0.8	1.1	0.9	1.1	0.9	1.0	1.0
Philippines	0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.4	0.4
Singapore	1.4	1.4	1.8	1.9	1.7	2.2	1.8	1.7	1.7
South Korea	1.8	2.1	2.7	3.3	2.4	3.6	3.5	3.7	3.7
Taiwan	1.6	1.9	2.1	2.2	2.3	2.2	2.1	2.2	2.4
Thailand	0.3	0.5	0.2	0.3	0.2	0.2	0.2	0.2	0.2

EU = European Union

NOTES: Gross value added reported equal to gross output less consumption of intermediate inputs and supplies. High-technology sectors include aerospace, computers and office machinery, communications equipment, pharmaceuticals, and medical, precision, and optical instruments. Asia includes only economies listed; all countries/economies includes countries/regions not listed separately.

SOURCES: Global Insight, Inc., World Industry Service database (2005). Historical data from United Nations (UN) Industrial Development Organization; UN Statistics Division, System of National Accounts; Organisation for Economic Co-operation and Development; and country sources.

FIGURE 38. Value added in high-technology manufacturing industries, by selected Asian country/economy: 1990–2003



SOURCE: Global Insight, Inc., World Industry Service database (2005), special tabulations.

High-Technology Manufacturing Exports

High-technology manufacturing exports provide an indication of a country's ability to produce high-technology goods that can compete in the international marketplace. S&T help to support competitiveness in international trade and to generate revenues needed for further investments in innovation. Data reported here reflect the value of exports by high-technology manufacturing industries.

- High-technology exports worldwide grew from $474 billion in 1990 to $1.9 trillion in 2003. Over the period, major shifts occurred in the relative positions of exporting regions/countries (table 17).
- Exports by Asia's high-technology manufacturing industries have grown especially rapidly since 1990, contributing to the region's strong economic performance. In 2003, Asia accounted for 43% of world high-technology exports, up from 33% in 1990 (figure 39).
- The 1990–2003 increase in Asia's share of world high-technology manufacturing exports was accompanied by declines in the EU share (from 37% to 32%) and the U.S. share (from 23% to 16%). Since 1992, Asia's share has been larger than that of the EU; since 2000 it has been more than twice the U.S. share (table 17).
- All of the Asian economies expanded their high-technology exports rapidly from 1990 to 2003, but two distinct patterns emerged. Japan, the largest

TABLE 17. High-technology industry exports, by selected region and country/economy: Selected years, 1990–2003

Region and country/economy	1990	1992	1994	1996	1998	2000	2001	2002	2003
	Millions of 1997 dollars								
All countries/economies	474,124	570,288	674,735	905,865	1,181,549	1,635,454	1,581,228	1,646,297	1,901,561
United States	109,175	125,859	140,491	181,209	231,870	291,783	268,902	247,545	303,541
EU-15	175,396	199,007	222,301	293,838	399,991	508,942	520,381	546,348	611,936
Asia	157,079	201,053	258,142	359,945	445,984	684,846	642,630	697,759	816,082
China	23,183	32,877	43,423	63,300	86,025	140,895	161,629	182,131	224,392
India	572	682	912	1,539	1,456	2,373	2,691	3,104	3,709
Indonesia	228	919	1,958	2,818	2,288	6,254	4,428	5,440	6,416
Japan	78,637	89,495	95,372	109,131	124,127	162,736	138,722	145,553	164,235
Malaysia	8,482	13,516	22,586	33,047	37,164	57,638	53,923	56,084	62,543
Philippines	578	1,024	1,653	8,649	18,467	24,888	24,637	25,648	29,121
Singapore	17,288	23,175	40,732	62,109	71,672	99,147	91,084	95,491	107,766
South Korea	11,685	15,322	19,307	30,216	43,038	83,002	70,029	79,123	94,113
Taiwan	13,385	18,601	24,532	38,091	49,472	86,375	75,395	82,653	97,294
Thailand	3,042	5,442	7,668	11,045	12,274	21,538	20,094	22,531	26,495
	Share of world total (%)								
All countries/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	23.0	22.1	20.8	20.0	19.6	17.8	17.0	15.0	16.0
EU-15	37.0	34.9	32.9	32.4	33.9	31.1	32.9	33.2	32.2
Asia	33.1	35.3	38.3	39.7	37.7	41.9	40.6	42.4	42.9
China	4.9	5.8	6.4	7.0	7.3	8.6	10.2	11.1	11.8
India	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2
Indonesia	0.0	0.2	0.3	0.3	0.2	0.4	0.3	0.3	0.3
Japan	16.6	15.7	14.1	12.0	10.5	10.0	8.8	8.8	8.6
Malaysia	1.8	2.4	3.3	3.6	3.1	3.5	3.4	3.4	3.3
Philippines	0.1	0.2	0.2	1.0	1.6	1.5	1.6	1.6	1.5
Singapore	3.6	4.1	6.0	6.9	6.1	6.1	5.8	5.8	5.7
South Korea	2.5	2.7	2.9	3.3	3.6	5.1	4.4	4.8	4.9
Taiwan	2.8	3.3	3.6	4.2	4.2	5.3	4.8	5.0	5.1
Thailand	0.6	1.0	1.1	1.2	1.0	1.3	1.3	1.4	1.4

EU = European Union

NOTES: High-technology sectors include aerospace, computers and office machinery, communications equipment, pharmaceuticals, and medical, precision, and optical instruments. Asia includes only economies listed; All countries/economies includes regions/countries not specifically listed.

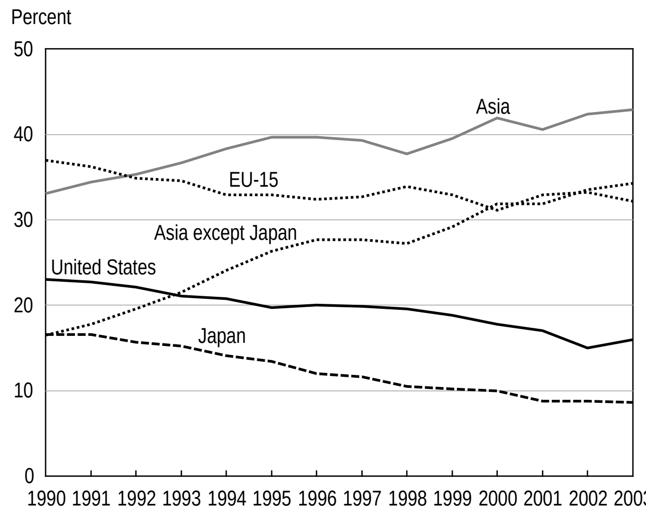
SOURCES: Global Insight, Inc., World Industry Service database (2005). Historical data are from United Nations (UN) Industrial Development Organization; UN Statistics Division, System of National Accounts; Organisation for Economic Co-operation and Development; and country sources.

Asian exporter, doubled the volume of such exports over the period, while combined exports of the other Asian economies grew more than eightfold, sending the Japanese world share plummeting from 17% in 1990 to 9% by 2003. During that period, the Japanese share of Asian high-technology manufacturing exports fell from half to 20% (table 17).

- In 2001, after years of double-digit growth in its high-technology manufacturing exports, China displaced Japan as Asia's leading exporter of such goods. The growth in Asia's share of world activity during the 1990s was also driven by increased exports from Singapore, South Korea, and Taiwan (figure 40).

- Among Asian economies, China's success as a high-technology exporter is the most prominent. In 2003, China accounted for 12% of world high-technology exports, up from 5% in 1990. Singapore, with the smallest population and landmass in Asia, was third at 6% in 2003. South Korea and Taiwan each had about 5%.

FIGURE 39. Share of global high-technology industry exports, by selected region and country/economy: 1990–2003

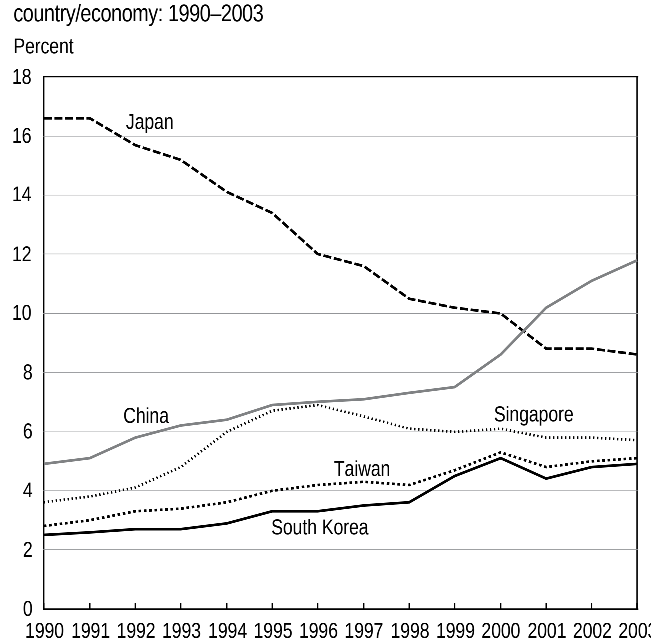


EU = European Union

NOTE: Asia includes Japan, China, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: Global Insight, Inc., World Industry Service database, (2005), special tabulations.

FIGURE 40. Share of global high-technology exports, by selected Asian country/economy: 1990–2003



SOURCE: Global Insight, Inc., World Industry Service database (2005), special tabulations.

High-Technology Service Industries

Service-sector industries account for about two-thirds of world economic activity, and high-technology or knowledge-based service industries are a large and growing part of the sector. OECD identifies five broad service industries that report high R&D intensities:[24] communication, finance and insurance, business, education, and health services.

- Asia lags behind both the EU and the United States in revenues generated by high-technology services. However, revenue growth in the high-technology service sector during 1990–2003 has been slightly faster in Asia than in either the EU or the United States (figure 41).

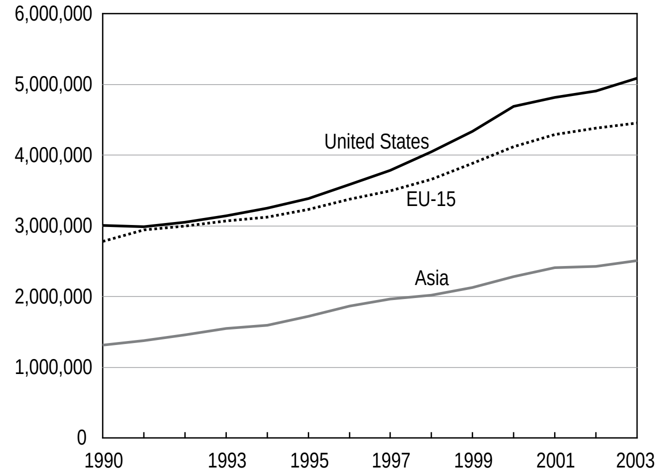
- Japan has by far the largest high-technology service sector of the 10 Asian economies for which data are available. However, compared with Japan, the sector is growing faster in most other parts of Asia (table 18).

- High-technology service industries in most Asian economies are in relatively early stages of development. In terms of revenue growth in the sector, China, South Korea, India, Malaysia, and Taiwan stand out. India's high-technology service industry has grown the fastest; yet, despite more than tripling its revenues from 1990 to 2003, India accounted for only about 1% of total world revenues in the high-technology service sector in 2003 (figure 42).

[24] Based on above-average ratios of R&D spending to total sales and on shares of scientific and technical employment.

FIGURE 41. Revenues generated by high-technology services, by selected region and country/economy: 1990–2003

1997 U.S. dollars (millions)



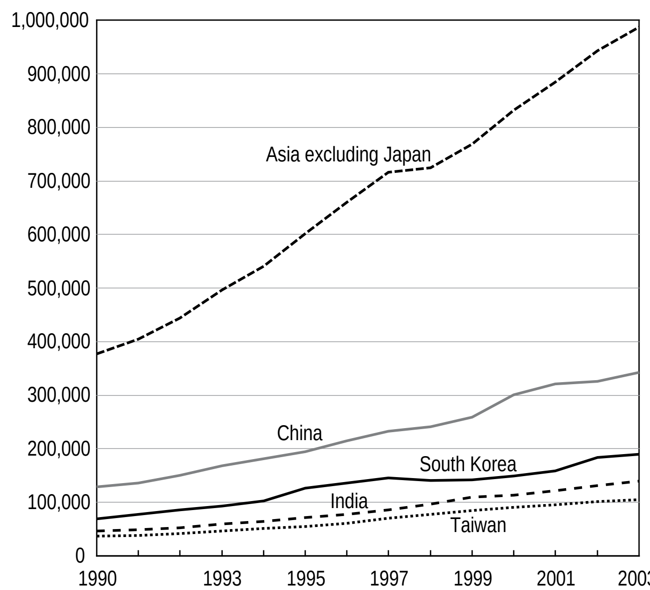
EU = European Union

NOTE: Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: Global Insight, Inc., World Industry Service database (2005), special tabulations.

FIGURE 42. Revenues generated by high-technology services, by selected Asian country/economy: 1990–2003

1997 U.S. dollars (millions)



EU = European Union

NOTE: Asia includes Japan, China, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: Global Insight, Inc., World Industry Service database, (2005), special tabulations.

TABLE 18. Revenue generated by high-technology service industries, by selected region and country/economy: Selected years, 1990–2003

Region and country/economy	1990	1992	1994	1996	1998	2000	2001	2002	2003
	Millions of 1997 U.S. dollars								
All countries/economies	8,477,935	8,958,165	9,500,546	10,463,948	11,509,241	13,006,297	13,478,975	13,733,723	14,118,836
United States	3,004,535	3,049,795	3,249,403	3,583,612	4,050,020	4,692,626	4,813,893	4,907,762	5,087,137
EU-15	2,783,084	2,998,765	3,124,478	3,376,493	3,656,600	4,117,062	4,288,194	4,380,060	4,454,916
Asia	1,310,079	1,456,677	1,596,708	1,860,509	2,019,552	2,277,065	2,406,294	2,424,872	2,503,846
China	128,595	149,931	181,895	214,968	241,192	301,155	320,691	325,379	342,268
India	46,061	52,619	64,692	77,822	97,172	113,719	122,051	130,772	139,229
Indonesia	25,671	30,051	34,512	44,038	37,875	40,309	42,795	48,303	53,155
Japan	933,154	1,012,751	1,055,349	1,199,855	1,294,623	1,444,622	1,521,145	1,482,073	1,516,605
Malaysia	13,492	16,454	21,128	26,687	29,400	32,062	35,353	38,666	39,976
Philippines	10,326	10,195	11,096	13,361	16,348	17,264	18,249	19,981	21,649
Singapore	25,792	30,642	39,387	46,017	51,396	57,631	59,867	60,360	60,654
South Korea	68,866	85,955	102,402	136,082	140,581	148,784	159,382	184,079	190,254
Taiwan	36,837	42,058	51,705	61,402	77,886	90,265	95,125	101,989	105,356
Thailand	21,287	26,022	34,541	40,278	33,082	31,256	31,636	33,271	34,701
	Share of world total (%)								
All countries/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	35.4	34.0	34.2	34.2	35.2	36.1	35.7	35.7	36.0
EU-15	32.8	33.5	32.9	32.3	31.8	31.7	31.8	31.9	31.6
Asia	15.5	16.3	16.8	17.8	17.5	17.5	17.9	17.7	17.7
China	1.5	1.7	1.9	2.1	2.1	2.3	2.4	2.4	2.4
India	0.5	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.0
Indonesia	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.4	0.4
Japan	11.0	11.3	11.1	11.5	11.2	11.1	11.3	10.8	10.7
Malaysia	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.3
Philippines	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Singapore	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
South Korea	0.8	1.0	1.1	1.3	1.2	1.1	1.2	1.3	1.3
Taiwan	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.7	0.7
Thailand	0.3	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.2

EU = European Union

NOTES: High-technology sectors include communications services, finance and insurance, business services, education, and medical and health care. Asia includes only the economies listed; All countries/economies includes regions/countries not specifically listed.

SOURCES: Global Insight, Inc., World Industry Service database (2005). Historical data from United Nations (UN) Industrial Development Organization; UN Statistics Division, System of National Accounts; Organisation for Economic Co-operation and Development; and country sources.

U.S.–Asia and U.S.–EU Trade Flows in Technological Know-How

Firms trade intellectual property when they license or franchise proprietary technologies, trademarks, patents, and inventions to entities in other countries. The data analyzed here represent U.S. receipts (royalties) and payments (fees paid) from technological know-how—the exchange and use of industrial processes with unaffiliated foreign companies in Asia and the EU.[25] The data indicate trends in the production and diffusion of technical knowledge.

- The United States is a net exporter of technological know-how, and trade with Asia accounts for most of the surplus. U.S.–EU trade in industrial processes generally shows only a small U.S. surplus (figure 43).

- In 2003, the latest available year with comparable data, U.S. receipts from technology licensing transactions with Asia were five times the amount of similar U.S. payments to Asia (table 19).

- Japan remains the largest customer in the world for technological know-how from the United States, although its purchases declined significantly in the late 1990s before rebounding in 2000 and 2001. In 1993, Japan's share of U.S. receipts was at its peak at approximately 51%; by 2003, Japan's share was 28% (figure 44; table 19).

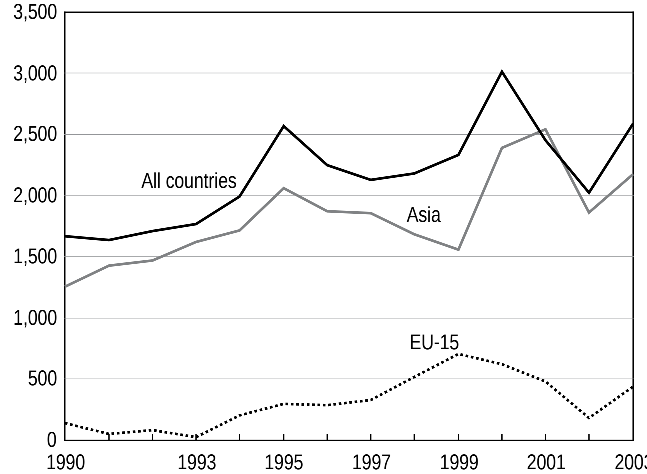
- South Korea has been the second largest customer in the world for U.S. technological know-how, accounting for between 9% and 19% of U.S. receipts from 1990 to 2003 and reaching its peak in 2000. Taiwan is the only other Asian economy to record any significant intellectual property trade activity with the United States.

- Japan is the only Asian country to receive any sizable payments from U.S. firms for access to technological know-how.

- U.S. receipts of licensing fees or royalties from China have been small, on the order of $100 million in 2003. U.S. payments to China have been minuscule, indicating little flow of technological know-how from China to the United States as yet.

FIGURE 43. U.S. trade balance in technological know-how, by selected region: 1990–2003

1997 U.S. dollars (millions)



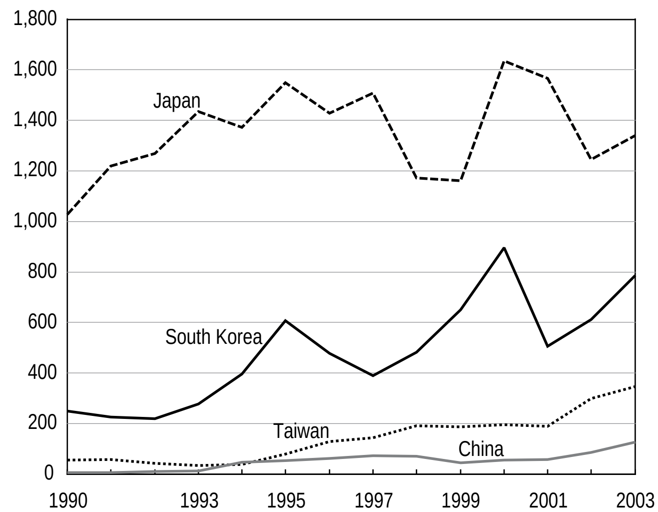
EU = European Union

NOTE: Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis (2004), special tabulations.

FIGURE 44. U.S. receipts from trade in technological know-how, by selected Asian country/economy: 1990–2003

1997 U.S. dollars (millions)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis (2004), special tabulations.

[25] Data represent U.S. firms' royalties and payments generated from the exchange and use of industrial processes with unaffiliated foreign companies. Such transactions between unaffiliated companies better reflect the market value of technical know-how than flows among affiliated firms.

TABLE 19. U.S. receipts and payments of royalties and license fees generated from exchange and use of industrial processes with unaffiliated foreign companies, by selected region and country/economy: Selected years, 1990–2003
(Millions of U.S. dollars)

Region and country/economy	1990	1992	1994	1996	1998	2000	2001	2002	2003
Receipts									
All countries/economies	2,333	2,525	3,026	3,566	3,499	4,705	4,174	4,021	4,775
EU-15	500	498	598	937	1,071	1,314	1,297	1,257	1,452
Asia	1,465	1,704	2,063	2,299	2,094	2,910	2,454	2,366	2,763
China	NA	NA	33	43	47	44	43	69	100
Hong Kong	6	11	15	19	23	12	14	18	26
India	21	34	28	37	20	23	20	13	22
Indonesia	11	13	20	13	11	15	10	19	21
Japan	1,028	1,268	1,372	1,429	1,172	1,636	1,567	1,245	1,341
Malaysia	2	7	19	D	43	10	11	10	9
Philippines	4	3	1	2	8	7	4	3	5
Singapore	19	20	73	37	37	20	D	27	31
South Korea	249	220	396	478	483	896	506	611	786
Taiwan	55	42	39	130	192	196	190	299	347
Other	70	86	67	D	58	D	60	51	75
Payments									
All countries/economies	665	818	1,034	1,319	1,319	1,695	1,720	2,000	2,188
EU-15	360	417	395	649	555	695	816	1,076	1,012
Asia	160	152	283	401	480	515	468	478	529
China	NA	NA	7	D	D	6	2	6	3
Hong Kong	0	—	3	2	—	2	1	—	—
India	—	—	—	D	—	D	2	D	1
Indonesia	0	—	0	—	—	D	D	0	0
Japan	141	145	262	308	374	460	411	455	524
Malaysia	0	0	0	3	—	—	D	0	—
Philippines	0	—	—	1	—	—	—	—	—
Singapore	0	D	—	—	—	—	D	1	D
South Korea	D	1	6	D	D	19	18	5	D
Taiwan	1	2	2	2	—	D	2	1	D
Other	D	D	3	—	D	D	D	—	—
Balance									
All countries/economies	1,668	1,707	1,992	2,247	2,180	3,010	2,454	2,021	2,587
EU-15	140	81	203	288	516	619	481	181	440
Asia	1,305	1,552	1,780	1,898	1,614	2,395	1,986	1,888	2,234
China	NA	NA	26	D	D	38	41	63	97
Hong Kong	6	11	12	17	23	10	13	18	26
India	21	34	28	D	20	D	18	D	21
Indonesia	11	13	20	13	11	D	D	19	21
Japan	887	1,123	1,110	1,121	798	1,176	1,156	790	817
Malaysia	2	7	19	D	43	10	D	10	9
Philippines	4	3	1	1	8	7	4	3	5
Singapore	19	D	73	37	37	20	D	26	D
South Korea	D	219	390	D	D	877	488	606	D
Taiwan	54	40	37	128	192	D	188	298	D
Other	D	D	64	D	D	D	D	51	75

NA = not available; D = suppressed to avoid disclosure of confidential information; — = <$500,000

EU = European Union

NOTES: Industrial processes (or manufacturing know-how) include patents and other proprietary inventions and technology. EU data for 1990, 1992, and 1994 exclude Austria, Finland, and Sweden, which joined EU in 1995.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* 84 (10):25–76 (2004).

Technical Notes on S&E Publication Indicators

Data on articles are drawn from a growing set of worldwide journals (4,460 in 1988, 5,315 in 2003) tracked by Thomson ISI's *Science Citation Index* and *Social Science Citation Index* and prepared for NSF use by CHI Research, Inc. (now ipIQ, Inc.). Counts, authorship, and citation data encompass articles, notes, and reviews but exclude material whose central purpose is not the presentation or discussion of research findings.

Field classification of articles is based on the journal in which an article appears. Journal classification, based on the pattern of a journal's inward and outward citations, was conducted by CHI Research, Inc. (now ipIQ, Inc.)

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