Overview

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Introduction

This overview of the National Science Board's *Science and Engineering Indicators 2012* highlights some major developments in international and U.S. science and technology (S&T). It is not intended to be comprehensive; the reader will find more extensive data in the body of each chapter. Major findings on particular topics appear in the Highlights sections that precede chapters 1–7.

The indicators included in *Science and Engineering Indicators 2012* derive from a variety of national, international, public, and private sources and may not be strictly comparable in a statistical sense. As noted in the text, some data are weak, and the metrics and models relating them to each other and to economic and social outcomes need further development. Thus, the emphasis is on broad trends; individual data points and findings should be interpreted with care.

The overview focuses on the trend in the United States and many other parts of the world toward the development of more knowledge-intensive economies in which research, its commercial exploitation, and other intellectual work are of growing importance. Industry and government play key roles in these changes.

The overview examines how these S&T patterns and trends affect the position of the United States, using broadly comparable data wherever possible for the United States, the European Union (EU[1]), Japan, China, and other selected Asian economies (the Asia-8: India, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand).

The overview sketches an analytical framework for, and a broad outline of, the main S&T themes, which it then examines through the lens of various indicators. R&D and human resources indicators feature prominently, along with indicators of research outputs and their use in the form of article citations and patents. The overview then describes the growth and structural shifts in international high-technology markets, trade, and relative trade positions.

Some of the data available as of this writing cover all or part of the period of the 2007–09 financial and economic crisis that continues to unsettle the world. The crisis has affected the range of S&T endeavors, from basic research to production and trade of high-technology goods and knowledge-intensive services. The full effects of these events will take years to become apparent, but, to the extent permitted by available data, the overview will comment on recession-induced changes in the major well-established trends.

Major Global Science and Technology Trends

Since the 1990s, a global wave of market liberalization has produced an interconnected world economy, accompanied by unprecedented levels of activity and growth and by ongoing structural changes. Governments in many parts of the developing world, viewing science and technology as integral to economic growth and development, have set out to build more knowledge-intensive economies. They have taken steps to open their markets to trade and foreign investment, develop their S&T infrastructures, stimulate industrial R&D, expand their higher education systems, and build indigenous R&D capabilities. Over time, global S&T capabilities have grown, nowhere more so than in Asia.

As more effective communication and management tools have been developed, multinational corporations (MNCs) seeking to access these new markets have evolved global corporate structures that draw on far-flung, specialized, global supplier networks. In turn, host governments have often attached conditions to market access that, along with technology spillovers, have aided in the development of indigenous S&T capabilities. Western- and Japan-based MNCs are increasingly joined in world S&T markets by newcomers headquartered in developing nations.

In most broad aspects of S&T activities, the United States continues to maintain a position of leadership. But it has experienced a gradual erosion of its position in many specific areas. Two contributing developments to this erosion are the rapid increase in a broad range of Asian S&T capabilities outside of Japan and the effects of EU efforts to boost its relative competitiveness in R&D, innovation, and high technology.

Asia's rapid ascent as a major world S&T center is chiefly driven by developments in China, which on most indicators continues to show long-term growth that would normally be regarded as unsustainable. But several other Asian economies (the Asia-8) have also played a role. All are intent on boosting quality of, and access to, higher education and developing world-class research and S&T infrastructures. The Asia-8 functions like a loosely structured supplier zone for China's high-technology manufacturing export industries. This supplier zone increasingly appears to include Japan. Japan, a preeminent S&T nation, is continuing to lose ground relative to China and the Asia-8 in high-technology manufacturing and trade. India's high gross domestic product (GDP) growth continues to contrast with a fledgling overall S&T performance.

The EU is seeking to hold its own in the face of these worldwide S&T shifts. Its innovation-focused policy initiatives have been supported by the creation of a shared currency and the elimination of internal trade and migration barriers. Much of the EU's high-technology trade is with other EU members. EU research performance is strong and marked by pronounced EU-supported, intra-EU collaboration. The EU is also focused on boosting the quality and international standing of its universities.

Other countries share this heightened focus on S&T as a means of economic growth. Brazil and South Africa show high S&T growth rates, but from low bases. Among the more developed nations, Russia's S&T establishment continues to struggle in both relative and absolute terms, whereas Israel, Canada, and Switzerland are examples of mature, high-performing S&T establishments.

Global Expansion of Research and Development Expenditures

Global R&D expenditures over the past decade have grown faster than global GDP,[2] an indication of widespread efforts to make economies more knowledge and technology intensive. The global total rose from an estimated $522 billion in 1996 to approximately $1.3 trillion in 2009, with the rate of growth slowing in the 2008–09 recession years (figure O-1). Although the specific data points in figure O-1 are imprecise estimates, the steady and strong upward trend illustrates the rapidly growing global focus on innovation through R&D.[3]

R&D investments of Western countries slowed markedly in the face of adverse economic conditions. After 2008, R&D growth stopped and decreased for both the United States and the EU, after accounting for inflation. Growth for the Asian region (China, Japan, and the Asia-8) and the rest of the world slowed somewhat in 2008 and 2009, but from very high rates in earlier years.

The United States remained by far the single largest R&D-performing country, with an R&D expenditure of $400 billion in 2009. For the first time, the Asian region's total of $399 billion[4] matched the U.S. total in 2009 (figure O-2).

China's 2008–09 R&D growth increased by a record 28%—well above its 1997–2007 trendline growth of 22%—and propelled it past Japan into second place. 2010 data released by China's National Bureau of Statistics show a further 22% increase.

R&D expenditures can be viewed as long-term investments in innovation. The R&D/GDP ratio is a convenient indicator of how much of a nation's economic activity is devoted to innovation through R&D. A U.S. goal in the 1950s was to achieve an R&D investment of 1% of GDP by 1957. More recently, many governments have set their sights at 3% of GDP in pursuit of developing knowledge-based economies, a figure the EU has formally made its long-term planning target.[5]

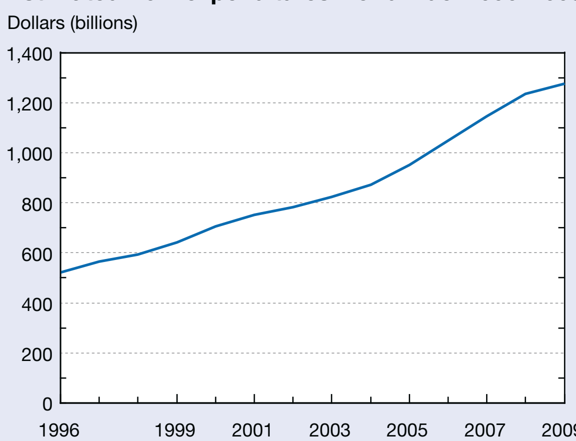
However, decisions affecting the bulk of R&D expenditures are generally made by industry, thus removing achievement of such a target from direct government control. In the United States, industry funds about 62% of all R&D. The EU average is 54%, but with considerable range (e.g., nearly 70% for Germany, but 45% for the United Kingdom). In China, Singapore, and Taiwan, industry funding ranges from 60% upward. Nevertheless, government planners monitor the R&D/GDP ratio as an indicator of innovative capacity, even as few countries reach the 3% mark.

Over the past decade, many developing economies in Asia have exhibited increased R&D/GDP ratios; conversely, the United States and the EU ratios have broadly held steady. Japan's comparatively high R&D/GDP ratio reflects the confluence of contracting GDP and flat R&D.

China's R&D/GDP ratio almost tripled, from 0.6% in 1996 to 1.7% in 2009, a period during which China's GDP grew at 12% annually—an enormous, sustained increase. The gap in China's R&D/GDP ratio relative to those of developed economies suggests that there is room for China's R&D volume to continue to grow rapidly (figure O-3).

The decade-long (1996–2007) R&D growth rates of mature S&T economies were lower than those of developing ones. Growth of R&D expenditures in the United States, the

Figure O-1
Estimated R&D expenditures worldwide: 1996–2009



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years) and United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org.

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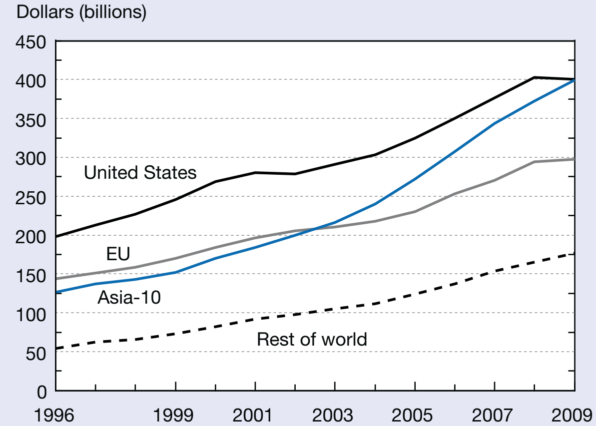
Figure O-2
R&D expenditures for United States, EU, and 10 Asian economies: 1996–2009



Asia-10 = China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years) and United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org.

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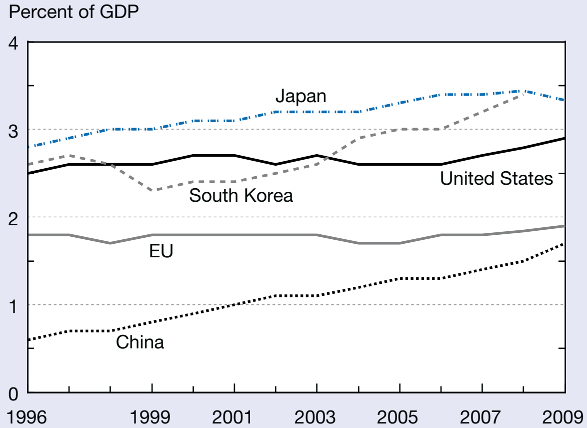
Figure O-3
R&D expenditures as a share of economic output of selected regions/countries: 1996–2009



EU = European Union; GDP = gross domestic product

NOTE: 2009 data unavailable for South Korea.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years).

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EU, and Japan were in the 5.4%–5.8% range while growth ranged from about 9.5%–10.5% for Singapore and Taiwan, to 12% for South Korea.

The effect of the global economic slowdown on R&D expenditures is dramatic—a sharp drop in growth in most locations in 2008–09 that is in stark contrast to a 28% rise in China's R&D spending, its highest growth rate since 2000 (figure O-4).

The relatively greater R&D growth rates of Asian economies (excluding Japan) resulted in changes in the global distribution of estimated R&D expenditures. Compared to 1996, the North America region's (United States, Canada, and Mexico) share of estimated world R&D activity decreased from 40% to 36% by 2009; the EU's share declined from 31% to 24%. The Asia/Pacific region's share increased from 24% to 35%, Japan's low growth notwithstanding (figure O-5).

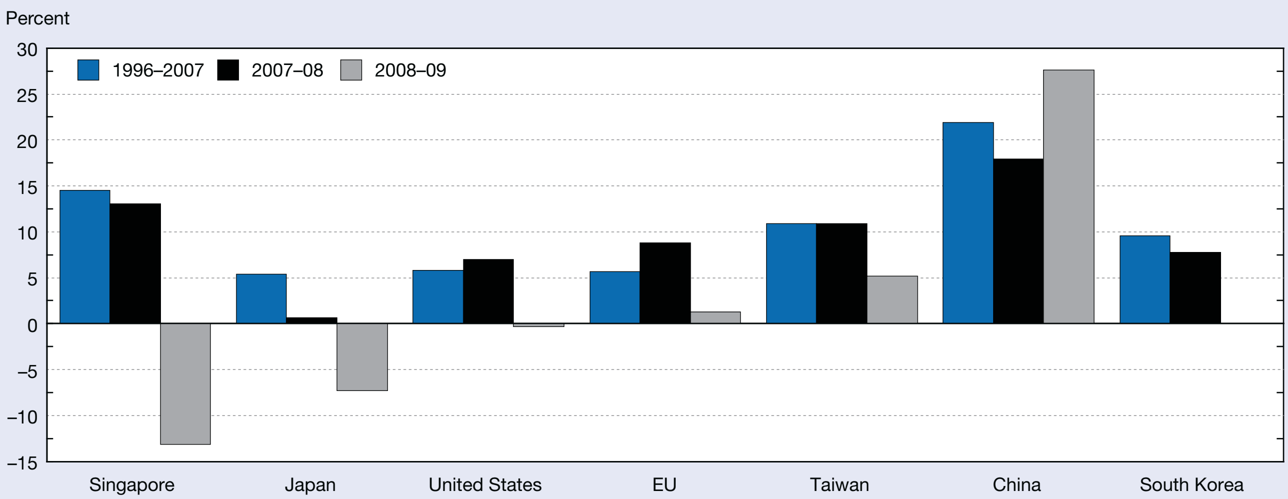
Overseas R&D by Multinational Corporations

The shift toward greater R&D expenditures in Asia is also reflected in R&D flows between MNCs and their overseas affiliates in which they hold majority ownership (figure O-6).

Overseas R&D expenditures of U.S.-based MNCs ($37 billion in 2008) shifted toward Asian markets whose combined share increased from 11% in 1998 to 20% a decade later, with increases in China, South Korea, Taiwan, and Singapore. In 1998, about 83% of all overseas R&D by U.S.-headquartered MNCs took place in Europe and Canada; by 2008, their combined percentage had decreased to 74%.

A crude indicator of the pace of utilization of overseas R&D talent and facilities by U.S. MNCs is the percentage of the MNCs' total R&D that is conducted by their majority-owned overseas affiliates. Over the past decade, this share has gradually risen from about 13% to 16% (figure O-7).

Figure O-4
Average annual growth of R&D expenditures for United States, EU, and selected Asian economies: 1996–2007, 2007–08, and 2008–09



EU = European Union

NOTE: 2009 data unavailable for South Korea.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years).

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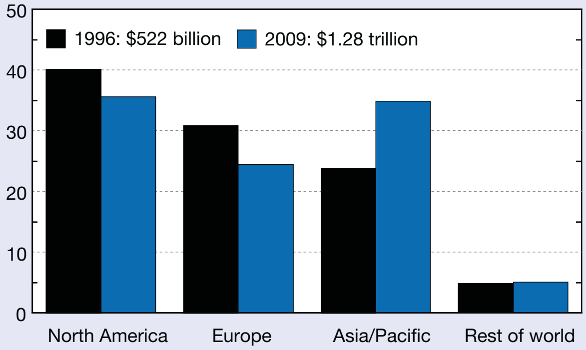
Affiliates of foreign-headquartered MNCs in 2008 spent about $40.5 billion on R&D in the United States, virtually unchanged from the preceding year. The companies' share of total U.S. business R&D has fluctuated between 13% and 15% since 2000.

Figure O-5
Location of estimated worldwide R&D expenditures: 1996 and 2009



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years) and United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org.

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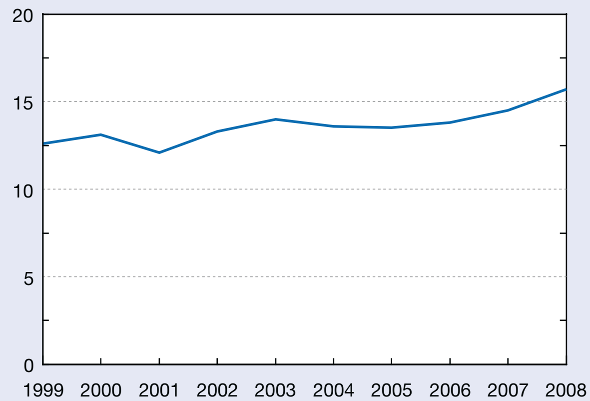
Figure O-7
U.S. multinational companies' R&D performed abroad: 1999–2008



NOTES: Data for majority-owned affiliates. Preliminary estimate for 2008.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad.

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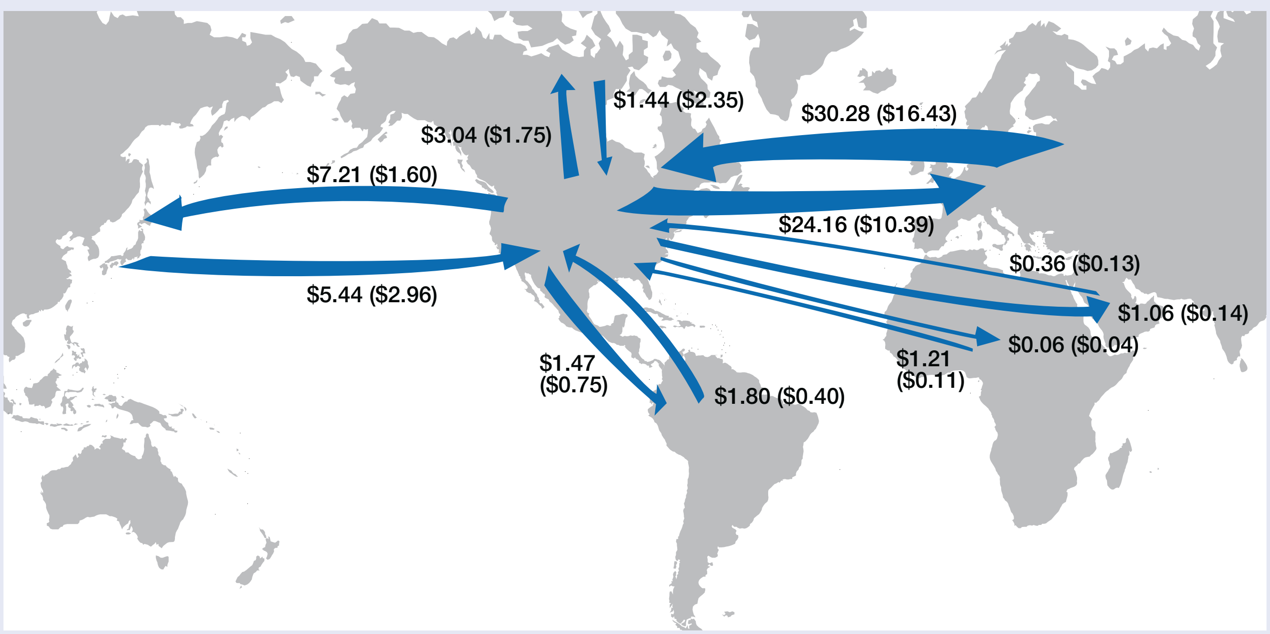
Figure O-6
R&D performed in the United States by U.S. affiliates of foreign companies, by investing region, and R&D performed abroad by foreign affiliates of U.S. multinational corporations, by host region: 1998 and 2008



NOTES: Preliminary estimates for 2008 (1998 data in parentheses).

SOURCES: Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States (annual series); Survey of U.S. Direct Investment Abroad (annual series).

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Global Higher Education and Workforce Trends

No comprehensive measures of the global S&E labor force exist, but fragmentary data indicate rapid growth, concentrated in developing countries, in the number of individuals who pursue education beyond the secondary level. Their number of degrees, especially degrees in the natural sciences and engineering (NS&E), has diminished the advantage that mature countries had in advanced education.[6] The low U.S. share of global engineering degrees in recent years is striking; well above half of all such degrees are awarded in Asia[7] (figure O-8).

Governments in many Western countries and in Japan are concerned about lagging student interest in studying NS&E, fields they believe convey technical skills and knowledge that are essential for knowledge-intensive economies. In the developing world, the number of students earning first university degrees—that are considered broadly comparable to a U.S. baccalaureate—in NS&E is rising.

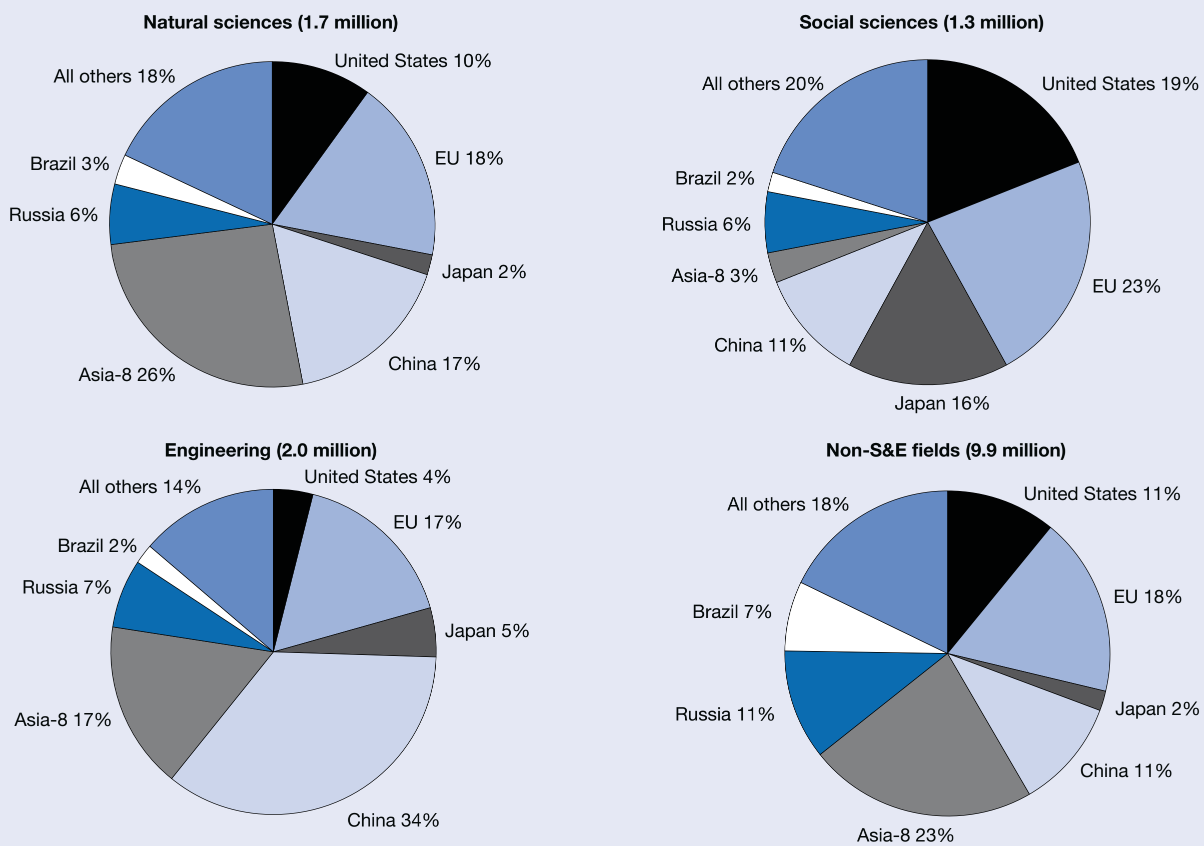
China, especially, has driven the rise of first university NS&E degrees—from about 280,000 in 2000 to 1 million in 2008 (figure O-9). Its degree structure has a pronounced concentration on engineering degrees, which represent about 30% of all first university degrees, 60% of S&E degrees, and 70% of NS&E degrees (the U.S. equivalents are 4%, 14%, and 28%).

South Korea, Taiwan, and Japan show similar field patterns. The combined NS&E degrees earned by their students, about 330,000 in 2008, exceeded the 248,000 earned by U.S. students, even though the U.S. population was considerably larger (300 million versus 200 million).

The expansion of NS&E degrees extends beyond first university degrees to degrees certifying completed advanced study. Since 2000, the number of NS&E doctorates awarded in Japan and India has increased to approximately 7,100 and 8,000, respectively. NS&E doctorate awards from universities in China have more than tripled since 2000, to about 26,000 in 2008, exceeding the comparable number of NS&E doctorates awarded in the United States (figure O-10).

Moreover, unlike in China, in the United States a large proportion of these degrees go to non-U.S. citizens. Most of the post-2000 increase in U.S. NS&E doctorate production reflects degrees awarded to temporary visa holders,

Figure O-8
First university degrees, by selected region/country: 2008 or latest data



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: Organisation for Economic Co-operation and Development, Education Online database, https://www.oecd.org/education/; and national statistical offices.

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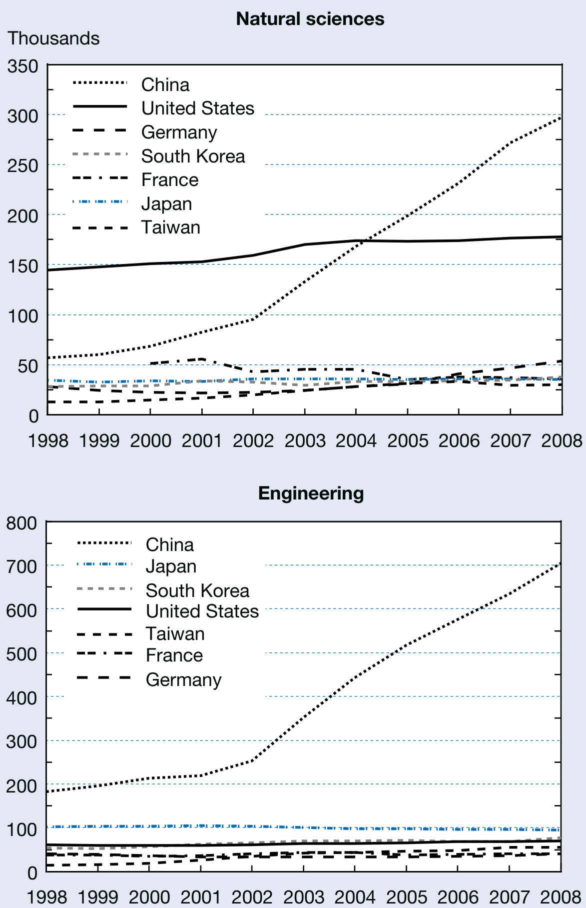
who in 2009 earned about 10,900 of the 24,700 U.S. NS&E doctorates.[8] Temporary visa holders, not counting foreign students with permanent visas, have earned 39% to 48% of U.S. NS&E doctorates since 2000. More than half of these students are from China, India, and South Korea.

For engineering alone, the numbers are considerably more concentrated. Since 2000, the share of U.S. engineering doctorates earned by temporary visa holders has risen from 51% to as high as 63% in 2005–07, before dropping to 57% in 2009. Nearly three-quarters of foreign national recipients of engineering doctorates were from East Asia or India.

Many of these individuals, especially those on temporary visas, will leave the United States after earning their doctorates, but if past trends continue, a large proportion—about 60%—will stay. It appears, though, that graduates from top-rated programs are somewhat less likely than others to stay.[9]

Figure O-9
First university degrees in natural sciences and engineering, by selected country/economy: 1998–2008



NOTE: Natural sciences include physical, biological, environmental, agricultural, and computer sciences, and mathematics.

SOURCES: Organisation for Economic Co-operation and Development, Education Online database, https://www.oecd.org/education/; and national statistical offices.

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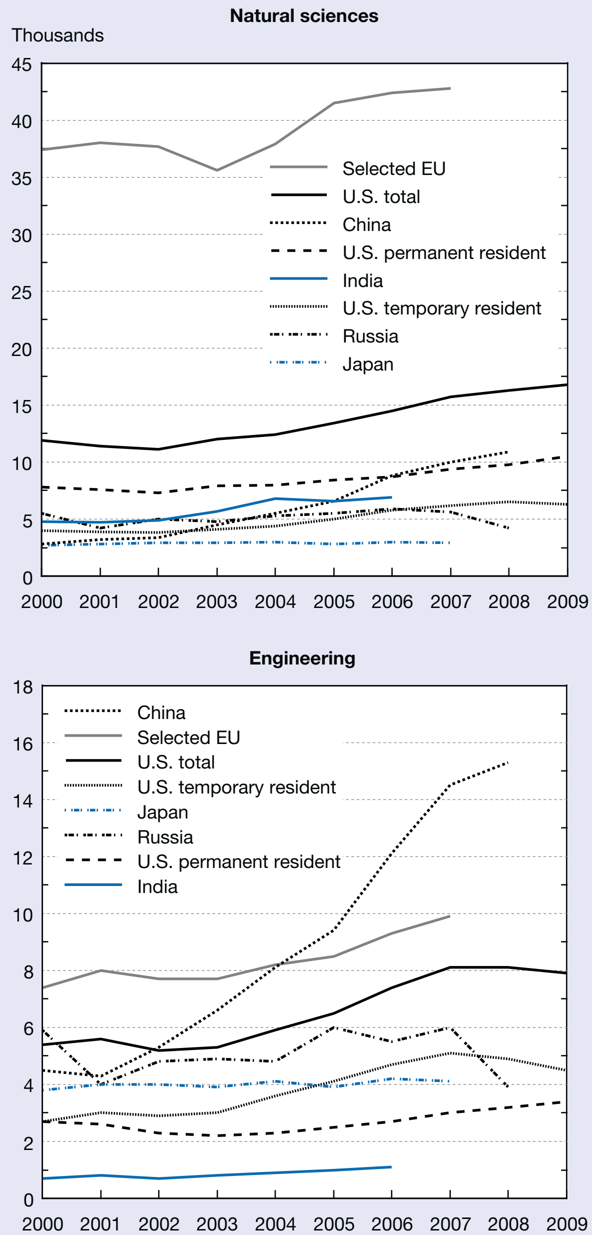
Expanding Global Researcher Pool

Estimates of the number of the world's researchers provide broad support for the trends and shifts suggested by R&D and degree data.

The estimated number of researchers grew from nearly 4 million in 1995 to about 6 million in 2008.[10] The United

Figure O-10
Doctoral degrees in natural sciences and engineering, by selected region/country: 2000 to most recent year



EU = European Union

NOTE: Natural sciences include physical, biological, environmental, agricultural, and computer sciences, and mathematics.

SOURCES: Organisation for Economic Co-operation and Development, Education Online database, https://www.oecd.org/education/; and national statistical offices.

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States and the 27 EU-member countries accounted for about 1.4 and 1.5 million researchers each—a combined 49% of the total but below the 51% share they had held a decade earlier. China's researchers tripled over the period.

Trends in researcher growth rates vary greatly by country and region (figure O-11). The United States and the EU had moderate annual growth in the 3%–4% range between 1995 and 2002, after which U.S. growth moderated. Comparable rates for Japan fluctuated between ±1%; Russia's researcher numbers kept contracting. Growth in the Asian region outside Japan was generally higher in the 2002–09 period than earlier and averaged 8%–9% for Taiwan, Singapore, and South Korea, capped by China's 12% annual average.

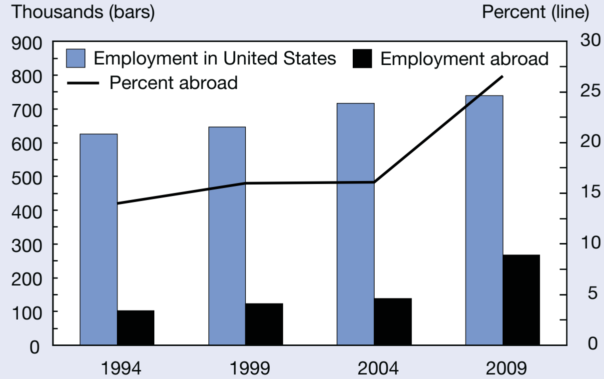
The contribution of multinational corporations to researcher growth in the overseas markets in which they operate is unknown. But preliminary data, available every 5 years, suggest a pronounced expansion of R&D employment by overseas affiliates (majority-owned only) of U.S.-based MNCs in recent years.[11] After gradually increasing from 102,000 in 1994 to 138,000 in 2004, their R&D employment almost doubled to 267,000 in 2009. Over the same 5 years, the MNCs's R&D employment in the United States rose from about 716,000 to about 739,000. This boosted the overseas share of their total R&D employment from 16% to 27% (figure O-12). Not included are researchers in overseas firms in which MNCs hold less than majority ownership or in unaffiliated firms that perform contract research for MNCs.

Data on employment of researchers by foreign-based MNCs in other countries are unavailable, except for those working in the United States. Growth in U.S. employment of researchers working for U.S. affiliates of foreign-based MNCs has been broadly in line with overall U.S. researcher trends.

Research Outputs: Journal Articles and Patents

Research produces new knowledge, products, or processes. Research publications reflect contributions to knowledge, patents indicate useful inventions, and citations on patents to the scientific and technical literature indicate linkages between research and practical application.

Figure O-12
R&D employment of U.S.-based multinational corporations: 1994, 1999, 2004, and 2009



NOTES: Employment abroad limited to majority-owned affiliates. 2009 data are preliminary.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad (2009 and previous years).

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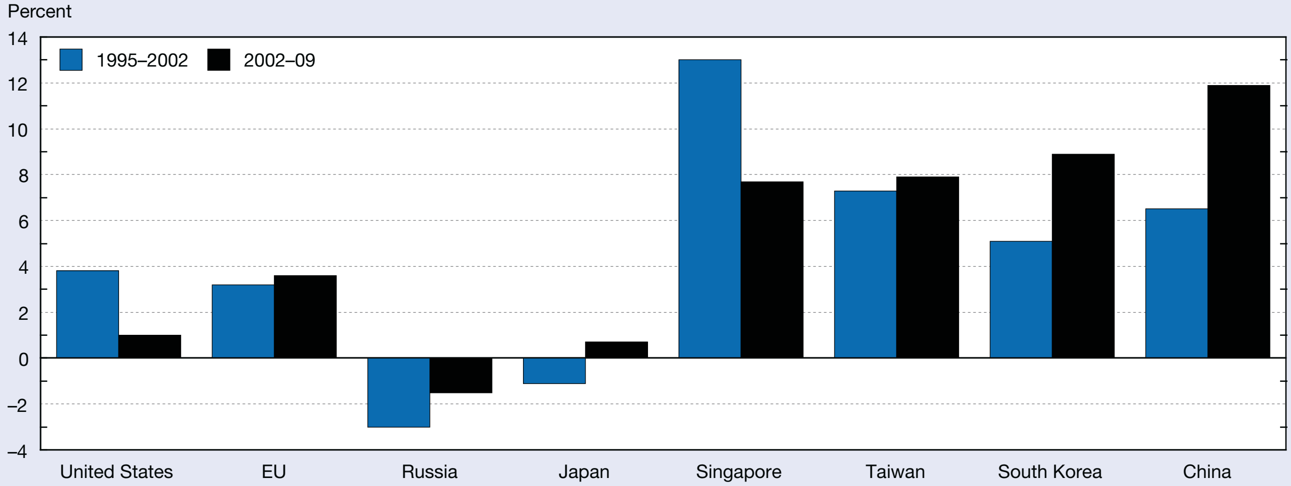
Figure O-11
Average annual growth in number of researchers, by region/country/economy: 1995–2002 and 2002–09



EU = European Union

NOTE: Growth rates through last available year in range indicated.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years).

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The number of research articles published in a set of international, peer-reviewed journals has grown from about 460,200 in 1988 to an estimated 788,300 in 2009.[12] The geographical distribution of the authors[13] provides an indication of the size of a country's or region's research enterprise and its production of research results (figure O-13).

Researchers in the EU and the United States have long dominated world article production, but their combined share of published articles decreased steadily from 69% in 1995 to 58% in 2009. In little more than a decade, Asia's world article share expanded from 14% to 24%, driven by China's 16% average annual growth. By 2007, China surpassed Japan's article output and moved into second place behind the United States—up from 14th place in 1995. By 2009, China accounted for about 9% of world article output.

India's output of scientific and technical articles, stagnating through the late 1990s, began to rise after 2000, but India's ranking hardly changed from 12th to 11th place in 2009. Japan's output declined in volume and global share. Russia's article output flattened after 2005, following a decade-long decline that resulted in a drop from 7th to 13th place in global output ranking.

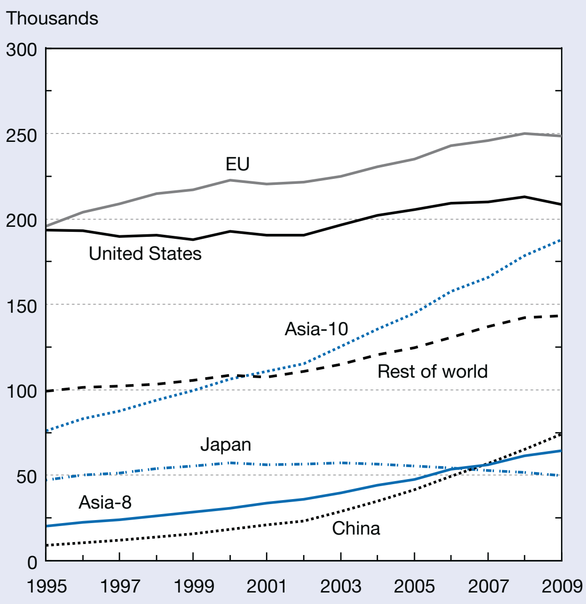
The distribution of a country's research publications across different fields is a broad reflection of its research priorities. A large portion of U.S. articles focused on the biomedical and other life sciences; scientists in Asia and some major European countries published a preponderance of articles in the physical sciences[14] and engineering. Recent shifts in emphasis include China's growing focus on chemistry R&D and South Korea's growing output in biological and medical sciences. These changes reflect government policy choices as China is building up its chemicals industry, and South Korea is trying to develop a world-class reputation in health sciences.

Worldwide, the number of engineering research articles have increased substantially faster than total S&E article production, particularly in Asia outside Japan (figure O-14). Growth in the United States and Japan averaged less than 2%; in the EU, about 4.4%. China's engineering article output grew by close to 16% annually, and the Asia-8 economies expanded their combined output by 10% a year.

Consequently, the production of engineering research articles has shifted away from established S&T nations. In 1995, the U.S. share of engineering articles was 25%, by 2009, 13%. Japan's share declined from 10% to 5% during the same period. The EU's share dipped from 25% to 19%. Asia's share, excluding Japan, increased from 9% to 23%, with China producing nearly half of these articles by 2009.

The relative preponderance of engineering articles in developing Asian economies reflects the region's emphasis on

Figure O-13
S&E journal articles produced, by selected region/country: 1995–2009



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; Asia-10 = Asia-8 plus China and Japan; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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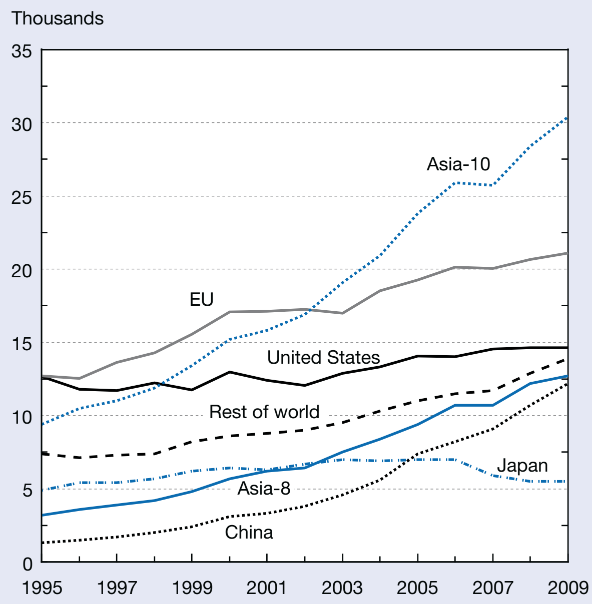
Figure O-14
Engineering journal articles produced, by selected region/country: 1995–2009



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; Asia-10 = Asia-8 plus China and Japan; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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building high-technology manufacturing capabilities. In the United States and the EU, 7%–8% of all articles are in engineering, in Asia, 11%–20% (figure O-15).

Patents list the prior scientific and technological knowledge on which they are built. Increasingly, U.S. patents have cited scientific articles as one such source. The foreign share of such patent-to-article citations is rising, indicating growing utilization of published research in foreign inventions.

Changing International Research Collaborations

Collaborative research is becoming the norm, and collaboration across national boundaries is generally increasing, as reflected in international coauthorship on research articles. In 1988, only 8% of the world's S&E articles had international coauthors; by 2009, this share had grown to 23%. For the world's major S&T regions, the 2009 rate ranged from about 27% to 42%.

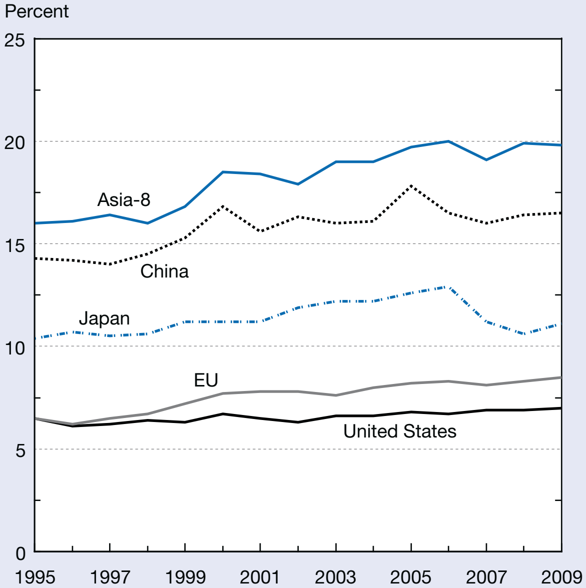
International coauthorship trends for China, South Korea, and Taiwan differ from this pattern. Each location had reached an international coauthorship level of 20%–30% of its total articles by the early 1990s. They broadly maintained the same relative level of international collaboration, indicating that the bulk of their rapid article growth was due to articles with only domestic authors (figure O-16).

As a result of the large volume of both U.S. and EU article outputs, along with EU policies that encourage intra-Union collaboration, U.S.-based authors appeared on 43%, and EU-based authors on 67%, of the world's internationally coauthored articles in 2009. Increasingly, Asia-based authors are participating in international collaborations, signaling maturing of their scientific and engineering capabilities (figure O-17).

Size matters: China, with its rapidly growing research capacity, can support more international collaborations than Singapore. An index of international collaboration corrects for different-sized science establishments and allows comparisons of regional and country coauthorship patterns. On this index, values above "1" indicate higher-than-expected, and values below "1" lower-than-expected, degrees of collaboration with researchers in a particular country.[15]

U.S. international collaborations measured by this index were widespread. Links were strongest with South Korea, Taiwan, Canada, and Israel; collaboration with China, Japan, and India was also above the U.S. average. The pattern of U.S. international collaborations remained mostly steady over the past decade (2000–10), though ties increased with China and weakened somewhat with a number of other Asian economies (figure O-18).

Figure O-15
Engineering journal articles as a share of total S&E journal articles, by selected region/country: 1995–2009



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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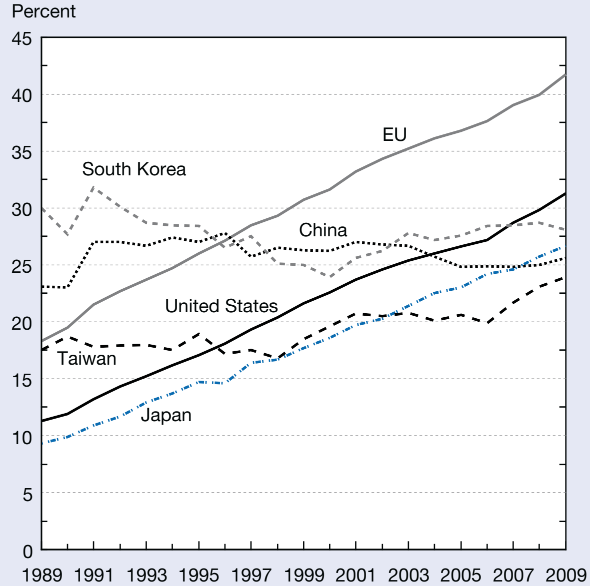
Figure O-16
Research articles with international coauthors, by selected region/country/economy: 1989–2009



EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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EU collaborations were equally widespread and increased measurably over the period, quite likely in response to explicit EU policies. Levels of collaboration with Asia were generally well below the expected level, and the EU collaboration index was lower (and declining) with China than with India (figure O-19).

Collaboration among Asia's growing number of researchers was generally substantially higher than expected, with high levels of collaboration between China and Japan, South Korea, Singapore, and Taiwan. Collaboration between China and India, as measured by this index, diminished noticeably over the decade amid rising Indian collaboration with South Korea and Japan (figure O-20). The underlying index values suggest the genesis of an intra-Asian zone of scientific collaboration that has a counterpart in the region's knowledge- and technology-intensive (KTI) economic activities.

New Research Capacity Reflected in World's Citations Base

Citations to the work of others in the literature are a broad indicator of the usefulness of this work in ongoing research.[16] In most major countries/regions, citations to the international literature have grown at the expense of citing purely domestic work. International citations make up 70% of all references in Japanese articles and 65% of all references in the combined output of the Asia-8. In the United States, the EU, and China, about half of all citations are to articles that include at least one author from another country (figure O-21).

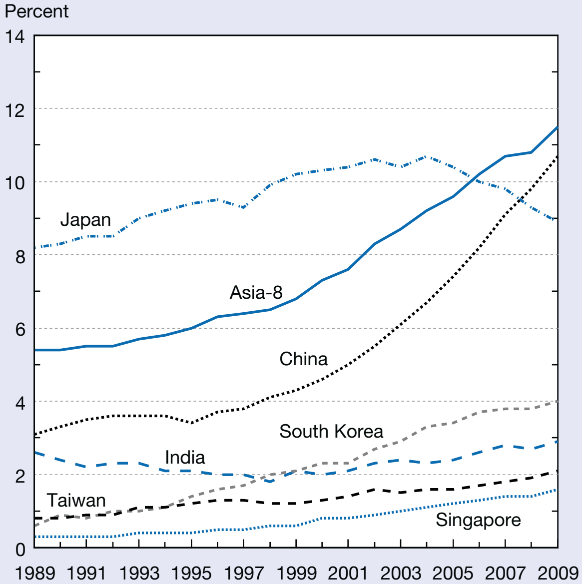
Intra-Asian citation patterns show a distinct reliance by Chinese researchers on the growing domestic literature, and on intra-Asia-8 articles by Asia-8 scientists, accompanied by rising Asia-8-China citations and vice versa. Citations to Japanese science and engineering articles are gradually declining (figure O-22).

Increasingly, high-quality research is being done not only in the United States, the EU, and Japan, but in a broader set of economies. This is illustrated by the declining proportion of citations to U.S. publications in articles originating elsewhere (figure O-23). The same trend appears in the references found in the top 1% of all cited articles.

Inventive Activity Shown by Patents

Government-issued patents protect inventions that are new, not obvious, and useful. The U.S. Patent and Trademark Office (USPTO) grants patents to inventors from all over the world, and the sheer volume of U.S. patents and

Figure O-17
Internationally coauthored articles with authors in Asia, by Asian author location: 1989–2009



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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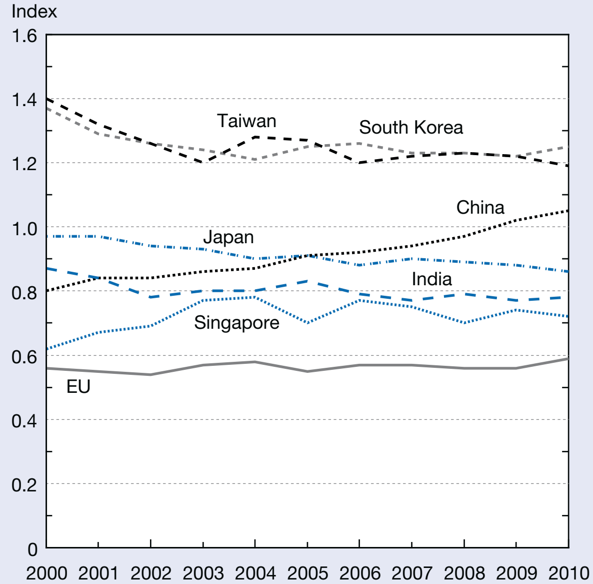
Figure O-18
U.S. research collaborations with EU and selected Asian countries/economies: 2000–10



EU = European Union

NOTE: Index value >1 indicates higher-than-expected degree of collaboration.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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the importance of the U.S. market makes them a useful indicator of trends in the geography of inventive activity.

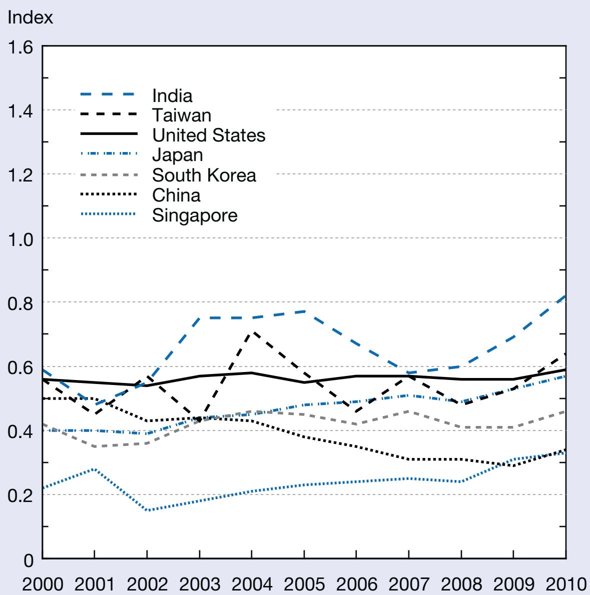
In 1992, about 54% of USPTO patents were granted to U.S.-based inventors; by 2010, this percentage had fallen to 49%, a possible indication of growing inventive activity elsewhere.[17]

Among patents granted to non-U.S. inventors, the shares of EU- and Japan-based individuals have eroded by 9–11 percentage points since 1992. Asia-8's share rose by 15 points over the period, mostly because of activity by South Korea and Taiwan (figure O-24).

The picture of inventive activity drawn by Chinese patents is mixed. Among USPTO awards to non-U.S. inventors, China's share rose from below 0.5% to 3%. By this indicator, broad-based indigenous inventive activity, a focus of Chinese government policy, appears to remain elusive. But patents granted in China to China-based inventors rose from 5,000 in 2001 to 65,000 in 2009, and the Chinese-inventor share of Chinese patent grants increased from 33% to more than 50%.

Not all patents are equal in presumed value. Seeking protection for the same invention in the United States, the EU, and Japan requires substantial resources, suggesting that such patents are considered especially valuable by their owners.

Figure O-19
EU research collaborations with the United States and selected Asian countries/economies: 2000–10



EU = European Union

NOTE: Index value >1 indicates higher-than-expected level of collaboration.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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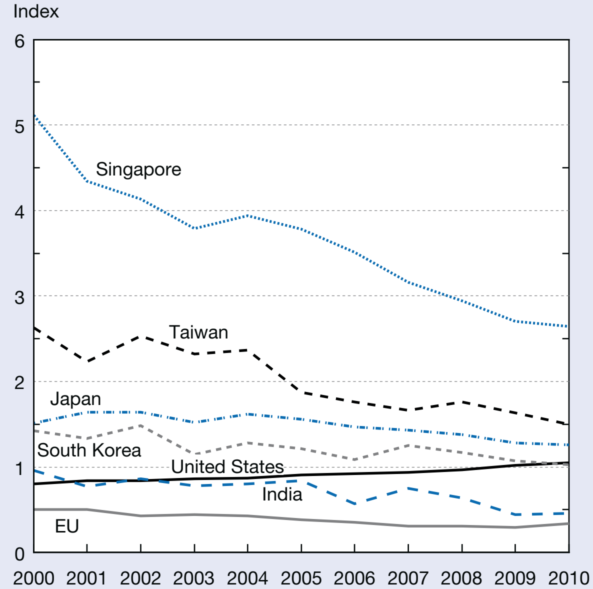
Figure O-20
Chinese research collaborations with the United States, EU, and selected Asian countries/economies: 2000–10



EU = European Union

NOTE: Index value >1 indicates higher-than-expected levels of collaboration.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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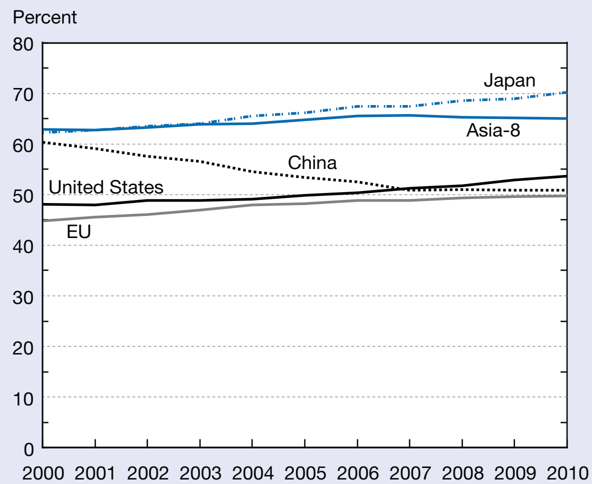
Figure O-21
Share of selected region's/country's citations to international literature: 2000–10



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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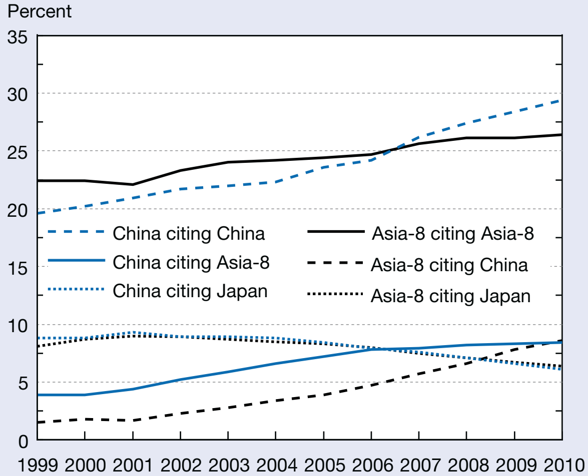
In 2008, U.S. and EU inventors each accounted for 30% of such high-value patents. Japan's share declined since 2000, while that of the Asia-8 rose, largely on the strength of Korean patenting activity (figure O-25). In contrast, China-based inventors appeared on only 1% of these high-value patents.

Figure O-22
Intra-Asia citation patterns for China, Asia-8, and Japan: 1999–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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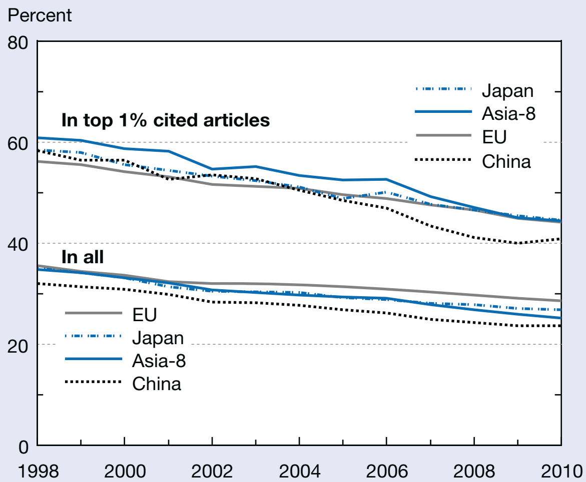
Figure O-23
Citations of U.S. research articles in non-U.S. literature, by region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

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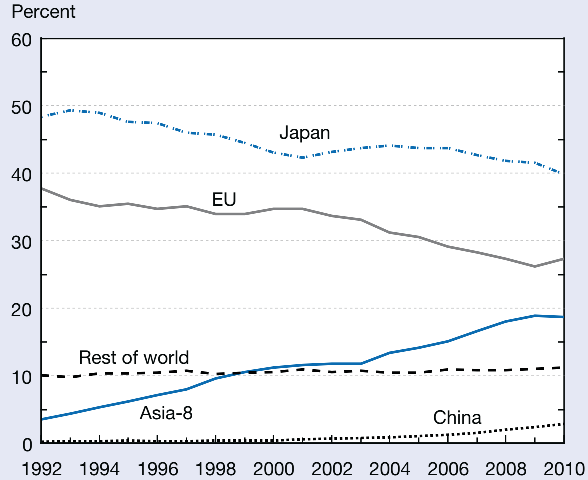
Figure O-24
Share of U.S. patents granted to non-U.S. inventors, by inventor region/country: 1992–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of U.S. Patent and Trademark Office, Number of Utility Patent Applications Filed in the United States, by Country of Origin: Calendar Years 1965 to Present, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.pdf.

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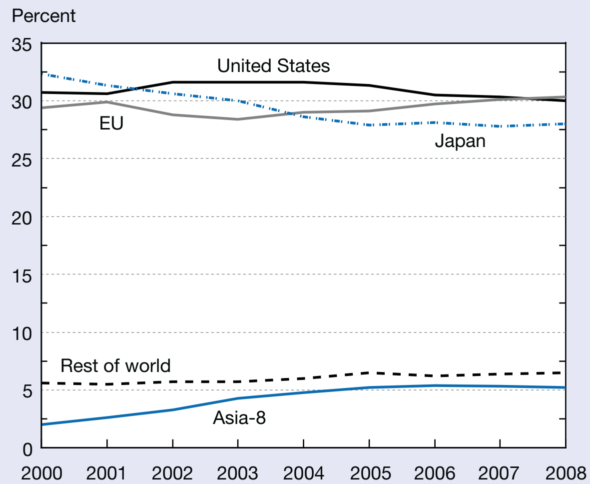
Figure O-25
Global high-value patents, by selected region/ country: 2000–08



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, OECD.StatExtracts, patent statistics, http://stats.oecd.org/index.aspx.

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Global Output of Knowledge- and Technology-Intensive Firms

Governments in developed countries believe that KTI economies create well-paying jobs, contribute high-value output, and ensure economic competitiveness. Governments in many developing countries believe the same and promote the growth of knowledge-intensive services and high-technology manufacturing industries.[18]

In 2010, these KTI industries contributed a combined $18.2 trillion to global economic output—about 30% of world GDP, and a growing share of many countries' economic output. Services are by far the largest aggregate, totaling $16.8 trillion: $10.9 trillion in tradable services, and $5.9 trillion in more location-bound health and education services. High-technology manufacturing added $1.4 trillion (figure O-26).

The effects of the 2007–09 recession on KTI industry output are visibly more severe than were those of the 2001 recession. A slowdown in growth in 2008 was followed by contraction or, in the case of knowledge-intensive services, lack of growth in 2009 and a sharp upswing in 2010. High-technology manufacturing went from 4.9% growth to a 5.7% contraction to 13.5% growth.

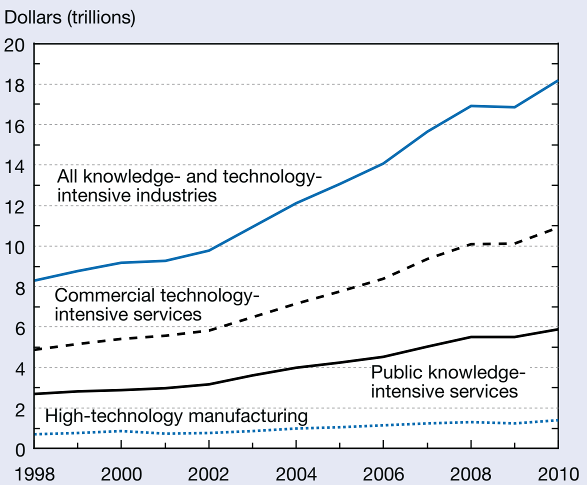
The largest aggregate in the KTI category is commercial knowledge-intensive services, which includes business and financial services and communications. The value of its global output increased from $4.9 trillion in 1998 to $9.4 trillion in 2007. As with all KTI industries, it showed recession effects that were more severe for the EU than for the United States (figure O-27). The United States, with $3.6 trillion in 2010, generated the largest value of these industries, as its output expanded after flat growth in 2008 and 2009.

The EU was particularly hard hit by the recession, resulting in declining output followed by shallow growth. The rest of the world suffered a 1-year slowdown or shallow declines, followed by sometimes vigorous growth. Increased production by China expanded its value-added output of commercial knowledge-intensive services and increased its global share from 3% in 2005 to 7% in 2010.

High-technology manufacturing value-added output suffered a global contraction in 2001 but offered a more varied picture in the 2007–09 recession: Brief but sharp contraction in Asia (excepting China) followed by an equally sizeable rebound in 2010; a sharper drop in the EU, followed by shallow growth; slowing growth followed by strong expansion in the United States; and unimpeded, rapid growth in China. By 2010, China's global share was 19%, up from 3% in 1998 (figure O-28).

The five high-technology manufacturing industries are, in decreasing order of the $1.4 trillion 2010 global value-added total: communications equipment and semiconductors ($512 billion), pharmaceuticals ($346 billion), scientific instruments ($275 billion), aerospace ($137 billion), and computers and office machinery ($127 billion). The United States ranked first overall in aerospace and tied with the EU in pharmaceuticals, but in communications equipment manufacturing it ranked behind Japan and the Asia-8, and in scientific instruments it ranked behind the EU.

Figure O-26
Global value added of knowledge- and technology-intensive industries: 1998–2010



NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database.

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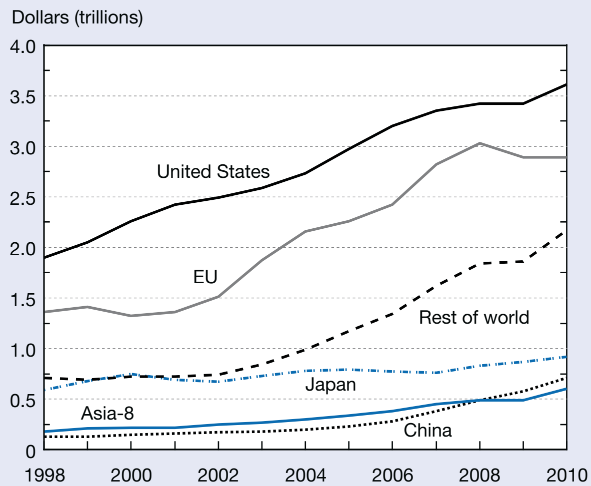
Figure O-27
Value added of commercial knowledge-intensive services, by selected region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database.

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China accounts for almost half of the global value of computer and office machinery production. This category saw a particularly rapid shift in relative world positions (figure O-29).

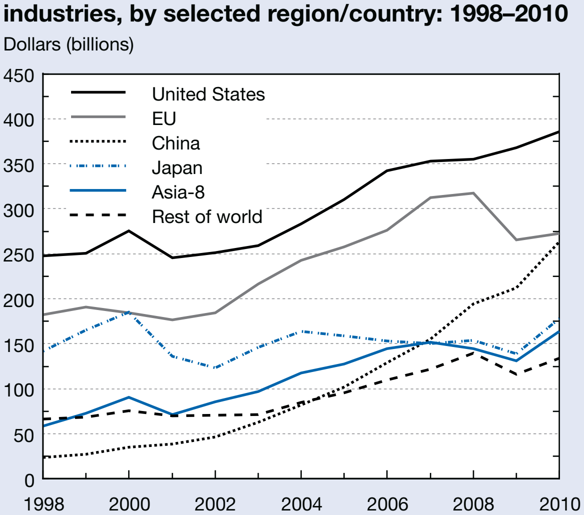
Employment in U.S. High-Technology Manufacturing

The effects of recessions go well beyond their impact on the value of the outputs of production. More far-reaching effects may be felt in the labor markets. Although internationally comparable data on KTI employment are fragmentary, employment data on U.S. high-technology manufacturing are illuminating (figure O-30).

Employment in the five U.S. high-technology manufacturing sectors reached a peak in 2000, just before the 8-month-long recession of 2001. This recession led to job losses in these industries that were substantial and permanent. The 18-month 2007–09 recession further squeezed employment in these industries. The total job loss in high-technology manufacturing over the period was 687,000—a decline of 28% since 2000.

The value of output generated by these industries contracted in 2001 and again slowed in 2007–08. However, over the decade, output per 1,000 employees doubled (unadjusted for inflation) (figure O-31).

Figure O-28
Value added of high-technology manufacturing industries, by selected region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database.

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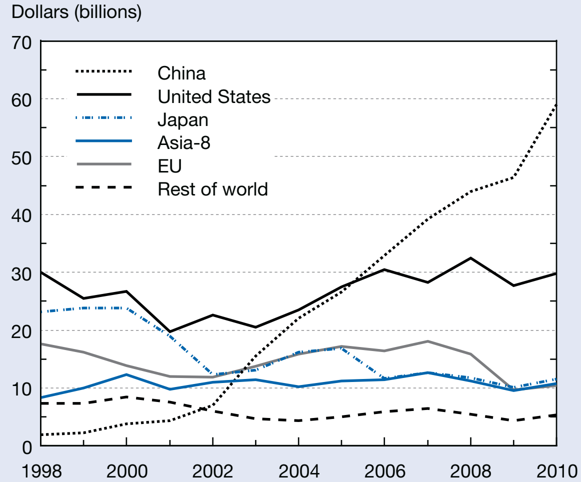
Figure O-29
Value added of computer and office machinery manufacturing, by selected region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database.

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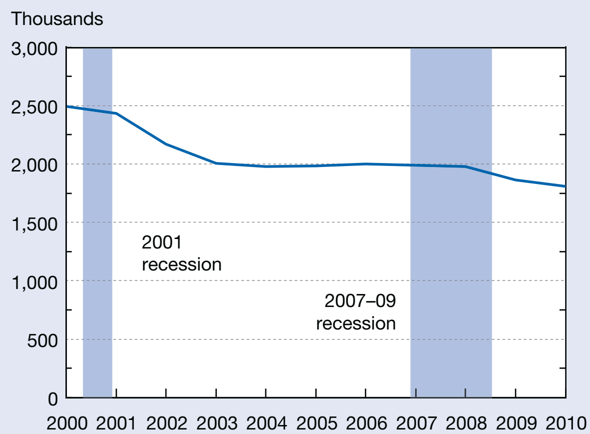
Figure O-30
U.S. high-technology manufacturing employment: 2000–10



NOTES: Industries defined by Organisation for Economic Co-operation and Development. Bars define recession periods.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Bureau of Labor Statistics, Current Employment Survey.

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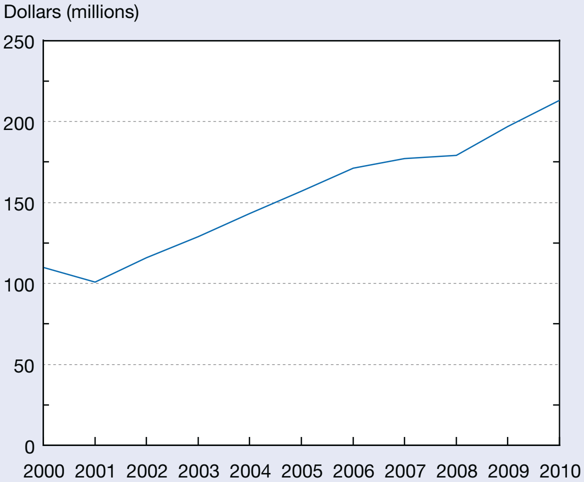
Figure O-31
Value of U.S. high-technology manufacturing output per 1,000 employees: 2000–10



NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database, and Bureau of Labor Statistics, Current Employment Survey.

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Global Exports of Commercial Knowledge-Intensive Services

The global value of trade in commercial knowledge-intensive services is gradually increasing but it represents less than 10% of global production of such services. The value of commercial knowledge-intensive services grew from $453 billion in 1998 to $1.46 trillion in 2008 and then contracted to $1.36 trillion in 2009.

The EU is the largest exporter of commercial knowledge-intensive services (excluding intra-EU exports), accounting for about 30% of the world total, followed by the United States with 22% and the Asia-8 with 15% (mostly from India and Singapore). The EU suffered a 10% drop in export volume in 2009, followed by less than 1% growth in 2010; the United States loss was 2%, followed by 6% growth.

Export declines in 2009 by China and the Asia-8 were in the 4%–6% range, after which the Asia-8 rebounded with 16% growth. 2010 data for China are unavailable (figure O-32).

Changing Global High-Technology Trade Patterns

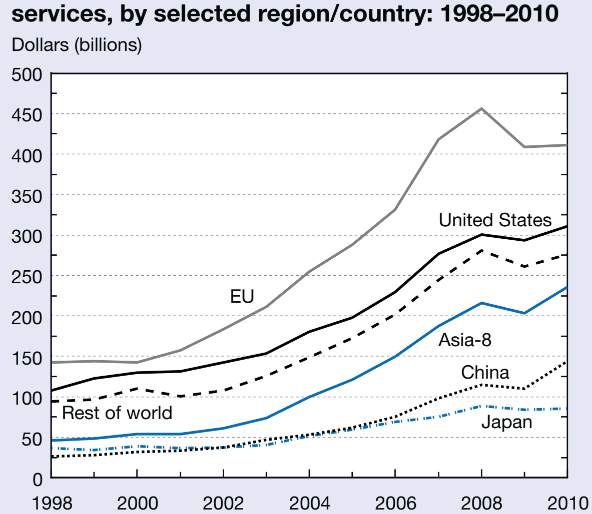
Two global recessions notwithstanding, total export volume of high-technology products increased at an 8% annual rate from 1998 to 2010, not accounting for inflation. This ranged from a low of 2% for Japan to a high of 19% for China, with the United States and EU in the 5%–7% range. The increase reflects a number of developments: growing international capacity for high-technology manufacturing, expansion of multinational companies' overseas production, and growing reliance on specialized and geographically dispersed supplier networks.

China became the largest single high-technology exporter in 2006 and, together with the Asia-8, has since accounted for about half of total world exports in high-technology goods. After relatively prolonged slowdowns following the 2001 global recession, China and Asia-8 high-technology exports accelerated until sharp declines in 2009, which were followed immediately by expansion beyond the 2008 levels. The general patterns were similar for the United States and the EU, but with a less complete recovery for the EU. Japan's high-technology exports have been flat, not accounting for inflation, for a decade or more (figure O-33).

These changes have affected the relative positions of the developed and developing countries. China's share of world high-technology exports increased from 7% in 1998 to 22% in 2010, while the Asia-8 share dropped to 26% in 2009 before easing upward again. Shares of the United States, EU, Japan, and the rest of the world—mostly developing countries—were flat or declined (figure O-34).

An Asian high-technology supplier zone has developed that is largely arrayed around China. The shift in output of high-technology goods toward developing Asian economies has been accompanied by the growth of intraregional supplier relationships that provide intermediate goods, many for further assembly and eventual export. The share of Asia-8 high-technology exports going directly to the United States

Figure O-32
Exports of commercial knowledge-intensive services, by selected region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTES: EU excludes internal trade. China includes Hong Kong.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of World Trade Organization, International Trade and Tariff database.

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and the EU declined from more than 50% to under 30%, while exports to China rose from 10% to 37% of their total (figure O-35).

China's high-technology exports withstood the global recession very well. Slowing sharply from double-digit to high single-digit growth in 2007–08, they declined by 9% in 2009 but rose by 22% in 2010. After 2009, China's high-technology exports to the United States jumped from $107 billion to $137 billion. Similarly large increases were evident for other export destinations (figure O-36).

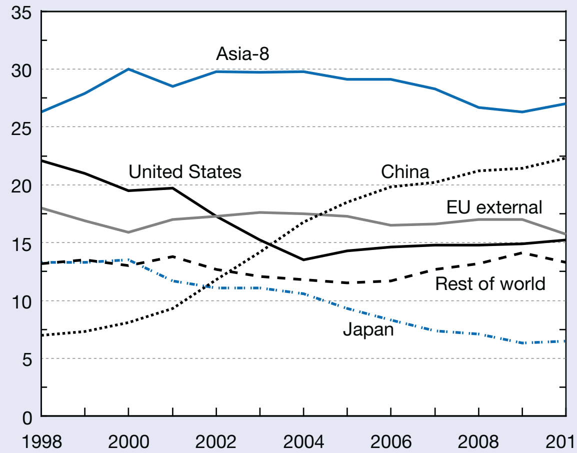
Deficit in Goods Trade, Surplus in Services and Intangibles

In high-technology goods trade, U.S. surpluses through the mid-1990s turned into substantial deficits after 1997 which reached almost $100 billion in 2010 (figure O-37). Major deficit drivers were communications and computer goods, whose production shift to Asia coincided with growing U.S. demand. Pharmaceuticals contributed to the deficit, while aerospace and scientific instruments counteracted it.

The EU's overall high-technology trade deficit was relatively stable, though lower than that of the United States. Its communications and computers deficit, however, was almost identical to that of the U.S., reflecting the same dynamic of rising domestic demand and relocated production.

Figure O-34
Share of global high-technology exports, by selected region/country: 1998–2010

Percent



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU external = European Union trade excluding intra-EU exports

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

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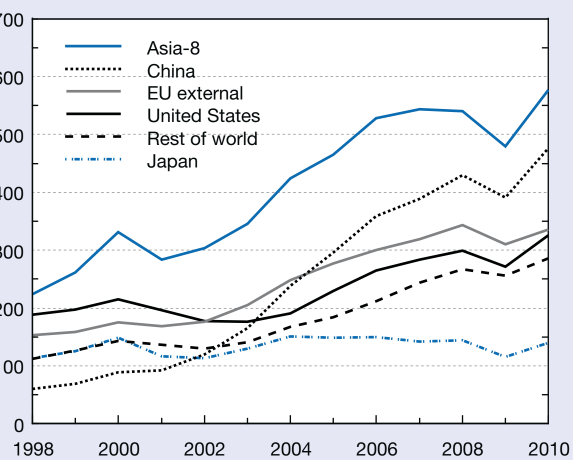
Figure O-33
High-technology exports, by selected region/country: 1998–2010

Dollars (billions)



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU external = European Union trade excluding intra-EU exports

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

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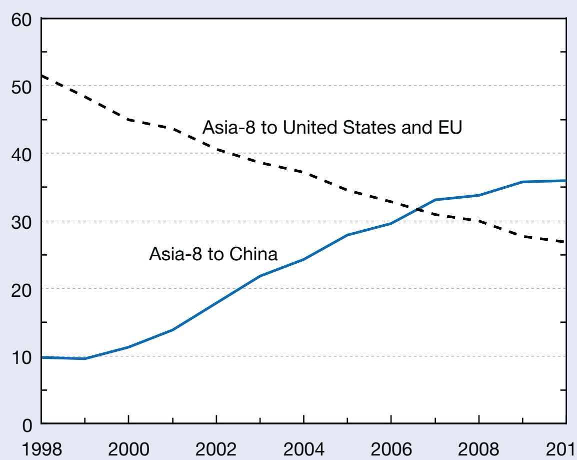
Figure O-35
Asia-8 global high-technology exports to United States/EU and China: 1998–2010

Percent



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

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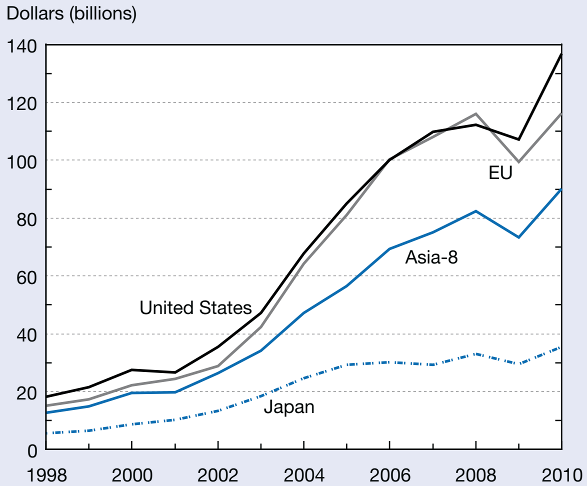
Figure O-36
China's high-technology exports to selected regions/countries: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

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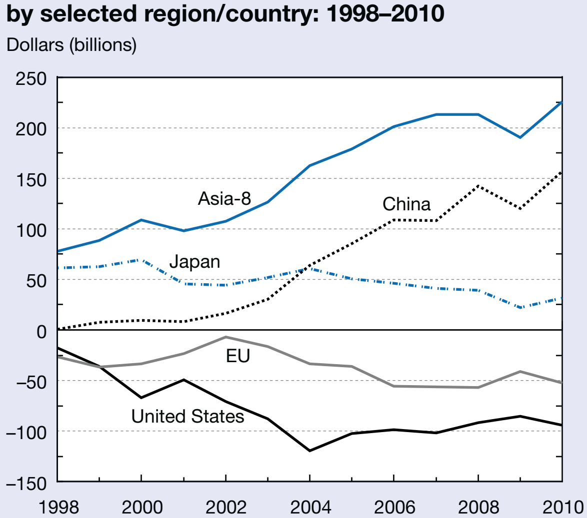
Figure O-37
Trade balance of high-technology goods, by selected region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

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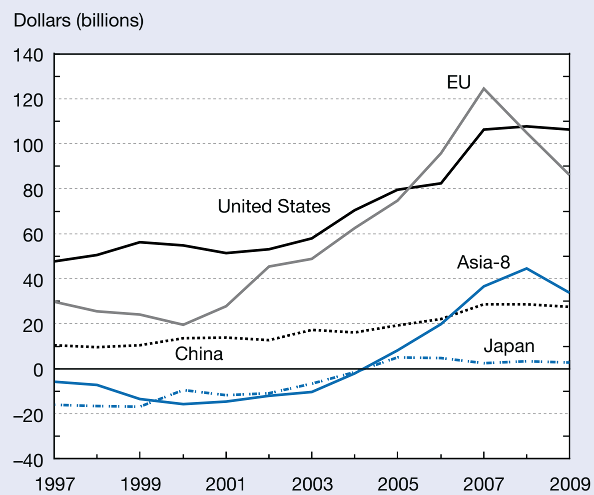
China and the Asia-8 had substantial 2010 high-technology trade surpluses of $157 billion and $226 billion, respectively, indicating that recession-induced reductions in their previous surpluses were likely to prove only temporary.

U.S. trade in commercial knowledge-intensive services and intangible assets—business, financial, and communications services, and payments of royalties and fees—has produced a consistent and growing surplus (figure O-38). It reached a record $108 billion in 2008, sufficient to counterbalance the high-technology goods deficit, and has been flat since then, reflecting the recession's effect. The EU's surplus was sharply off, and that of the Asia-8 fell as well—reflections of the continuing effects of the global recession.

Conclusion

Science and technology are becoming ubiquitous features of many developing countries, as they integrate into the global economy. As a group, developing countries appear to either have been less severely affected by the worldwide financial crisis and recession than the United States, EU, and Japan, or to have recovered more rapidly. Governments in these countries have held firm in building S&T into their development policies, as they vie to make their economies more knowledge- and technology-intensive to ensure their competitiveness. These policies include long-term investments in higher education to develop human talent, infrastructure development, support for research and development,

Figure O-38
Trade balance in knowledge-intensive services and intangible assets, by selected region/country: 1997–2009



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of World Trade Organization, International Trade and Tariff database.

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attraction of foreign direct investment and technologically advanced multinational companies, and the eventual development of indigenous high-technology capabilities.

The resulting developments open the way for widespread international collaboration in science and engineering research.[19] The broad trend in this direction is reflected in increasing numbers of research articles in the world's leading journals with authors in multiple countries. These researchers are increasingly able to draw on high-quality work done outside the traditional S&T locales, and international connections are deepened by globally mobile experts.

Competitive elements, such as the quest for international talent, enter as well. Once largely limited to major Western nations, the quest for international talent is now pursued by many and "brain drain" has evolved into cross-national flows of highly trained specialists. Governments are eager to develop more modern economies that will increase the wealth of their populations. They seek to establish specialty niches and indigenous world-class capacity and to become competitive in international investment, development, and trade.

The globalization of the world economy has brought unprecedented levels of growth to many countries, demonstrating that benefits can accrue to all. These trends continue, but the structural changes that are part and parcel of rapid growth bring with them painful dislocations that are amplified by the continuing changes forced by the recent recession.

Notes

1. Unless otherwise noted, EU refers to the 27 member countries of the European Union.

2. World Bank estimates of global gross national income.

3. These estimates rely on data from the Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization Institute for Statistics. They are not precise measures. Reported data are converted to dollar totals using purchasing power parities, the local costs of a standard market basket of goods and services. The accuracy of this standard economic conversion may degrade in the case of developing economies. In addition, estimation of some missing data and variable reporting mean that there is uncertainty about any specific point estimate. The reader's focus is directed to the overall trend, which reflects an internally consistent estimate over time.

4. The latest updated 2009 U.S. R&D estimate is $400.5 billion. The overview uses the most recent OECD numbers to allow comparison with other countries' values.

5. European Commission, Barcelona European Council, *Presidency Conclusions* (Barcelona, Spain, March 2002).

6. See Joan Burrelli and Alan Rapoport, *Reasons for International Changes in the Ratio of Natural Science and Engineering Degrees to the College-Age Population,* SRS 09-308 (Arlington, VA: National Science Foundation, January 2009).

7. No data are available for India, making this share estimate an upper bound.

8. Both figures exclude those with unknown citizenship (1,600 in 2007) and those with degrees in medical/other life sciences. Engineering figures exclude about 630 with unknown citizenship. The U.S. figures include individuals with permanent visas.

9. Michael G. Finn, Stay Rates of Foreign Doctorate Recipients From U.S. Universities, 2007 (Oak Ridge, TN: Oak Ridge Institute for Science and Education, January 2010).

10. Both estimates are based on data from a limited number of countries reporting their data, on a full-time equivalent basis, to OECD.

11. Preliminary 2009 data from Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad (2009 and previous years); National Science Foundation tabulation.

12. The database used is the expanding set of journals included in the Thomson Scientific, Science and Social Sciences Citation Indexes; IpIQ, Inc.; and National Science Foundation tabulations.

13. Author location is determined by location of institutional affiliation. For example, an American scientist listed at a Japanese university is considered located in Japan; a Japanese scientist listed at a U.S. university is considered located in the United States.

14. The physical sciences are physics; chemistry; earth, atmospheric, and ocean sciences; and astronomy.

15. Expectation is based on a location's total international collaborations. The index numerator is the percentage of country A's international collaborations with country B; the denominator is country B's percentage of the world's international collaborations. See appendix table 5-41.

16. Citation indicators are subject to a number of distortions: self-citation, citation of failed theories, hypotheses, and approaches; citation of domestic versus foreign articles; language and cultural barriers; etc. However, when aggregated over many articles, citation indicators carry information about the relative use of an accumulated knowledge base in subsequent work.

17. In these data, USPTO patents are assigned to the location of the first-named inventor.

18. These industry groups are defined by OECD and form the basis for databases of economic activity that cover a large number of the world's economies. Knowledge-intensive services industries include the commercially tradable business, financial, and communications services; and education and health services, which are considered more nearly location-bound and closer to government functions. High-technology manufacturing industries include aircraft and spacecraft; pharmaceuticals; office, accounting, and computing machinery; radio, television, and communication equipment; and medical, precision, and optical instruments.

19. See National Science Board, *International Science and Engineering Partnerships: A Priority for U.S. Foreign Policy and Our Nation's Innovation Enterprise,* NSB-08-4 (Arlington, VA: National Science Foundation, 2008).

Glossary

Asia-8: Includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

Asia-10: Includes China, Japan, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

European Union: The 27 member states of the European Union since 2007 include Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

High-technology manufacturing: Includes air- and spacecraft; pharmaceuticals; office, accounting, and computing machinery; radio, television, and communication equipment; and medical, precision, and optical instruments.

Knowledge-intensive services: Includes commercial business, financial, and communication services and largely publicly supported education and health services. Commercial knowledge-intensive services exclude education and health.