Chapter 6
Industry, Technology, and the Global Marketplace

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Highlights

Key Economic Indicators of National Competitiveness

Key economic indicators show that the U.S. economy continues to be a leading competitor among other advanced economies.

- ♦ Key economic indicators of national competitiveness, gross domestic product (GDP) growth, rising per capita income, and productivity growth, suggest that the United States continues to be very economically competitive. The United States has generally outperformed the European Union (EU) and Japan on these measures during the past two decades.
- ♦ China and India show higher productivity growth and per capita income growth than exhibited by the United States and other advanced economies. Despite these rapid gains, the absolute levels of productivity and per capita income remain far lower for China and India.

U.S. Technology in the Global Marketplace

The United States has a leading position in the market-oriented knowledge-intensive service industries that are key contributors to economic growth around the world.

- ♦ Market-oriented knowledge-intensive services—business, financial, and communications—are driving growth in the service sector, which now accounts for nearly 70% of global economic activity. Market-oriented knowledge-intensive services generated $12 trillion in gross revenues (sales) in 2005 and grew almost twice as fast as other services between 1986 and 2005.
- ♦ The United States is the leading provider of market-oriented knowledge-intensive services, responsible for about 40% of world revenues on a value-added basis (gross revenue sales minus the purchase of domestic and imported supplies and inputs from other industries) over the past decade. The U.S. world share of value added exceeds world share of both the EU and Asia in all three industries.
- ♦ Asia, ranked third compared with the United States and the EU, has shown a steady rise in its world value-added share over the past two decades. China and India are leading Asia's increase, primarily in communications.

High-technology manufacturing industries are key contributors to global manufacturing sector growth.

- ♦ Over the past 20 years, the rate of growth in world gross revenue in high-technology manufacturing industries was double that of other manufacturing industries. Asia has the largest high-technology manufacturing industry sector, followed by the United States and the EU, which ranks a distant third.
- ♦ The United States has the single largest value-added world share (35% in 2005) of any country in high-technology manufacturing industries. It is ranked first in three of the five high-technology industries (scientific instruments, aerospace, and pharmaceuticals) and is ranked second in the other two (communications equipment and office machinery and computers).
- ♦ China has made remarkable progress: its world share of high-technology manufacturing value added has more than quadrupled during the past decade. Estimates for 2005 show China accounting for 16% of world value added, making it the third-ranked country globally, just shy of Japan, whose world share in these industries fell sharply from 30% in 1989 to an estimated 16% in 2005.
- ♦ U.S. manufacturing has become more technology intensive, with the high-technology share of manufacturing industries increasing from 14% in 1990 to 24% in 2005. The high-technology share of China and India's manufacturing industries has also increased, suggesting that manufacturing output in lower-wage countries is also shifting toward technology-intensive goods.

U.S. Trade Balance in High-Technology Manufacturing and Technology Products

The U.S. trade balance in high-technology manufacturing industries and advanced products has declined.

- ♦ The U.S. world market share of exports by high-technology industries dropped from about 20% in the early 1990s to 12% in 2005, primarily because of losses in export share by U.S. industries producing communications equipment and office machinery and computers.
- ♦ The trend for China has been quite different. China's share has grown rapidly; its world market share of high-technology industry exports has more than doubled, from 8% in 1999 to an estimated 19% in 2005. Exports by China's high-technology industries surpassed those of Japan in 2001, the EU (excluding intra-EU exports) in 2002, and the United States in 2003. China has become the world's largest exporter.
- ♦ The reduction of U.S. industry's world export share has coincided with the decline in the U.S. trade balance in high-technology manufacturing industries that began in the late 1990s.
- ♦ The historically strong U.S. trade balance in advanced technology products exhibited a similar reduction, shifting from surplus to deficit starting in 2002. The overall U.S. trade deficit is largely driven by U.S. trade with Asian countries, especially China and Malaysia.

U.S. Royalties and Fees Generated From Intellectual Property

The United States continues to be a net exporter of intellectual property, primarily in manufacturing technology know-how and licensing of computer software.

- U.S. companies received $33 billion in net revenues generated by intellectual property from affiliated and unaffiliated foreign companies in 2005.
- The United States ran surpluses in manufacturing know-how and licensing of computer software with unaffiliated companies, largely driven by trade with Asia, the largest purchaser of U.S. intellectual property in these areas.

New High-Technology Exporters

Indicators that may be relevant to long-term high-technology export potential show that China is the highest ranked among the six large developing economies examined.

- China is the highest ranked high-technology exporter of the six large developing economies (the other economies are India, Russia, Mexico, Brazil, and Indonesia) according to its composite score in 2007. China was ranked fourth a decade ago, then moved to second in 1999 and first in 2002, overtaking India, the previous leader.
- Russia is ranked third of the larger developing economies in 2007, although this ranking has fluctuated over the last decade. Mexico, ranked fourth, improved its position compared with past cycles. Brazil, ranked fifth, continued a decade-long decline in its ranking.

S&E Publications in Peer-Reviewed Journals

U.S. S&E publications in peer-reviewed journals with at least one author from private industry declined in both absolute and relative terms between 1988 and 2005 (a period during which intensified, global competition emerged), and the share of such publications appearing in basic research journals has also declined during this period.

- Industry's share of overall U.S. S&E article output declined from just below 9% to about 6% between 1988 and 2005.
- After peaking at 26% in 1995, the percentage of S&E articles with an industrial author published in basic research journals declined to 22% by 2005.

Global Trends in Patenting

The United States continues to be the leading source of newly patented inventions compared with the EU and Asia. Asia's patenting activity is growing rapidly, however, especially in Japan, South Korea, and Taiwan.

- Inventors residing in the United States accounted for 53% of U.S. patent applications in 2005. Asia, the second-ranked source of U.S. patent applications, more than doubled its share from 13% two decades ago to 29% in 2005, led by growth from Japan, South Korea, and Taiwan. U.S. patent applications from China and India are also growing, although from a low level.
- U.S. inventors are also the leading source of economically valuable patents known as triadic patents. (Triadic patents include only those inventions for which patent protection is sought in all three major world markets: the United States, Europe, and Japan.)
- In 2005, the U.S. share of triadic patents was estimated at 37%, followed by the EU (30%) and Asia (28%). Asia's share of these more important, economically valuable patents has been flat, unlike its rising share of U.S. patent applications.
- U.S. inventors are the leading source of U.S. patents granted in two key technology areas: (1) information and communications technology (ICT) and (2) biotechnology. Asia is ranked second as a source of U.S. patent grants in ICT and third in biotechnology, and the EU is ranked third as a source in ICT and second in biotechnology.

U.S. High-Technology Small Businesses

High-technology small businesses are a key sector for developing, adopting, and diffusing new technologies in the U.S. economy. Two types of financing, angel and venture capital, are critical for the formation and growth of high-technology small businesses.

- High-technology small businesses employed 5 million workers in 2004, one-third of the total high-technology labor force. Service industries account for two-thirds of these workers, and manufacturing employs most of the remainder (31%).
- Angel investment plays an important role in the formation of high-technology companies. Angel investors financed 51,000 firms with $26 billion in 2006, an 11% increase compared with 2005. The top three technology areas receiving angel investment in 2006 were healthcare and medical devices, biotechnology, and computer software.
- Venture capital plays a key role in financing young high-technology firms that are expanding. Venture capitalists financed nearly 3,000 firms with $26 billion in 2006, 14% higher than 2005. Technology areas that received the largest share of venture capital investment were computer software (20%), biotechnology (18%), and communications (16%).

Introduction

Chapter Overview

This chapter focuses on industry's vital role in the nation's science and technology (S&T) enterprise and how the national S&T enterprise develops, uses, and commercializes S&T investments by industry, academia, and government.[1] Various indicators that track U.S. industry's national activity and standing in the international marketplace for technology products and services and technology development are discussed. Using public and private data sources, U.S. industry's technology activities are compared with those of other major regional economies, particularly the European Union (EU) and Asia.[2]

Past assessments showed the United States to be a leader in many technology areas. *Science and Engineering Indicators 2006* showed that advancements in information technologies (computers and communications products and services) drove the rising trends in new technology development and dominated technical exchanges between the United States and its trading partners. The chapter will examine whether the United States continues to be a leader in technology products and services and assess the competitiveness of the United States in the global economy.

Chapter Organization

This chapter leads off with a new section about how several key economic indicators that provide some perspective on trends in U.S. competitiveness compare with those of Europe, Japan, and the emerging economies of China and India. The chapter then examines the U.S. position in the global marketplace within the service and manufacturing industries, focusing on industries that have a particularly strong linkage to S&T. Because the service sector has become a key driver of global economic activity, considerable discussion is devoted to the U.S. global position in these industries.

Following this discussion, trends in the U.S. global position in production and trade of high-, medium-, and low-technology industries are examined and compared with trends in the EU and Asia. The U.S. trade position in advanced technology goods and intellectual property is also discussed. The chapter next presents indicators that may be useful for assessing the potential for countries to become more important exporters of high-technology products. For the first time, the chapter looks at trends in publishing output, as measured by articles by U.S. industry authors in peer-reviewed journals, to examine changes in one measure of the role of industry in the performance of research. This discussion is followed by analysis of U.S. inventiveness trends using data on U.S., European, and triadic patents. Trends in patenting by U.S. inventors are compared with those by European and Asian inventors, focusing on trends of two technologies: biotechnology and information and communications technology (ICT). Finally, the chapter looks at trends in high-technology-oriented U.S. small businesses that can have a particularly strong relationship to entrepreneurship in S&T. Data are presented on small businesses by technology area, employment, formation, and sources of financing.

Key Economic Indicators of U.S. Competitiveness

S&E and the technological innovations that emerge from R&D activities enable high-wage nations such as the United States to compete in today's highly competitive global marketplace. Many of the innovative new products found around the world, many of the inventions and manufacturing process innovations that improve worker productivity, and many of the transformative innovations that create not just new companies but new industries can be traced back to earlier national investments in S&E and R&D. Business application and marketing of these innovations make large contributions to national economic growth and support U.S. economic competitiveness in the marketplace at home and abroad (Okubo et al. 2006).[3]

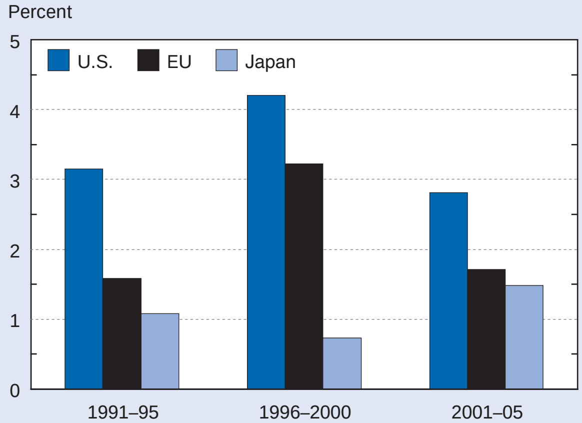
An international standard used to judge a nation's competitiveness rests on the ability of its industries to produce goods that sell in the marketplace while simultaneously maintaining, if not improving, the standard of living for its citizens (OECD 1996). Three macroeconomic indicators that help to measure this standard of national competitiveness are economic growth, standard of living, and productivity. Trends in these indicators for the United States are presented alongside those for the EU and Japan, which also rely on R&D and other S&E investments to support national competitiveness.

Trends in National Economic Growth, Standard of Living, and Labor Productivity

National Economic Growth

The U.S. economy, the largest of any nation, continues to be one of the fastest growing compared with other large, advanced economies (figure 6-1; appendix table 6-1). With the expansion of country membership, the EU has become an economic area slightly larger than the United States, $13.0 trillion versus $12.4 trillion on a purchasing power parity basis in 2005. (Purchasing power parity (PPP) is the exchange rate required to purchase an equivalent market basket of goods.) Both economies measured more than three times larger than that of Japan. Breaking down the past 15 years into three 5-year periods, the U.S. economy grew faster than either the EU or Japan during each of the three periods. U.S. gross domestic product (GDP) grew at an average annual rate of 3.2% from 1991 to 1995, by 4.2% from 1996 to 2000, and by 2.8% from 2001 to 2005 (figure 6-1). During 2005, the most recent year for which these internationally comparable data are available, U.S. GDP grew by 3.2%.

Figure 6-1
Average annual GDP growth for United States, EU, and Japan: 1991–2005



EU = European Union; GDP = gross domestic product

NOTES: GDP converted to U.S. dollars using 2002 purchasing power parities at 2005 price level. EU excludes Bulgaria and Romania.

SOURCE: Conference Board and Groningen Growth and Development Centre, Total Economy Database (January 2007), http://www.ggdc.net/dseries/totecon.shtml. See appendix table 6-1.

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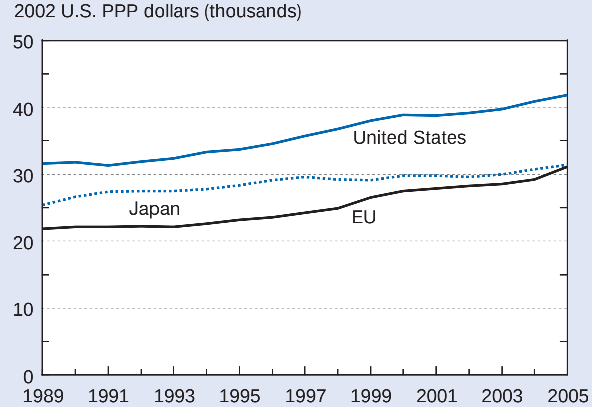
Figure 6-2
GDP per capita for United States, EU, and Japan: 1989–2005



EU = European Union; GDP = gross domestic product; PPP = purchasing power parity

NOTES: GDP converted to U.S. dollars using 2002 PPPs at 2005 price level. GDP per capita calculated using midyear population estimates. EU excludes Bulgaria and Romania.

SOURCE: Conference Board and Groningen Growth and Development Centre, Total Economy Database (January 2007), http://www.ggdc.net/dseries/totecon.shtml. See appendix table 6-1.

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Standard of Living

Faster growth of the U.S. economy, however, is due partially to more rapid population growth in the United States compared with the other two economies. Normalizing the value of all national economic activity (GDP) for population size provides a widely recognized measure of the national standard of living. During the same 15-year period discussed previously (1991–2005), U.S. GDP per capita increased each year except 2001, rising from $31,312 (inflation adjusted to PPP 2005 dollars) in 1991 to $41,824 in 2005 (figure 6-2; appendix table 6-1). GDP per capita in the EU was generally 25%–30% lower (in inflation adjusted to PPP dollars) than U.S. GDP per capita but followed a similar upward trend; 1993 was the EU's single year of declining GDP per capita. By comparison, during the same time period, Japan's standard of living grew much more slowly, experiencing several years of decline.[4]

Productivity of the United States and Other Advanced Economies

The high and rising standard of living enjoyed by the three advanced economies, the United States, the EU, and Japan, is influenced by the efficiency with which their resources (labor and capital) are employed, measured by labor or multifactor productivity. Labor and multifactor productivity are the change in GDP per unit of labor and combined unit of labor and capital, respectively.

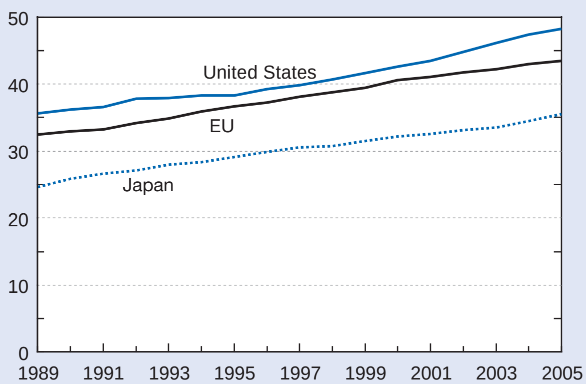
Process innovations and the application of new capital equipment in the manufacturing process help to raise labor's productivity, allowing high-wage nations such as the United States to compete successfully in the global marketplace.

Labor productivity of the United States has exceeded that of the EU and Japan for at least several decades (figure 6-3; appendix table 6-2). Growth in U.S. productivity lagged behind that of the EU and Japan in the early 1990s, but rebounded in the latter half of the 1990s. U.S. productivity growth during this period has been attributed to the widespread diffusion of information technology (IT) throughout the economy.[5] The EU's and Japan's growth rates in productivity fell during the 1995–2000 period, and the EU's rate continued to decline from 2000 to 2005. As a result, the gaps between the levels of labor productivity of the United States, the EU, and Japan have widened over the past decade.

International Comparisons of Labor Compensation

Productivity growth can directly affect the level and growth of wages in a country. Existing data allow only limited international comparison. An international indicator of relative wages across economies is compensation costs (direct wages and benefits) for production workers in manufacturing, which measure whether gains in productivity and per capita GDP have been accompanied by an increase in labor compensation. These compensation data do not fully take into account cost-of-living differences across countries, however.

Figure 6-3
GDP per hour worked for United States, EU, and Japan: 1989–2005



EU = European Union; GDP = gross domestic product; PPP = purchasing power parity

NOTES: GDP converted to U.S. dollars using 2002 PPPs at 2005 price level. EU excludes Bulgaria and Romania.

SOURCE: Conference Board and Groningen Growth and Development Centre, Total Economy Database (January 2007), http://www.ggdc.net/dseries/totecon.shtml. See appendix table 6-2.

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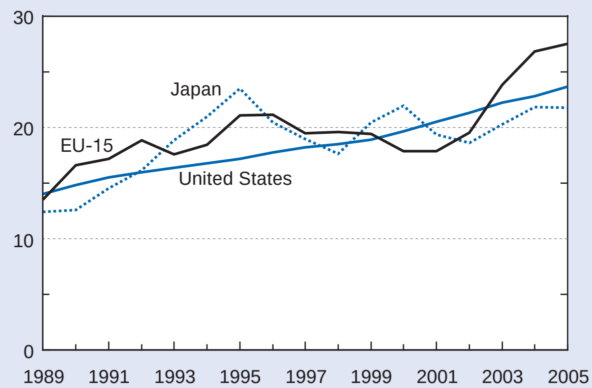
U.S. workers have enjoyed steady gains in compensation during the past decade and a half, coinciding with gains in U.S. productivity (figure 6-4; appendix table 6-3). The trend in compensation in the EU and Japan has been more volatile (in part reflecting fluctuations in exchange rates), but their levels are comparable to that of the United States. EU production workers generally fared better during this period than production workers in the United States and Japan, although this measurement does not adjust for differences in PPP within the three economies.

Data on wages and benefits for U.S. workers employed in broad sectors of the economy show that productivity growth has been accompanied by an increase in real wages and benefits paid to U.S. workers in private industry (table 6-1). Between 1989 and 2005, compensation for U.S. workers in the goods sector (manufacturing, construction, mining, and utilities) and the services sector (financial, retail, communications, and business) grew at 0.7% on an average annual basis adjusted for inflation. Compensation grew faster for white collar workers compared with blue collar workers in both sectors (table 6-1).

Judging from the measures discussed above, the United States continues to be highly competitive in the global marketplace. The U.S. economy continues to expand, finding demand for its products and services while maintaining relatively high compensation for U.S. workers and rising GDP per capita for its citizens.

Figure 6-4
Hourly compensation costs for manufacturing production workers for United States, EU-15, and Japan: 1989–2005



EU = European Union

NOTES: EU-15 includes member countries before enlargement in September 2004. Hourly compensation costs include direct wages and benefits. Wages in current dollars converted at market exchange rates of EU-15 and Japan.

SOURCES: Bureau of Labor Statistics, International Comparisons of Hourly Compensation Costs for Production Workers in Manufacturing (November 2006), http://www.bls.gov/news.release/ichcc.toc.htm, accessed 15 January 2007. See appendix table 6-3.

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Table 6-1
Average annual growth of real wages and benefits paid to U.S. workers and labor productivity, by selected economic sectors: 1989–2005
(Percent)

Sector	Annual growth/ productivity
Private industry	0.7
Goods sector	0.7
White collar	0.9
Blue collar	0.6
Services	0.7
White collar	0.8
Blue collar	0.5
Labor productivity (economywide)	1.8

NOTES: Productivity growth measured on basis of gross domestic product (GDP) per employee. GDP is 2005 U.S. dollars converted at 2000 purchasing power parities. Goods sector includes manufacturing, construction, mining, and utilities. Service sector includes financial, retail, communications, and business.

SOURCES: Conference Board and Groningen Growth and Development Centre, Total Economy Database (15 September 2006), http://www.ggdc.net/; and U.S. Bureau of Labor Statistics, Employment Cost Index, Historical Listing, Constant-dollar, 1975-2005, http://www.bls.gov/web/ecconst.pdf, accessed 25 June 2007.

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Rising Competitiveness of China and India

Economic growth in China and India has been rapid in recent years, and these two countries have increased their global market share, trade, and investment in many industries. Productivity and per capita income growth of these two countries, particularly China, appear to have been much more rapid in recent years than that of the United States and other advanced economies (table 6-2). Despite these apparently rapid gains, their absolute level of productivity and per capita income remain far lower than that of industrialized countries (see sidebar, "Measuring National Competitiveness of China and India").

U.S. Technology in the Global Marketplace

National investments in S&E, technological innovations developed from related activities, and R&D performed in all sectors of the economy, almost certainly play an important role in supporting U.S. competitiveness. This section of the chapter takes a closer look at both the industries that perform the bulk of R&D in the United States and recent trends of high-technology and lower-technology industry activity in the global marketplace.

Policies in many countries reflect a belief that a symbiotic relationship exists between investment in S&T and success in the marketplace: S&T supports industry's competitiveness in international trade, and commercial success in the global marketplace provides the resources needed to support new S&T. Consequently, a nation's economic health is a performance measure for the national investment in R&D and S&T.

At least to some degree, S&T is important for growth and competitiveness of all industries. However, the Organisation for Economic Co-operation and Development (OECD) has identified 10 industries in services and manufacturing that have a particularly strong linkage to S&T:

- **Knowledge-intensive service industries.** Communications services, financial services, business services (including computer software development), education services, and health services (OECD 2001).[6] These five service industries incorporate sciences, engineering, and technology in either their services or the delivery of their services. Knowledge-intensive service industries are further divided into industries that are either largely market driven and known as market oriented (communications, financial, and business services) or are largely provided by the public sector (education and health services) (see sidebar, "U.S. Global Market Position in Education and Health Services").
- **High-technology manufacturing industries.** Aerospace, pharmaceuticals, computers and office machinery, communications equipment, and scientific (medical, precision, and optical) instruments.[7] These five science-based industries manufacture products while spending a relatively high proportion of their revenues on R&D.

This section presents revenue and trade data for the market-oriented knowledge-intensive services and high-technology manufacturing industries in 70 countries[8] (see sidebar, "Comparison of Data Classification Systems Used"). S&T is not exclusive to knowledge-intensive services and high-technology manufacturing; therefore this section will also examine the U.S. market position in other services and industries.

A critical issue is how to credit companies' output to industries and countries, given that production has become more global and dispersed across companies and industries. Companies increasingly use subsidiaries or contract other companies in a variety of industries located within and across national borders to help create their output.

Two measures are used in this chapter: *gross revenue* and *value-added revenue*, referred to as *value added*. Gross revenue is the value of the industry's shipments or services, equivalent to the industry's sales, including domestic and imported supplies and inputs from other industries. Gross revenue is an

Table 6-2
Selected economic and productivity indicators for United States, China, and India: 1995–2004

	Productivity growth (% average annual change)			GDP (US$)		
Country	1995–2004	1995–2000	2000–04	Per employee 2004	Per capita 2004	2004
United States	2.0	2.3	1.7	100	100	100
China	5.5	3.1	8.6	13	16	71
India	4.2	4.0	4.4	10	8	28

GDP = gross domestic product

NOTES: Productivity growth measured on basis of GDP per employee. GDP is U.S. dollars converted at 1990 purchasing power parities. China does not include Hong Kong.

SOURCE: Conference Board and Groningen Growth and Development Centre, Total Economy Database (September 2006), http://www.ggdc.net/dseries/totecon.shtml.

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Measuring National Competitiveness of China and India

The rapid economic advancement of China and India has sparked considerable interest and uncertainty about the measurement of their economies and productivity advancements. In the case of China, some scholars contend that official estimates of China's GDP, GDP per capita, and productivity growth have been overstated because of the difficulty and inaccuracy of estimating economic output within China's industry and service sectors.

Official estimates by the Chinese government and most international organizations suggest that labor productivity growth rates, as measured by real GDP per person employed, increased by an average of 7.3% between 1995 and 2004. Although a more conservative estimate by the Groningen Growth and Development Centre (GGDC) and The Conference Board (TCB) indicates an average productivity growth rate of 5.6% during the same period, this estimate also finds faster growth from 2000 to 2004 (8.6%) than official sources (7.6%) (table 6-2).

GGDC and TCB estimate that India's productivity growth averaged 4.4% during this period, as measured by GDP per employee (table 6-2). This is slower than China's growth, but significantly faster than the United States or other industrialized economies.

Despite uncertainties over the size of China's economy and its level of productivity, GGDC and TCB estimate that China's GDP and productivity are between 4 to 5 times higher on a purchasing power parity (PPP) basis than would be determined using China's official exchange rate. A PPP adjustment implies that China and India's GDP levels are about 71% and 28%, respectively, of the U.S. GDP level (table 6-2). China's and India's levels of productivity, however, remain far below that of the United States, estimated to be 13% and 10%, respectively, of U.S. 2004 levels.

U.S. Global Market Position in Education and Health Services

Many nations' governments serve as the primary provider of education and health services. The size and distribution of each country's population profoundly affect delivery of these services. For these reasons, global comparisons based on market-generated revenues are less meaningful for education and health services than for other service industries.

Education services include governmental and private educational institutions of all types that offer primary, secondary, and university education, as well as technical, vocational, and commercial schools. In 2005, fees (tuition) and income from education- and service-related operations amounted to $1.3 trillion in world value-added revenue (table 6-3; appendix tables 6-4 and 6-5). The U.S. education sector generated the most value added by far (41% in 2005), with the EU second (29%) and Asia third (14%). Asia's world share of education services revenues increased by 3 percentage points during the past decade, led by China and India. China's world share doubled from 3% to 6%, and India's share increased from 0.8% to 1.2%, coinciding with the rapid expansion in these countries of university-level enrollment and graduation of students in S&E and other fields. (See Chapter 2, section "Global Higher Education in S&E" for discussion about trends in S&E higher education in Asia and other countries.)

The United States, with arguably the least government involvement, has the largest health-service industry in the world, followed by the EU and Asia (table 6-3). In 2005, the U.S. health-service industry accounted for 38% of the $1.7 trillion in world revenue (value added) of the health-care sector, whereas the EU share was 29% and Asia's share was 19%.

Table 6-3
Value-added revenue and world share for selected service industries, by selected regions/countries: 1996, 2001, and 2005
(Percent)

Industry and region/country	1996	2001	2005
Education			
All regions/countries (2000 constant $trillion)	1.07	1.18	1.28
United States	40.0	39.8	40.6
EU	32.7	31.5	29.0
Asia	11.3	12.6	14.4
Health			
All regions/countries (2000 constant $trillion)	1.29	1.55	1.71
United States	40.5	36.5	38.4
EU	32.9	30.5	28.9
Asia	12.8	20.3	19.4

EU = European Union

NOTES: Value-added revenue excludes purchases of domestic and imported materials and supplies. EU excludes Cyprus, Estonia, Latvia, Lithuania, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007).

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Comparison of Data Classification Systems Used

This chapter incorporates several thematically related but very different classification systems. These measure activity in high-technology manufacturing and knowledge-intensive service industries, measure U.S. trade in advanced technology products, and track both the patenting of new inventions and trends in venture capital investments. Each classification system is described in the introduction to the section that presents those data. This sidebar shows the classification systems used in the chapter in tabular format for easy comparison.

System	Type of data	Basis	Coverage	Data source	Data preparation
High-technology manufacturing industries	Industry shipments (sales), value-added exports, and imports in constant (2000) dollars	Industry by International Standard Industrial Classification	Aerospace, pharmaceuticals, office and computing equipment, communications equipment, scientific instruments	United Nations Commodity Trade Statistics and Global Insight, Inc.	Global Insight, Inc., proprietary special tabulations
Knowledge-intensive service industries	Industry production (revenues from services) in constant (2000) dollars	Industry by International Standard Industrial Classification	Business, financial, communication, health, education services	United Nations Commodity Trade Statistics and Global Insight, Inc.	Global Insight, Inc., proprietary special tabulations
Trade in advanced technology products	U.S. product exports and imports, in current dollars	Product by technology area, harmonized code	Biotechnology, life sciences, optoelectronics, information and communications, electronics, flexible manufacturing, advanced materials, aerospace, weapons, nuclear technology, software	U.S. Census Bureau, Foreign Trade Division	U.S. Census Bureau, Foreign Trade Division, special tabulations
Patents	Number of patents for inventions, triadic patents (invention with patent granted or applied for in U.S., European, and Japan patent offices)	Technology class, country of origin	More than 400 U.S. patent classes, inventions classified according to technology disclosed in application	U.S. Patent and Trademark Office, European Patent Office, and Organisation for Economic Co-operation and Development (OECD)	U.S. Patent and Trademark Office and OECD
Angel capital	Funds invested by U.S. angel investors	Technology	Biotechnology, electronics, financial services, healthcare, industrial/energy, information technology, media, telecommunications	Center for Venture Research, University of New Hampshire	Center for Venture Research, University of New Hampshire
Venture Capital	Funds invested by U.S. venture capital funds	Technology area defined by data provider	Biotechnology, communications, computer hardware, consumer related, industrial/energy, medical/health, semiconductors, computer software, Internet specific	National Venture Capital Association	Thomson Financial Services, special tabulations

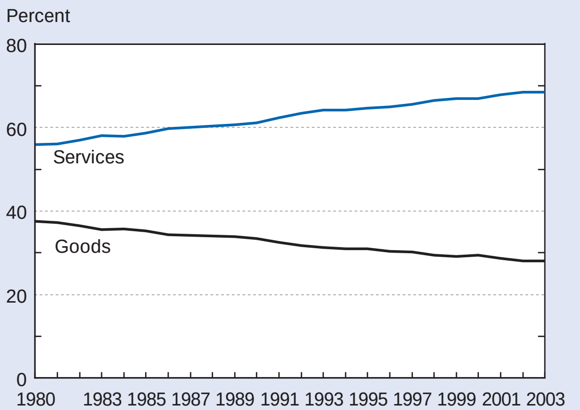
appropriate measure of the industry's impact on the national or global economy, because the industry's use of inputs boosts output in other domestic industries or countries.

Value added is gross revenue sales minus purchases of domestic and imported supplies and inputs from other industries. It is a more suitable indicator of an industry's direct contribution to the national economy because it excludes inputs from other industries and countries. In addition, value added adjusts for differences in the mix of labor, capital, and inputs used by an industry, which can vary across countries. The crediting of value-added output to regions or countries is imperfect, however, because a country receives credit on the basis of where the company reported the activity, which may be different from where the activity occurred.

Trade data are available for high-technology manufacturing industries but not market-oriented service industries. Trade data are on a gross-revenue basis, and country shares of world trade volume encompass inputs purchased from other industries and countries.

Another issue is classifying industries within a manufacturing or service category. In the data used here, companies are assigned to a single manufacturing or service industry on the basis of the largest share of the company's shipment of goods or delivery of services. This method of categorizing company activity is imperfect, because an industry classified as manufacturing may include services, and a company classified as being within a service industry may include manufacturing or directly serve a manufacturing company. Furthermore, the single industry classification is not a good measure for companies that have diversified activities in many categories of industries.

Figure 6-5
Services and goods shares of global economic activity: 1980–2003



NOTES: Services include wholesale and retail trade, hotels and restaurants, transportation, finance, real estate, education, health, and government. Goods include manufacturing, mining, construction, and utilities.

SOURCE: World Bank, World Development Indicators 2006, http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20899413~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html, accessed 25 June 2007.

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Global Trends in Market-Oriented Knowledge-Intensive Service Industries

The service sector has been growing faster than the manufacturing sector for at least two decades and is driving economic activity around the world (figure 6-5). The World Bank estimates that services constituted 68% of global economic activity in 2003 compared with a 56% share in 1980. Market-oriented knowledge-intensive services constitute a large and growing part of the service sector's output.[9] The worldwide gross revenue generated by market-oriented knowledge-intensive services more than doubled from $4.5 trillion in 1986 to $11.5 trillion in 2005, on a constant dollar basis (table 6-4).[10] Market-oriented knowledge-intensive service revenues grew at an average annual inflation-adjusted rate of 4.8% compared with 2.7% by other services during this 20-year period (table 6-4). In 1986, gross revenues of market-oriented knowledge-intensive services comprised 22% of all services; by 2005, their share had increased to 30%.

The United States, the EU, and Asia are the leading providers of market-oriented knowledge-intensive services, comprising nearly 90% of global value-added activity in 2005. The United States has the largest share among the three, responsible for about 40% of world service revenues on a value-added basis, a share that has remained constant for the past decade (figure 6-6; appendix tables 6-4 and 6-5). The EU is the next leading provider of high-technology services. Its share of world revenues, however, slipped from 26% in the mid-1990s to 25% in 2005 because of declines in service industry activity in Germany and Italy.

The third-leading provider of market-oriented knowledge-intensive services, Asia, shows a steady rise in world share over the past two decades (figure 6-6; appendix tables 6-4 and 6-5).[11] Over the past 10 years, Asia's world share rose by 2 percentage points to 22%. China, and to a lesser degree India, have driven the increase in Asia's world share. Between

Table 6-4
Global gross revenue of market-oriented knowledge-intensive and other service industries: Selected years, 1986–2005
(Trillions of 2000 constant dollars)

Industry	1986	1995	2000	2005	Average annual growth (%)
All service industries	20.24	27.52	33.06	38.49	3.3
Market-oriented knowledge-intensive services	4.54	6.86	9.44	11.52	4.8
Service industries not classified as market-oriented knowledge intensive	15.71	20.66	23.62	26.97	2.7
Market-oriented knowledge-intensive share of all services (%)	22.4	24.9	28.6	29.9	na

na = not applicable

NOTES: Knowledge-intensive services classified by Organisation for Economic Co-operation and Development and consist of business, financial, communications, education, and health services. Market-oriented knowledge-intensive services exclude education and health services. Gross revenue includes purchases of domestic and imported materials and inputs.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-4 and 6-5.

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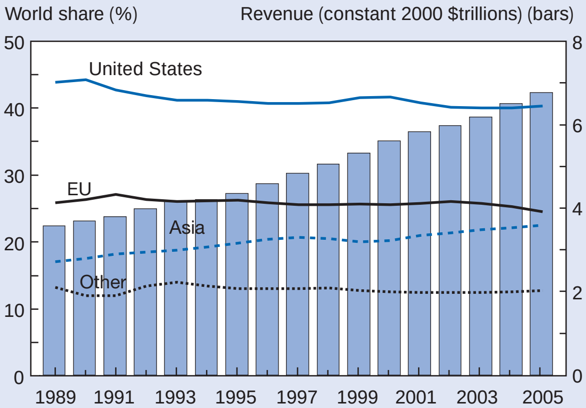
Figure 6-6
Value-added revenue and world share of market-oriented knowledge-intensive service industries, by selected regions/countries: 1989–2005



EU = European Union

NOTES: Knowledge-intensive services classified by Organisation for Economic Co-operation and Development and include business, financial, communications, education, and health services. Market-oriented knowledge-intensive services exclude education and health. Revenue on value-added basis, which excludes purchases of domestic and imported materials and inputs. EU excludes Cyprus, Estonia, Latvia, Lithuania, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-4 and 6-5.

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1996 and 2005, China's growth in revenues was nearly twice the rate of the average for all of Asia, and its share of world revenues increased from 2.3% to 4.9%. India's revenues also grew considerably faster than Asia's average growth rate, although from a low level: India's world share rose from 0.7% to 1.1% during this period. Japan's revenues grew slower than the average rate for all of Asia, and its share of world revenues fell from 14.1% to 12.6% during this period.

U.S. Global Position in Market-Oriented Knowledge-Intensive Service Industries

The United States holds the leading position in all three industries that comprise market-oriented knowledge-intensive services (business, communications, and financial services) (table 6-5; appendix tables 6-4 and 6-5). The U.S. market is large and mostly open, which benefits U.S. industries in the global market in two important ways. First, supplying a domestic market with many consumers offers U.S. producers scale effects resulting from potentially large rewards for new ideas and innovations. Second, the relative openness of the U.S. market to foreign competitors in these three industries pressures U.S. producers to be innovative to maintain domestic market share.

Table 6-5
Global value-added revenue of market-oriented knowledge-intensive service industries and world share of selected regions: 1996 and 2005

Industry and region/country	1996	2005
Business		
Global revenue (2000 constant $trillions)	2.38	3.38
World share (%)		
United States	43.3	42.6
EU	28.2	29.3
Asia	17.1	16.9
Financial		
Global revenue (2000 constant $trillions)	1.61	2.28
World share (%)		
United States	36.9	37.6
EU	23.3	19.0
Asia	27.2	29.9
Communications		
Global revenue (2000 constant $trillions)	0.59	1.11
World share (%)		
United States	42.1	38.7
EU	22.7	22.2
Asia	16.2	22.6

EU = European Union

NOTES: Knowledge-intensive services classified by Organisation for Economic Co-operation and Development and consist of business, financial, communications, education, and health services. Market-oriented knowledge-intensive services exclude education and health services. Value-added revenue excludes purchases of domestic and imported materials and inputs. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007).

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Business Services

Business services, which include computer and data processing and commercial R&D, generated $3.4 trillion in 2005 as measured by value added, making this the largest knowledge-intensive industry (table 6-5; appendix tables 6-4 and 6-5). The United States has a leading position in this industry, and its share of global revenues (43% in 2005) has remained constant for the past decade. The EU and Asia rank second and third, respectively, in business services, and their world market shares have also remained essentially flat during this same period.

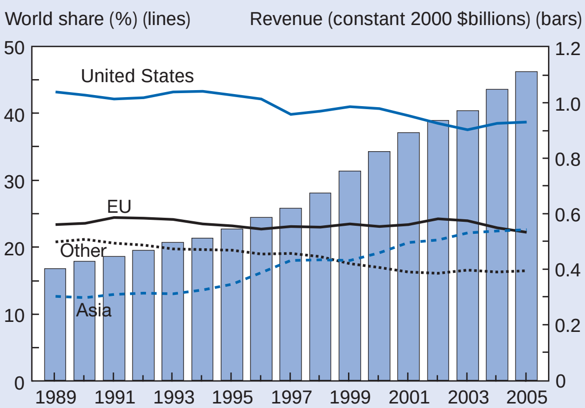
Financial Services

Financial services accounted for 34% of global value-added revenues generated by market-oriented knowledge-intensive service industries in 2005 (table 6-5; appendix tables 6-4 and 6-5). The United States is also a leader in this industry, with a world share of 38% in 2005, 1 percentage point higher than its share in 1996. Asia is ranked second in financial services, with a world share of 30% in 2005, 3 percentage points higher than its 1996 level. China's world share increased from 4% in 1996 to 8% in 2005. The EU ranked third in financial services, with a 19% share of world financial services industry revenues in 2005. Its share has declined by 4 percentage points over the past decade, primarily driven by declining revenues in industries within Germany and Italy.

Communications Services

The smallest of the knowledge-intensive industries ($1.1 trillion in 2005), communications services, is arguably the most technology driven. Provision of local and national communications services, however, is not fully open and competitive in many markets. In the United States, competition and new technologies have led to reductions in prices to consumers. In this industry, U.S. companies again hold a lead position, generating revenues equal to 39% of world value-added revenues in 2005 (figure 6-7; appendix tables 6-4 and 6-5). The U.S. world share in 2005, however, was 3 percentage points less than its share a decade ago. From 1996 to 2005, Asia's world market share jumped 6 percentage points, overtaking the EU in 2005 with a level of 23%. China and India drove Asia's ascent, with their communications industries averaging close to an annual average growth rate of 20% over the last decade. China and India's world shares more than doubled during this period, reaching 7% and 2%, respectively, in 2005. Japan's world share remained unchanged at 9%.

Figure 6-7
Global value-added revenue of communication services and world share of selected regions: 1989–2005



EU = European Union

NOTES: Revenue on value-added basis, which excludes purchased domestic and imported materials and inputs. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-4 and 6-5.

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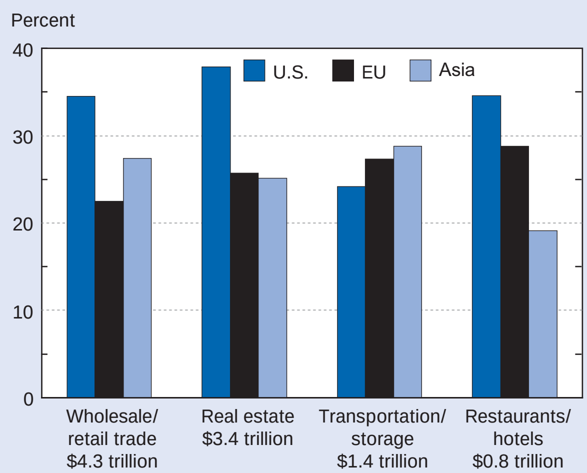
U.S. Global Position in Other Services

Commercially oriented services not classified as knowledge intensive include the wholesale and retail, restaurant and hotel, transportation, and real estate industries. These four industries incorporate S&T in their services or delivery of their services, but at a lower intensity compared with knowledge-intensive services. For example, inventory control incorporating IT technology has enabled the retail sector to cut costs and more precisely tailor and match inventory to meet customer demand.

The United States is leading in value added on a constant dollar basis within three of these four service industries: wholesale and retail, restaurant and hotel, and real estate (figure 6-8; appendix tables 6-6 and 6-7). The U.S. world market share has remained relatively constant during the past decade, although its position has changed in some industries. In the largest of these, wholesale and retail ($4.3 trillion in value added in 2005), the U.S. world share rose from 30% in 1996 to 35% in 2005, coinciding with the rapid rise of Wal-Mart and other retailers that compete aggressively on price and use sophisticated technology to manage their inventories.

Figure 6-8
Global value-added revenue and world share of selected service industries, by selected regions/countries: 2005



EU = European Union

NOTES: Global revenue in 2005 of each sector shown in 2000 constant dollars. Revenue on value-added basis, which excludes purchases of domestic and imported materials and inputs. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-6 and 6-7.

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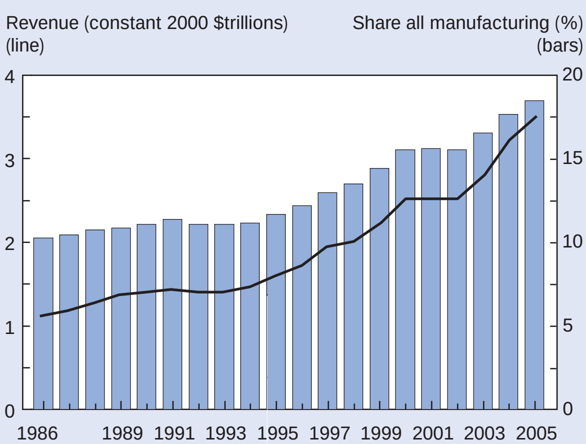
Importance of High-Technology Industries to Manufacturing

High-technology industries are driving growth in manufacturing activity worldwide. Between 1986 and 2005, high-technology manufacturing gross revenue rose from $1.1 trillion to $3.5 trillion in constant dollars (figure 6-9). Average annual growth during this 20-year period was 6%, more than double the rate for other manufacturing industries. In 2005, the high-technology share of all manufacturing output was 18% compared with 10% in 1986.

High-technology industries spend a relatively high proportion of their revenues on R&D compared with other manufacturing industries (table 6-6). R&D can lead to innovation, and companies that innovate tend to gain market share, create new product markets, and use resources more productively (NRC, Hamburg Institute for Economic Research, Kiel Institute for World Economics 1996; Tassey 2002).[12] High-technology industries also tend to develop high-value-added products, export more, and, on average, pay higher salaries than other manufacturing industries.[13] Moreover, industrial R&D performed by high-technology industries benefits other commercial sectors by developing new products, machinery, and processes that increase productivity and expand business activity.

Figure 6-9
Global high-technology manufacturing industry gross revenue and share of all manufacturing industries: 1986–2005



NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications equipment, office machinery and computers, pharmaceuticals, and scientific instruments. Revenue on gross basis, which includes purchases of domestic and imported materials and inputs.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007).

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U.S. Global Position in High-Technology Manufacturing Industries

The United States, the EU, and Asia collectively dominate global activity in high-technology manufacturing industries (more than 90% of world activity), similar to their strong position in market-oriented knowledge-intensive services. U.S. high-technology manufacturers rank second, as measured by their share of world value added, compared with the EU and Asia (figure 6-10; appendix tables 6-8 and 6-9). After moving up sharply in the late 1990s, the U.S. share has remained essentially flat at 34%–35% since 2001. U.S. consumption of high-technology manufactured goods also exhibited a sharp increase in the late 1990s (see figure 6-11 in sidebar, "Consumption of High-Technology Manufactured Goods"). Asia has ranked first in high-technology manufacturing value added since 1987, with the exception of 2001. The United States, however, has the largest share of any country in high-technology industries since overtaking Japan in 1997.

The EU has a sizably smaller world share than the United States or Asia (figure 6-10; appendix tables 6-8 and 6-9), and its world share has fallen continuously from 25% in 1995 to 18% in 2005. Reduced manufacturing activity in four EU countries (Italy, the United Kingdom [UK], Germany, and Spain) led to the EU share's decline over the past 10 years.

Several Asian countries, mainly China and Japan, have had dramatic shifts in their market positions during the past two decades (table 6-7; appendix tables 6-8 and 6-9):

- Japan's share of world value added peaked in 1989 at 29%, nearly doubling its level in the early 1980s before declining steeply in the late 1990s. In 2005, Japan's high-technology manufacturers accounted for 16% of world value added. As a result of the decline in its world share, Japan's country ranking slipped from first to second.
- China's world share rose from 2% in the late 1980s to 4% by 1997, then accelerated sharply to reach 16% in 2005, just 0.1 percentage point below Japan's share. The fifth-ranked country by world share in 1998, China rose to third-ranked in 2005, overtaking the UK and Germany.
- South Korea's world share nearly doubled from 2% in 1993 to almost 4% in 2005. Its country ranking moved from 10th to 5th during this period, overtaking Italy, France, and the UK.
- India's world share, although doubling between 1989 and 2005, remained very small, at less than 0.5%.

High-Technology Industries and Domestic Production

Increasingly, manufacturers in countries with high standards of living and labor costs have moved their manufacturing operations to locations with lower labor costs. High-technol-

Table 6-6
Classification of manufacturing industries based on average R&D intensity: 1991–97
(Percent)

Industry	ISIC rev. 3	R&D intensity	
		Total[a]	United States
Total manufacturing	15–37	2.5	3.1
High-technology industries			
Aircraft and spacecraft	353	14.2	14.6
Pharmaceuticals	2,423	10.8	12.4
Office, accounting, and computing machinery	30	9.3	14.7
Radio, television, and communication equipment	32	8.0	8.6
Medical, precision, and optical instruments	33	7.3	7.9
Medium-high-technology industries			
Electrical machinery and apparatus nec	31	3.9	4.1
Motor vehicles, trailers, and semi trailers	34	3.5	4.5
Chemicals excluding pharmaceuticals	24 excl. 2423	3.1	3.1
Railroad equipment and transport equipment nec	352 + 359	2.4	na
Machinery and equipment nec	29	1.9	1.8
Medium-low-technology industries			
Coke, refined petroleum products, and nuclear fuel	23	1.0	1.3
Rubber and plastic products	25	0.9	1.0
Other nonmetallic mineral products	26	0.9	0.8
Building and repairing of ships and boats	351	0.9	na[b]
Basic metals	27	0.8	0.4
Fabricated metal products, except machinery and equipment	28	0.6	0.7
Low-technology industries			
Manufacturing nec and recycling	36–37	0.4	0.6
Wood, pulp, paper, paper products, printing, and publishing	20–22	0.3	0.5
Food products, beverages, and tobacco	15–16	0.3	0.3
Textiles, textile products, leather, and footwear	17–19	0.3	0.2

na = not applicable

ISIC = International Standard Industrial Classification; nec = not elsewhere classified

[a]Aggregate R&D intensities calculated after converting R&D expenditures and production with 1995 gross domestic product purchasing power parities.
[b]R&D expenditures in shipbuilding (351) included in other transport (352 and 359).

NOTE: R&D intensity is direct R&D expenditures as percentage of production (gross output).

SOURCES: Organisation for Economic Co-operation and Development, ANBERD database, http://www1.oecd.org/dsti/sti/stat-ana/stats/eas_anb.htm; and STAN database, http://www.oecd.org/document/54/0,3343,en_2649_201185_21573686_1_1_1_1,00.html.

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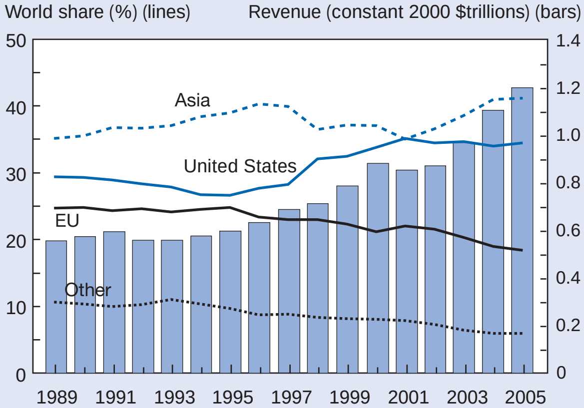
ogy industries and their factories are coveted by local, state, and national governments because these industries consistently show a larger share of value added to gross revenue in the final product than do other manufacturing industries. (Value-added revenue equals gross revenue excluding purchases of domestic and foreign supplies and inputs.)

In the United States, high-technology industries created about 20% more value-added per dollar of gross revenue than other manufacturing industries (figure 6-12).[14] High-technology industries also generally pay higher wages than other manufacturing industries.[15] Recognition of these contributions has led to intense competition among nations and localities to create, attract, nurture, and retain high-technology industries.[16]

During the 1990s, manufacturing output in the United States and other high-wage countries continued to shift into higher value-added, technology-intensive goods, often referred to as *high-technology manufactures* (figure 6-13). In 1990, high-technology manufacturing accounted for about 14% of all U.S. manufacturing value added. Growth in demand for communications and computer equipment increased the high-technology share of U.S. manufacturing to 19% in 2000 and 24% in 2005. The EU also saw high-technology manufactures account for a growing share of its total domestic production, although to a lesser degree. In 1990, high technology accounted for 10% of EU manufacturing value added, but by 2005 this had risen to 14%.

Asia's manufacturing production is also driven by high-technology industries (figure 6-13). The high-technology share of Asia's total manufacturing value added increased from 16% in 1990 to 22% in 2005. Japan's share, however, remained flat between 2000 and 2005. China's high-technology share of its total manufacturing more than doubled from 11% in 1990 to 28% in 2005, exceeding the comparable figure for the United States. India's share grew modestly from 6% to 9% during this period.

Figure 6-10
Value-added revenue and world share of high-technology manufacturing industries, by selected regions/countries: 1989–2005



EU = European Union

NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications equipment, office machinery and computers, pharmaceuticals, and scientific instruments. Revenue on value-added basis, which excludes purchases of domestic and imported materials and inputs. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCES: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-8 and 6-9.

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Global Competitiveness of Individual High-Technology Industries

The global market for communications equipment is the largest of the high-technology markets, as measured by share of global value added, accounting for nearly half of the total output of high-technology industries in 2005 (table 6-9; appendix tables 6-10 and 11).[17] Pharmaceuticals are the next largest segment, comprising 19%, followed by scientific instruments (14%), office machinery and computers (14%), and aerospace (8%).

The United States has a leading position, as measured by its world share of value added, in scientific instruments, aerospace, and pharmaceuticals compared with Asia and the EU. The United States is ranked second of the three economies in communications equipment and office machinery and computers (table 6-9; appendix tables 6-10 and 6-11). The large size and openness of the U.S. market that benefits U.S. service industries similarly benefits high-technology manufacturing industries. Additionally, the U.S. government influences the size and growth of the nation's high-technology industries through 1) investments in industrial R&D purchases of new products, 2) laws regulating sales to foreign entities of certain products produced by each of the five high-technology industries, and 3) policies that create an enabling environment by promoting innovation, investment, and entrepreneurship.[18]

Communications equipment. In this industry, U.S. manufacturers reversed downward trends evident during the 1980s to grow and gain market share in the mid- to late 1990s, partly because of increased capital investment by U.S. businesses (see sidebar, "U.S. IT Investment"). The U.S. share of world communications equipment value added grew by more than 20 percentage points between 1995 and 2005 to reach 34% (figure 6-14; appendix tables 6-10 and 6-11). Asia's world share slipped by about 10 percentage points because of the rapid decline of Japan, which had been the world's leading supplier of communications equipment until 2000. Japan's share fell from 42% to 23% during this period. China's world share tripled, rising from 5% to 15%. The EU's world share decreased from 19% to 12%, led by losses by Italy and the UK.

Table 6-7
World share of value-added revenue of high-technology manufacturing industries for selected Asian countries: Selected years, 1989–2005
(Percent)

Region/country	1989	1993	1997	2000	2003	2005
Asia	35.1	37.0	39.9	37.0	38.6	41.2
China	1.9	3.3	3.9	5.3	11.1	16.1
India	0.2	0.3	0.4	0.3	0.4	0.4
Japan	29.3	27.3	27.3	22.0	17.9	16.2
Malaysia	0.2	0.6	1.0	1.0	0.9	1.0
Singapore	0.9	1.3	1.6	1.5	1.2	1.2
South Korea	1.2	1.8	2.7	3.7	3.8	3.6
Taiwan	1.3	2.0	2.1	2.5	2.4	1.7

NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications equipment, office machinery and computers, pharmaceuticals, and scientific instruments. Value-added revenue excludes purchases of domestic and imported materials and inputs. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-8 and 6-9.

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Consumption of High-Technology Manufactured Goods

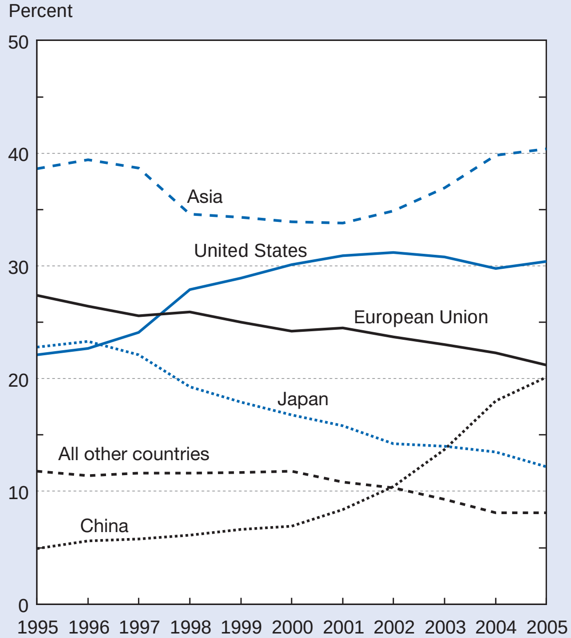
Production of high-technology goods feeds both domestic demand and foreign markets. A broad measure of domestic use is provided by adding domestic sales to imports and subtracting exports. Use so defined encompasses two different concepts: consumption of final goods and capital investment for further production (intermediate goods). Available data series do not permit examining these two concepts separately.

During the past decade, use of high-technology goods has more than doubled after accounting for inflation, from $1.6 trillion to $3.5 trillion (table 6-8). The strong U.S. economy registered higher growth, more than tripling from 1995 to 2005, compared with below-average growth for the EU and almost no change for Japan. In China, use of high-technology manufactures rose ninefold, approaching the level of the EU.

The Chinese trend underscores the difficulty of teasing out *final consumption* from use as intermediate goods. The strong rise in the Chinese trend is considered by many observers to reflect the rising inflow of intermediate goods, often previously produced in China, from other Asian manufacturing centers into China for further assembly and ultimate export.

Patterns of the world's use of high-technology manufactures have changed considerably over the past decade. Bearing in mind the difficulty of breaking these trends into final consumption versus investment, the U.S. share rose from 22% in 1995 to about 30% in 2000 and has largely stayed at that level (figure 6-11). The EU's share fell from 27% to 21% during the same decade (1995–2005), and Japan's declined by nearly half from 23% to 12%. China's share accelerated from 7% in 1999 to 20% in 2005.

Figure 6-11
World share of apparent consumption of high-technology manufacturing industries: 1995–2005



NOTES: Apparent consumption is domestic production and imports minus exports. European Union excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007).

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Table 6-8
Domestic use of high-technology goods, by selected regions/countries/economies: Selected years, 1995–2005
(Billions of constant 2000 dollars)

Region/country/economy	1995	1997	1999	2001	2003	2005
All countries	1,565	1,904	2,245	2,524	2,819	3,533
United States	346	458	649	781	867	1,074
European Union	429	488	561	617	649	747
Asia	604	736	771	853	1,039	1,426
China	76	111	148	212	385	709
Japan	357	421	401	399	395	432
South Korea	45	55	71	97	103	127
Taiwan	42	49	68	57	66	74
All others	185	221	264	273	263	285

NOTES: Domestic use is sum of domestic production and imports minus exports. High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications equipment, office machinery and computers, pharmaceuticals, and scientific instruments. European Union excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007).

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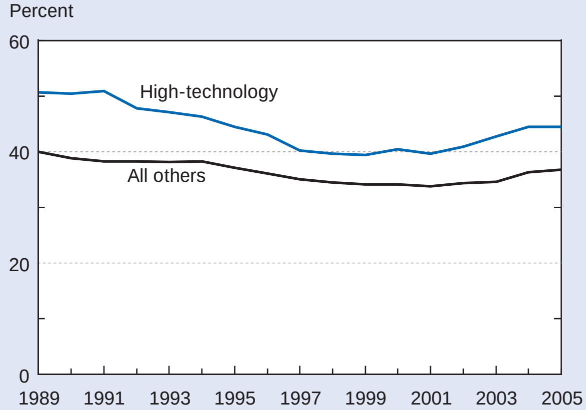
Figure 6-12
Value-added share of gross revenue of U.S. manufacturing industries: 1989–2005



NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications equipment, office machinery and computers, pharmaceuticals, and scientific instruments. Value-added revenue excludes purchases of domestic and imported materials and inputs. Gross revenue includes purchases of domestic and imported materials and inputs.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007).

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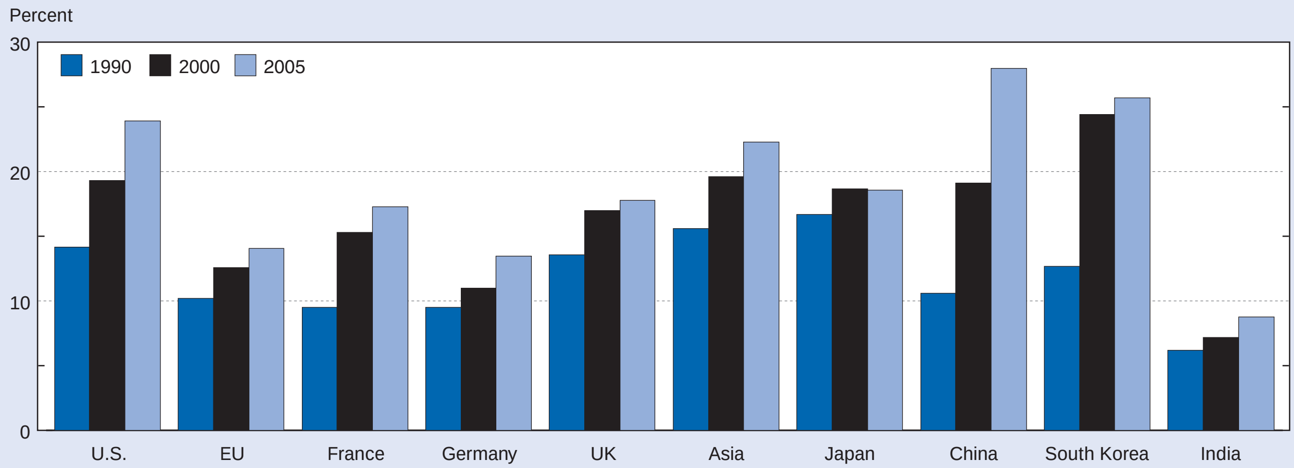
Computers and office machinery. The trends in the office and computer machinery manufacturing industry were similar to those in communications equipment. The United States, which was the second-ranked country by its world value added in 1995 (13%), doubled its share over a decade, surpassing Japan in 2000, to become the largest country until 2003, when it was overtaken by China (figure 6-15; appendix tables 6-10 and 6-11). Japan, which had been the largest country producing computer and office machinery equipment for most of the past two decades, had a sharply lower value added share, from 45% in 1995 to 9% in 2005. China's progress, however, was remarkable; its share of world value added expanded from 2% in 1995 to 46% in 2005. This rapid rise resulted in China surpassing both Japan in 2002 and the U.S. in 2003 to become the largest producing country in this industry.

Pharmaceuticals. As a result of varying degrees of public financing and regulation of pharmaceuticals throughout the world, as well as differing national laws governing the distribution of foreign pharmaceuticals, market comparisons in this industry may be less meaningful. The United States, the EU, and Asia accounted for 90% of global value-added revenue in 2005 (table 6-9; appendix tables 6-10 and 6-11). The United States is the leader by a small margin, and its world share has fluctuated between 30% and 35% over the past decade. The EU's world market share was roughly

Figure 6-13
High-technology share of all manufacturing industry value-added revenue for selected regions/countries: 1990, 2000, and 2005



EU = European Union; UK = United Kingdom

NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications equipment, office machinery and computers, pharmaceuticals, and scientific instruments. Revenue on value-added basis, which excludes purchases of domestic and imported materials and inputs. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007).

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Table 6-9
Global value-added revenue of high-technology manufacturing industries and world share of selected regions/countries: 1995 and 2005
(Percent)

Industry and region/country	1995	2005
Aerospace		
Global value-added revenue (2000 constant $billions)	77.0	91.7
World share		
United States	56.9	49.4
EU	27.1	26.8
Asia	5.4	15.6
Pharmaceuticals		
Global value-added revenue (2000 constant $billions)	135.5	233.8
World share		
United States	29.8	32.2
EU	28.5	29.5
Asia	28.0	28.4
Office and computing machinery		
Global value-added revenue (2000 constant $billions)	65.7	163.5
World share		
United States	12.8	23.9
EU	20.6	8.4
Asia	60.6	64.2
Communications equipment		
Global value-added revenue (2000 constant $billions)	218.7	544.0
World share		
United States	13.6	34.4
EU	18.9	11.7
Asia	60.1	50.5
Medical, precision, and optical instruments		
Global value-added revenue (2000 constant $billions)	101.1	168.3
World share		
United States	36.4	40.1
EU	33.4	29.8
Asia	19.3	20.1

EU = European Union

NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development. Value-added revenue excludes purchases of domestic and imported materials and inputs. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-10 and 6-11.

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steady during the past decade. In Asia, Japan, China, and South Korea are the largest producers of pharmaceuticals (appendix tables 6-10 and 6-11). Although Japan still has the larger domestic industry, China's share has grown steadily while Japan's has generally declined. In 1995, domestic production by Japan's industry accounted for 21% of global value-added revenue, but by 2005 this proportion had fallen to 13%. In 2005, China's pharmaceutical industry accounted for an estimated 8% of global value-added revenue, quadruple its share in 1995. South Korea's share of global value added edged up from 2% to 3%, and India's share doubled from 1% to 2% during this period.

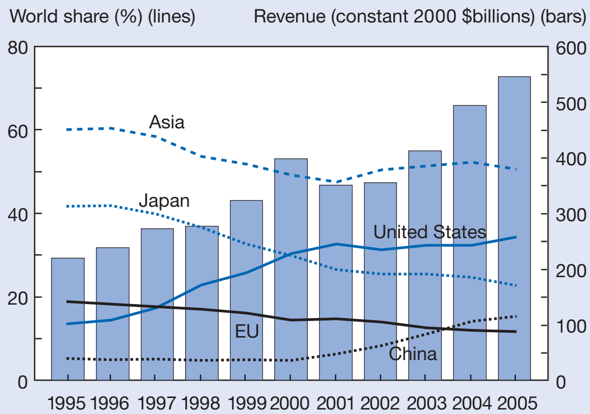
Scientific instruments. In 2001, the industry that produces scientific instruments (medical, precision, and optical instruments) was added to the group of high-technology industries, reflecting that industry's high level of R&D within advanced nations (table 6-6). The United States is the leading producer of scientific instruments, accounting for 40% of global revenue on a value-added basis in 2005 (table 6-9; appendix tables 6-10 and 6-11). The U.S. position has strengthened since 1995, as measured by world share, which rose 4 percentage points. Ranked second, the EU lost 3 percentage points in world share between 1995 and 2005, resulting from declines on the part of the UK, Italy, and Germany.

In Asia, Japan and China are the largest producers of scientific instruments. As in some other high-technology manufacturing industries, Japan's share of value-added global revenue in this industry is declining while China's share is increasing (appendix tables 6-10 and 6-11). In 1995, Japan's industry producing scientific instruments accounted for 15% of world value-added output; however, its share declined to about 11% in 2005. China's industry, which accounted for 2% of global value-added revenue in 1995, tripled to 6% in 2005.

Aerospace. The U.S. aerospace industry has long maintained a leading position in the global marketplace. The U.S. government is a major customer for the U.S. aerospace industry, contracting for military aircraft, missiles, and spacecraft. Since 1989, production for the U.S. government has accounted for approximately 40%–60% of total annual sales (AIA 2005). The U.S. aerospace industry position in the global marketplace is enhanced by this longstanding customer-supplier relationship.

In recent years, however, the aerospace industry's manufacturing share has fallen more than any other U.S. high-technology industry. Since peaking at 73% of global value-added revenue in 1987, the U.S. share fell to 58% in 1999 and continued to decline to less than half of global value-added revenue in 2005 (table 6-9; appendix tables 6-10 and 6-11). European aerospace manufacturers, particularly within Germany and the UK, made gains during this time. By 2005, the EU accounted for 27% of world aerospace value-added revenue, up from 19% in 1985 (appendix tables 6-10 and 6-11).[19] Asia's share of the global aerospace market reached 5% by the mid-1990s and then, accelerating sharply, grew to 16% in 2005, driven by gains in Japan and China. Japan's share of value-added global revenue rose from 3% in 1996 to almost 7% in 2005. China's aerospace industry grew just as rapidly, and exceeded 6% in 2005.

Figure 6-14
Global value-added revenue of communications equipment and world share of selected regions/countries: 1995–2005



EU = European Union

NOTES: Communications equipment includes communications, radio, and television equipment. Revenue on value-added basis, which excludes purchases of domestic and imported materials and inputs. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-10 and 6-11.

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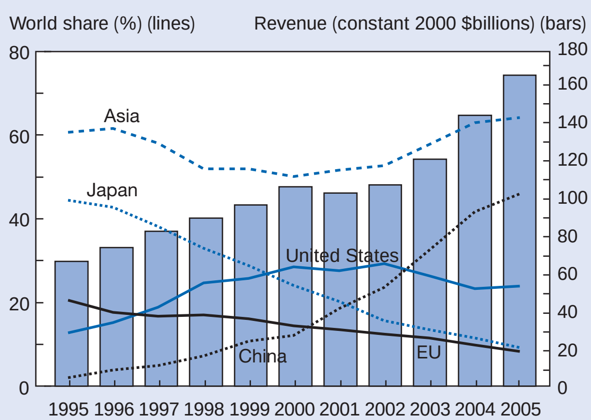
Figure 6-15
Global value-added revenue of computer manufacturing industry and world share of selected regions/countries: 1995–2005



EU = European Union

NOTES: Computer manufacturing includes computer, office, and accounting machinery. Revenue on value-added basis, which excludes purchases of domestic and imported materials and inputs. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCES: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-10 and 6-11.

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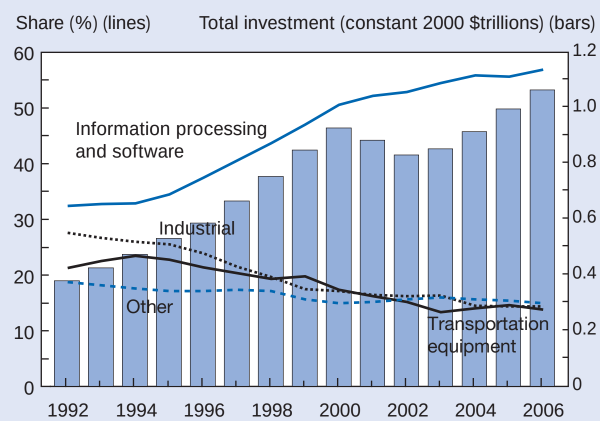
U.S. IT Investment

Information technology (IT) was a major contributor to innovation and productivity gains during the 1990s. In addition to technical changes within the IT field, companies used IT to transform how their products performed and how their services were delivered. IT applications also improved the flow of information within and among organizations, which has led to productivity gains and production efficiencies.

From 1992 through 2006, U.S. industry purchases of IT equipment and software exceeded industry spending on all other types of capital equipment (figure 6-16). Despite the bursting of the dot.com bubble beginning in the spring of 2000 and the economic downturn that began in March 2001, U.S. companies continued to place a high value on investments in IT. Industry spending on IT equipment and software accounted for 41% of all industry investment (including structures and equipment) in 1997, 53% in 2002, and 57% in 2006.

Figure 6-16
U.S. industry investment in capital equipment and share of equipment type: 1992–2006



SOURCE: Bureau of Economic Analysis, National Income and Product Accounts, http://www.bea.gov/national/nipaweb/NIPA_Underlying/TableView.asp?SelectedTable=39&FirstYear=2006&LastYear=2007&Freq=Qtr, accessed 15 March 2007.

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U.S. Global Position in Medium- and Low-Technology Manufacturing Industries

S&T is used in many industries, not just high-technology manufacturing and services. Manufacturing industries not classified as high technology are divided into three categories: medium-high technology, medium-low technology, and low technology. Relevant industries include motor vehicle manufacturing and chemicals production excluding pharmaceuticals (medium-high technology), rubber and plastic production and basic metals (medium-low technology), and paper and food product production (low technology).

These industries use advanced manufacturing techniques, incorporate technologically advanced inputs in manufacture, and/or perform or rely on R&D in applicable scientific fields. The U.S. value added world share in medium- and low-technology industries is lower than its share of high-technology industries, but the U.S. global position in these industries is fairly strong (table 6-10; appendix tables 6-12 and 6-13):

- **Medium-high-technology industries:** These industries produced $1.7 trillion in year 2000 constant dollars of value added in 2005. Although the United States is ranked third (23%) after Asia and the EU in share of world value added, it has the largest share of any individual country. U.S. and EU shares fell slightly between 1996 and 2005 while Asia's share increased from 32% to 37%, largely because of the doubling of China's world share from 4% to 8%.
- **Medium-low-technology industries:** The United States is also ranked third in these industries compared with Asia and the EU, although it has the largest share of any single country. Between 1996 and 2005, Asia's share grew 4 percentage points to 35%, largely because China's world share rose from 4% to 11%. Japan's share fell from 20% to 15%.
- **Low-technology industries:** The United States is ranked first in these industries, which produced $2 trillion in constant dollars in value added in 2005. The U.S. share of low-technology industry value added has remained steady during the past decade (30% in 2005). Asia's share rose slightly during this period, even though Japan's share fell from 18% to 14%, because China's world share doubled from 4% to 9%.

In addition, some industries are not classified as either manufacturing or services (see sidebar, "U.S. Global Market Position in Other Industries").

U.S. Exports of Manufacturing Industries

High-Technology Manufacturing Industries

Data on international trade attribute products to a single country of origin and in some cases to a single industry. For goods manufactured in more than one country, the United States and many other countries determine country of origin on the basis of where the product was "substantially transformed" into the final product. For example, a General Motors car destined for export to Canada that was assembled in the United States with components imported from Germany and Japan will be labeled "Made in the USA." The country where the product was "substantially transformed" may not necessarily be where the most value was added, although that often is the case.

In this chapter, trade in U.S. high-technology products is counted in two different ways. The contrasting methods may attribute products to different countries of origin (see sidebar, "Classifying Products in Trade").

During the 1990s, U.S. high-technology industries accounted for about one-fifth of world high-technology exports, approximately twice the level of all other U.S. manufacturing industries.[20] Starting in the late 1990s, however, the U.S.

Table 6-10
Value-added revenue and world share of manufacturing industries by select technology levels for selected regions/countries: Selected years, 1996–2005
(Percent)

Industry and region/country	1996	2001	2005
Medium-high technology			
All regions/countries (2000 constant $trillions)	1.391	1.422	1.682
United States	26.3	24.4	22.9
EU	29.8	31.2	28.2
Asia	31.5	31.0	36.7
Japan	21.4	20.1	20.7
China	3.5	4.5	7.8
Medium-low technology			
All regions/countries (2000 constant $trillions)	1.190	1.272	1.459
United States	23.7	22.8	22.0
EU	28.6	28.2	25.2
Asia	31.0	31.0	35.2
Japan	19.5	17.1	15.1
China	4.3	5.5	10.6
Low technology			
All regions/countries (2000 constant $trillions)	1.721	1.783	1.953
United States	29.7	29.4	30.3
EU	26.6	27.2	25.0
Asia	27.6	26.4	28.6
Japan	18.2	15.9	13.9
China	4.2	4.7	9.0

EU = European Union

NOTES: Technology level of manufacturing industries classified by Organisation for Economic Co-operation and Development on basis of R&D intensity of output. Value-added revenue excludes purchases of domestic and imported materials and inputs. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-12 and 6-13.

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U.S. Global Market Position in Other Industries

Agriculture, construction, mining, and utilities are not classified as either manufacturing or service industries and are not categorized by their level of technology or knowledge intensity. Like those in the manufacturing and service sectors, however, these industries incorporate and use S&T in their products and processes. For example, agriculture relies on breakthroughs in biotechnology, construction uses knowledge from materials science, mining is dependent on earth sciences, and utilities rely on advances in energy science.

In construction and utilities, the United States produces more than a fourth of the world's value added (table 6-11). The U.S. share of the global construction industry, valued at $1.7 trillion in constant dollars in 2005, rose from 23% to 27% during the past decade. At 17%, however, the U.S. world share of mining in 2005 was 5 percentage points less than a decade ago. The U.S. world share of agriculture edged up from 8% to nearly 11% during this period.

Table 6-11
U.S. world share and global value-added revenue of agriculture, construction, mining, and utilities: Selected years, 1996–2005

Sector/year	U.S. world share (%)	Value-added world revenue (2000 constant $billions)
Agriculture		
1996	8.4	913
1999	9.3	975
2002	9.6	1,003
2005	10.6	1,081
Construction		
1996	22.7	1,606
1999	26.1	1,626
2002	26.5	1,621
2005	26.5	1,730
Mining		
1996	23.2	580
1999	22.6	605
2002	20.1	643
2005	17.3	722
Utilities		
1996	27.7	686
1999	27.9	727
2002	28.1	745
2005	26.8	805

NOTES: Value-added revenue excludes purchase of domestic and foreign materials and supplies. Agriculture includes forestry, fishing, and hunting. Utilities include electricity, gas, and water.

SOURCE: Global Insight, Inc., World Industry Service database (2007).

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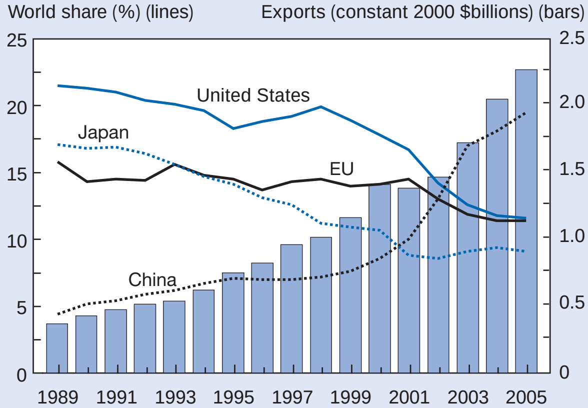
Classifying Products in Trade

The characteristics of goods in international trade can be determined from either an industry or a product perspective:

- **Industry perspective.** U.S. industry exports and imports are collected from government surveys of companies with physical operations in the United States, where respondents are asked to report the value of foreign shipments and purchases from abroad. These shipments, both exports and imports, are classified by the primary industry of the responding company. Under this scheme, whether Ford Motor Company exports automobiles or tires, both types of exports would be classified under Ford's primary industry code "manufacturer of motor vehicles and parts." The value of industry exports includes the value of components, inputs, or services purchased from domestic industries or imported from other countries. The value of industry imports includes the value of components, inputs, or services that may have originated from a different industry or country than the country of origin.
- **Product perspective.** Data on product trade, such as that reported below in the section about U.S. trade in advanced technology products, are first recorded at U.S. ports of entry. Each type of product is assigned a product trade code by the customs agent according to the harmonized system.* Exporters generally identify the product being shipped and include its proper code. Because many imported products are assessed an import duty and these duties vary by product category, the receiving country customs agent inspects or reviews the shipment to make the final determination of the proper product code and country of origin. The value of products entering or exiting U.S. ports may include the value of components, inputs, or services classified in different product categories or originating from other countries than the country of origin.

*The Harmonized Commodity Description and Coding System, or Harmonized System (HS), is a system for classifying goods traded internationally, developed under the auspices of the Customs Cooperation Council. Beginning on 1 January 1989, HS numbers replaced previously adhered-to schedules in more than 50 countries, including the United States.

Figure 6-17
Global exports of high-technology manufacturing industries and world share of selected regions/countries: 1989–2005



EU = European Union

NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications equipment, office machinery and computers, pharmaceuticals, and scientific instruments. EU exports do not include intra-EU exports. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-14 and 6-15.

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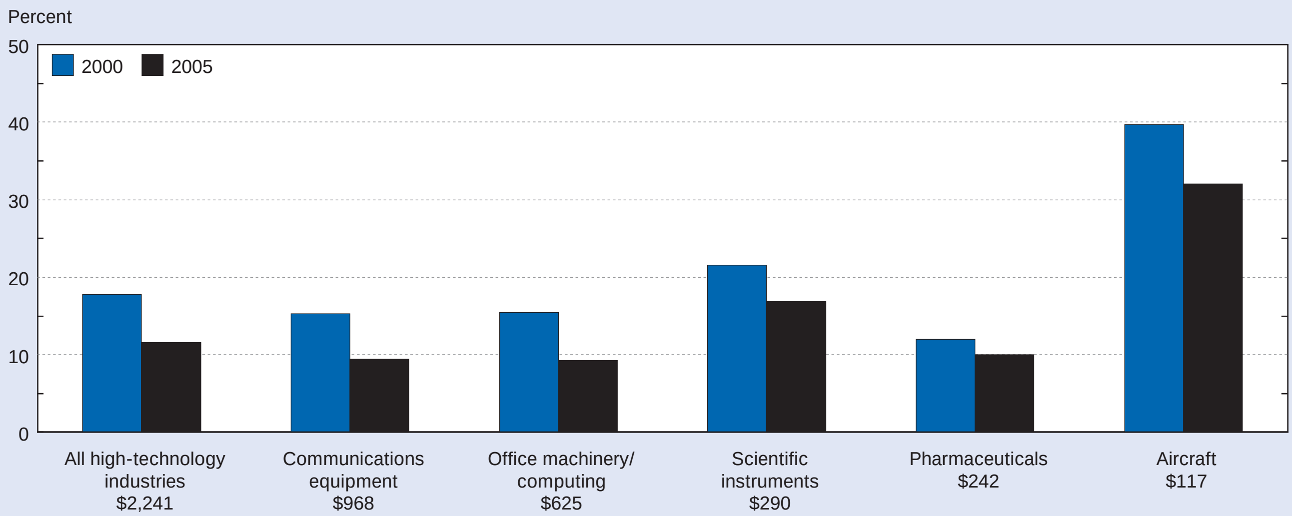
world export share declined continuously across all five high-technology manufacturing industries, dropping to an average of 12% in 2005 (figure 6-17; appendix tables 6-14 and 6-15). Losses in communications equipment and office machinery and computers, which collectively account for nearly 60% of U.S. high-technology exports, primarily drove the decline in U.S. export share (figure 6-18; appendix tables 6-16 through 6-19).

The drop in the U.S. export share coincided with the rapid rise of China's high-technology export industries that began in 1999 (figure 6-17; appendix tables 6-14 and 6-15). Between 1999 and 2005, China's export share more than doubled from 8% to 19%. China surpassed Japan in 2001, the EU in 2002, and overtook the United States in 2003, becoming the world's largest exporter as measured by world market share.[21] China's rise in market share has been driven by its exports from the office machinery and computers and communications equipment industries (appendix tables 6-16 through 6-19). Between 2000 and 2005, China's world export share in office machinery and computers tripled from 10% to 30% and its share in communications equipment more than doubled from 10% to 21%. Japan's share of world high-technology industry exports fell from 17% in the early 1990s to 9% in 2001 and has remained essentially flat.

Figure 6-18
U.S. world export share for individual high-technology manufacturing industries: 2000 and 2005



NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development. 2005 exports in billions of 2000 dollars shown below each industry.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-14 to 6-19.

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Medium- and Low-Technology Manufacturing Industries

Compared with trends for high-technology industries, the United States has historically had lower world export shares in non-high-technology manufacturing industries, although these, too, have converged somewhat starting in the late 1990s. The U.S. share of world exports in medium-high-technology industries was 11% in 2005, nearly equal to its share in high-technology industries (table 6-12; appendix tables 6-12 and 6-13). This makes the United States the third-ranked exporter in these industries behind Japan (13%) and the EU (excluding intra-EU exports) (12%). The market position of these three economies has not changed over the past decade. China, however, has made rapid strides; its world export share in these industries has doubled from 4% in 1996 to 8% in 2005.

The United States ranks third in exports of medium-low-technology industries, with a world share in 2005 of 7% (table 6-12; appendix tables 6-12 and 6-13). The EU at 13% of world share and China at 11% of world share are the first- and second-ranked exporters in these industries. The U.S. share of exports of low-technology industries in 2005 was 8%, ranked third behind the EU (14%) and China (16%). China's world export share is nearly double that of the United States, having grown 5 percentage points since 1996.

Table 6-12
Global export revenue of manufacturing industries by technology level and world share of selected regions/countries: 1996, 2001, and 2005
(Percent)

Industry and region/country	1996	2001	2005
Medium-high technology			
All regions/countries (2000 constant $billions)	1,673	1,830	2,833
United States	13.1	13.5	11.1
EU	12.2	12.1	12.4
Japan	13.5	11.0	13.1
China	3.6	4.7	8.4
Medium-low technology			
All regions/countries (2000 constant $billions)	662	747	1,020
United States	8.1	8.6	6.6
EU	14.7	13.1	12.8
Japan	8.3	6.4	6.3
China	5.2	6.3	10.7
Low technology			
All regions/countries (2000 constant $billions)	1,142	1,288	1,716
United States	10.6	10.6	8.4
EU	17.0	15.1	14.2
Japan	2.8	3.3	3.3
China	10.9	10.4	16.1

EU = European Union

NOTES: Technology level of manufacturing industries classified by Organisation for Economic Co-operation and Development on basis of R&D intensity of output. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU exports do not include exports within each region.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-12 and 6-13.

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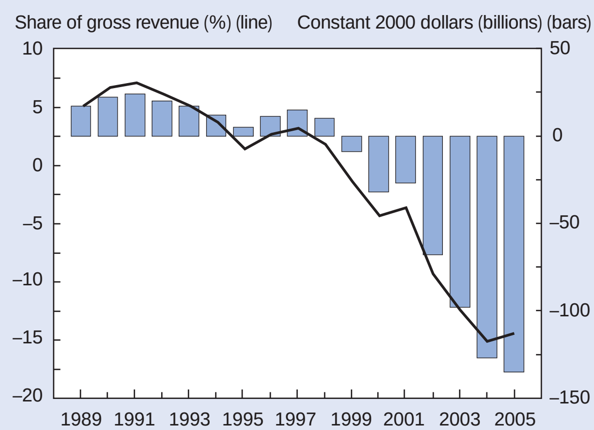
Trade Balance of High-Technology Industries

U.S. high-technology industries consistently exported more than they imported throughout the 1980s to early 1990s, in contrast to the consistent deficits recorded by other U.S. manufacturing industries.[22] The trade balance of high-technology industries shifted from surplus to deficit in the late 1990s, however, because imports of high-technology manufacturing industries grew almost twice as fast as exports during that decade (figure 6-19; appendix tables 6-14 and 6-15). In 2000, the deficit was $32 billion in constant dollars, equivalent to 4% of gross revenues of U.S. high-technology manufacturing industries; in 2005, the deficit widened to $135 billion, amounting to 14% of gross revenue.

Two industries are driving the U.S. high-technology industry trade deficit: communications equipment and office machinery and computing. In 2005, these two industries ran a collective deficit of more than $140 billion in constant dollars (figure 6-20). The emergence of large deficits in these industries coincided with rising domestic output, stimulating imports of components. The deficit in office machinery and computing was not only a major driver of the overall trade deficit but was also quite large when viewed as a share of

Figure 6-19
Trade balance and share of gross revenue for U.S. high-technology manufacturing industries: 1989–2005



NOTES: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications equipment, office machinery and computers, pharmaceuticals, and scientific instruments. Revenue on gross basis, which includes purchase of domestic and foreign materials and inputs.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-14 and 6-15.

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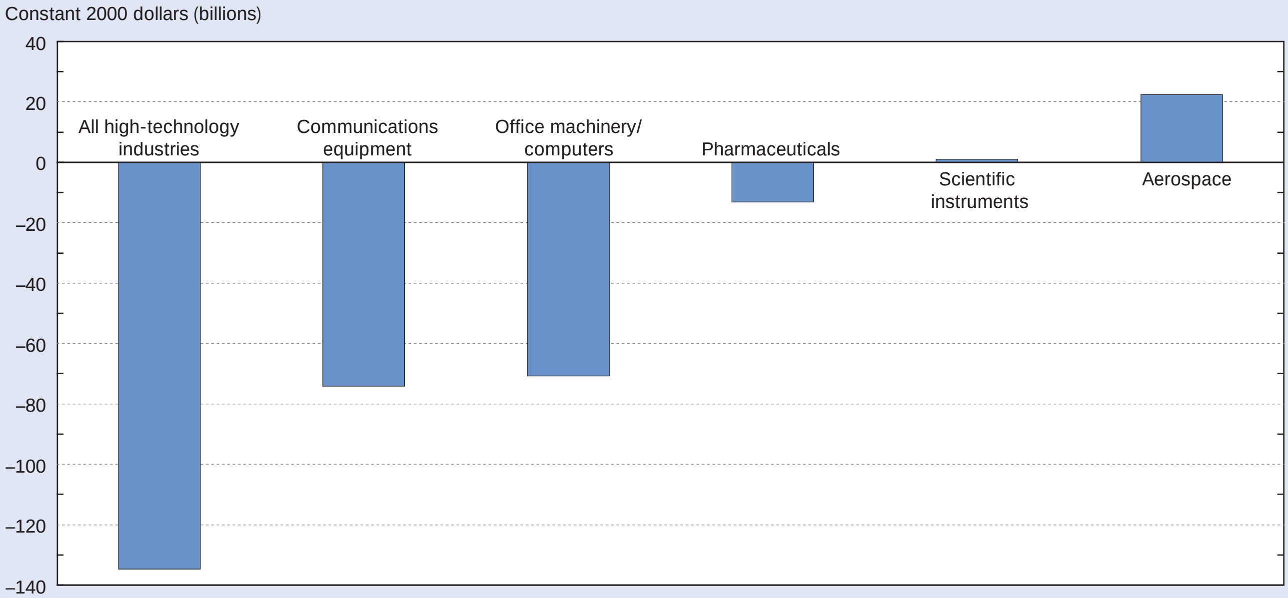
Figure 6-20
U.S. trade balance for individual high-technology manufacturing industries: 2005



NOTE: High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development.

SOURCE: Global Insight, Inc., World Industry Service database, special tabulations (15 April 2007). See appendix tables 6-16 to 6-19.

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gross revenue of this industry. In 2005, this industry's trade deficit represented about a 60% share of gross revenues, the largest share of any U.S. high-technology industry (appendix tables 6-18 and 6-19). The pharmaceuticals industry ran a deficit of $13 billion in 2005.

Two other high-technology industries, scientific instruments and aerospace, are not contributors to the trade deficit. The U.S. aerospace industry registered a $22 billion trade surplus in 2005, continuing its trend of sizable trade surpluses since the late 1990s. The U.S. scientific instruments manufacturing industry had a modest $1 billion surplus in 2005.

U.S. Trade Balance in Technology Products

The methodology used to identify high-technology industries relies on a comparison of R&D intensities. R&D intensity is typically determined by comparing industry R&D expenditures or the number of technical people employed (e.g., scientists, engineers, and technicians) with industry value added or the total value of shipments (see sidebar, "Comparison of Data Classification Systems Used"). Classification systems based on industry R&D intensity tend to overstate the level of high-technology exports by including all products shipped overseas by those high-technology industries, regardless of the level of technology embodied in each product, and by the somewhat subjective process of assigning products to specific industries.

In contrast, the Census Bureau has developed a classification system for exports and imports that embody new or leading-edge technologies. The system allows a more highly disaggregated, focused examination of embodied technologies and categorizes trade into 10 major technology areas:

- **Biotechnology.** The medical and industrial application of advanced genetic research to the creation of drugs, hormones, and other therapeutic items for both agricultural and human uses.
- **Life science technologies.** The application of nonbiological scientific advances to medicine. For example, advances such as nuclear magnetic resonance imaging, echocardiography, and novel chemistry, coupled with new drug manufacturing techniques, have led to new products that help control or eradicate disease.
- **Optoelectronics.** The development of electronics and electronic components that emit or detect light, including optical scanners, optical disk players, solar cells, photosensitive semiconductors, and laser printers.
- **Information and communications.** The development of products that process increasing amounts of information in shorter periods of time, including computers, video conferencing, routers, radar apparatus, communications satellites, central processing units, and peripheral units such as disk drives, control units, modems, and computer software.
- **Electronics.** The development of electronic components (other than optoelectronic components), including in-

tegrated circuits, multilayer printed circuit boards, and surface-mounted components, such as capacitors and resistors, that improve performance and capacity and, in many cases, reduce product size.

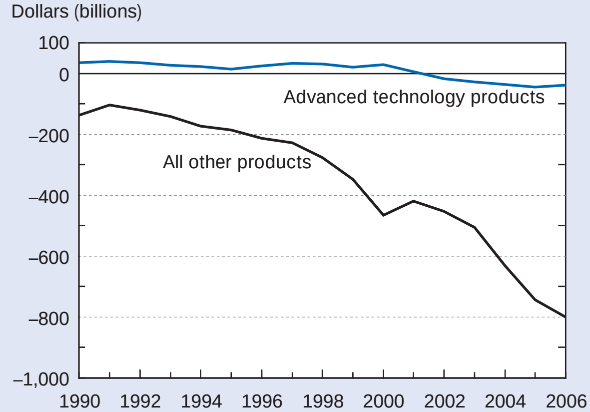
- **Flexible manufacturing.** The development of products for industrial automation, including robots, numerically controlled machine tools, and automated guided vehicles, that permit greater flexibility in the manufacturing process and reduce human intervention.
- **Advanced materials.** The development of materials, including semiconductor materials, optical fiber cable, and videodisks, that enhance the application of other advanced technologies.
- **Aerospace.** The development of aircraft technologies, such as most new military and civil airplanes, helicopters, spacecraft (communications satellites excepted), turbojet aircraft engines, flight simulators, and automatic pilots.
- **Weapons.** The development of technologies with military applications, including guided missiles, bombs, torpedoes, mines, missile and rocket launchers, and some firearms.
- **Nuclear technology.** The development of nuclear production apparatus (other than nuclear medical equipment), including nuclear reactors and parts, isotopic separation equipment, and fuel cartridges. (Nuclear medical apparatus is included in life sciences rather than this category.)

To be included in a category, a product must contain a significant amount of one of these leading-edge technologies, accounting for a significant portion of the product's value. In this report, computer software is examined separately, creating an 11th technology area.[23] In official statistics, computer software is included in the information and communications technology area (see sidebar, "Comparison of Data Classification Systems Used").

Importance of Advanced Technology Products to U.S. Trade

During much of the 1990s, U.S. trade in advanced technology products grew in importance as it accounted for larger and larger shares of overall U.S. trade (exports plus imports) in merchandise, producing consistent trade surpluses for the United States. Beginning in 2000 and coinciding with the dot.com collapse, the trade balance for U.S. technology products began to erode, about the same time the U.S. trade balance in high-technology industries shifted to a deficit (figures 6-20 and 6-21; appendix table 6-20).[24] In 2002, U.S. imports of advanced technology products exceeded exports, resulting in the very first U.S. trade deficit in this market segment. The U.S. trade deficit in advanced technology products grew larger each year thereafter until 2006, when it contracted somewhat. In 2002, the U.S. trade deficit in advanced technology products was $17.5 billion; in 2003, it increased to $27.4 billion, then again increased to $37.0 billion in 2004 and $44.4 billion in 2005. Contract manufacturing by U.S. companies in Asia and elsewhere may be a factor in this trend. The deficit was smaller in 2006, dropping to $38.3 billion, although still larger than any year except 2005.

Figure 6-21
U.S. merchandise trade balance, by product type: 1990–2006



NOTES: Technology products from special tabulations. All other products trade = total merchandise trade minus trade in advanced technology products.

SOURCE: Census Bureau, Foreign Trade Division, special tabulations (2006); and data on total product trade, http://www.fedstats.gov. See appendix tables 6-20 and 6-21.

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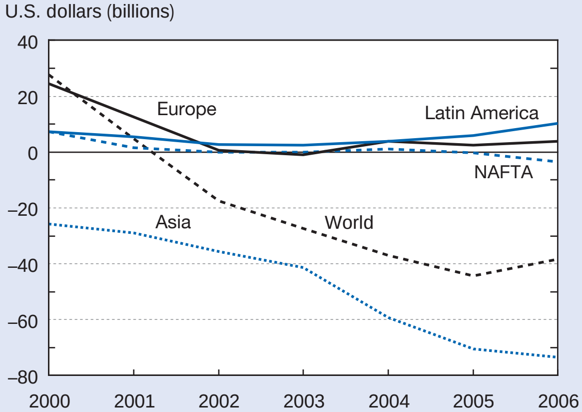
The U.S. trade deficit is largely driven by trade deficits with Asia, especially with China and Malaysia. U.S. trade with the rest of the world is either relatively balanced or in surplus (figure 6-22; appendix table 6-21).

Technologies Generating a Trade Surplus

Throughout most of the 1990s, U.S. exports of advanced technology products generally exceeded imports in 8 of the 11 technology areas.[25] Since 2000, the number of technology areas showing a trade surplus has slipped to five or six (figure 6-23; appendix table 6-20).

Trade in aerospace products has consistently produced the largest surpluses for the United States since the 1990s. In 2005, U.S. trade in aerospace products generated a net inflow of $37.2 billion, which rose to $53.6 billion in 2006 (figure 6-23; appendix table 6-20). U.S. trade classified as electronics products (e.g., electronic components including integrated circuits, circuit boards, capacitors, and resistors) is the only other technology area that has generated large surpluses in recent years. In 2000, U.S. trade in electronics products generated a net inflow of $15.2 billion, which increased to $16.1 billion in 2002, then rose to more than $21 billion in both 2003 and 2004, and rose again to $25.4 billion in 2006. Trade activity in biotechnology, computer software, flexible manufacturing products (e.g., industrial automation products, robotics), and weapon technologies also has generated small surpluses during the past few years.

Figure 6-22
U.S. advanced technology product trade balance, by world and region: 2000–06



NAFTA = North American Free Trade Agreement

NOTES: Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. Europe includes Austria, Belgium, Czech Republic, Denmark, Germany, Finland, France, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, and United Kingdom. Latin America includes Argentina, Brazil, Chile, Costa Rica, Peru, and Venezuela. NAFTA includes Canada and Mexico.

SOURCE: Census Bureau, Foreign Trade Division, special tabulations (2007). See appendix table 6-21.

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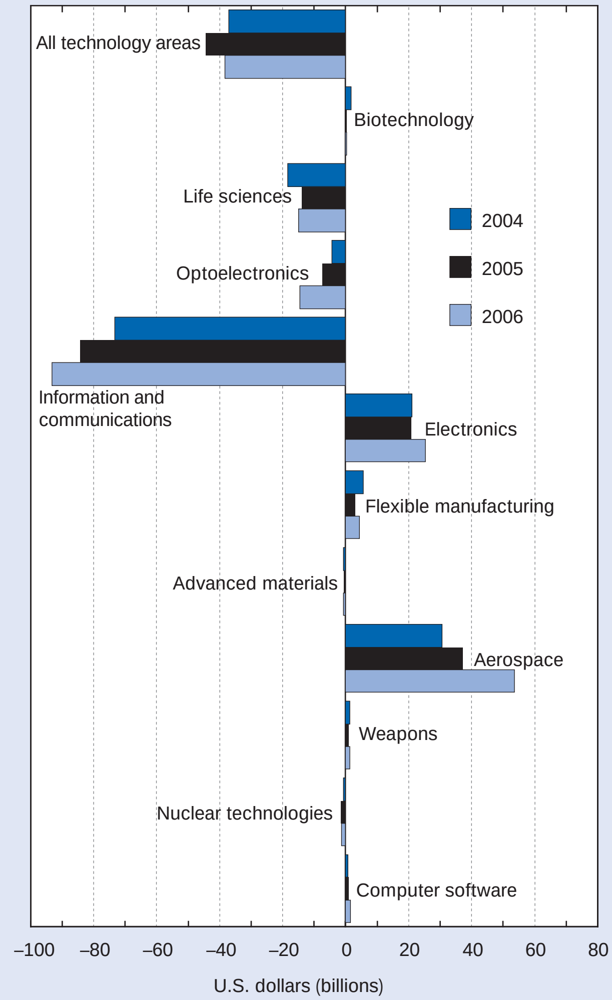
Technologies Generating a Trade Deficit

Throughout most of the 1990s, trade deficits were recorded in just 2 of the 11 technology areas: information and communications and optoelectronics. Rapidly rising imports of life science technologies during the late 1990s produced the first U.S. trade deficit in that third technology area in 1999. Since 2000, U.S. imports have exceeded exports in about half of the 11 technology areas; the largest trade deficits continue to be in the information and communications technology area (figure 6-23; appendix table 6-20). In 2006, imports exceeded exports in five technology areas. U.S. trade in information and communications resulted in a net outflow of $93.2 billion; net outflows in life science technologies and optoelectronics were $15 billion and $14.5 billion, respectively. Small deficits were also recorded in nuclear technologies ($1.4 billion) and advanced materials ($0.8 billion).

Top Customers by Technology Area

Asia, Europe, and North America together purchase nearly 85% of all U.S. exports of advanced technology products. Asia is the destination for about 40% of these exports, Europe about 26%, and Canada and Mexico together about 17% (appendix table 6-21). China, Canada, and Japan are the largest country customers across a broad range of U.S. technology products, with China accounting for about 10% of all U.S. exports of advanced technology products in 2006, Canada for about 9%, and Japan about 8% (table 6-13; appendix table 6-21). In 2006, China ranked among the top three customers in 5 of the 11 technology areas, Mexico in 4 areas, Canada in 3 areas, and Japan in 7 areas.

Figure 6-23
U.S. trade balance, by technology area: 2004, 2005, and 2006



SOURCES: Census Bureau, Foreign Trade Division, special tabulations (2007); and FedStats data on total product trade, http://www.fedstats.gov.

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Asia is a major export market for the United States. In addition to the broad array of technology products sold to Japan, the latest data show that China is among the top three customers in aerospace, advanced materials, software, electronics, and information and communications technologies. Taiwan is among the top three customers in optoelectronics, flexible manufacturing, and nuclear technologies, South Korea in flexible manufacturing and weapons technologies, and Malaysia in electronics technologies.

European countries are also important consumers of U.S. technology products, particularly Germany, the UK, France, and the Netherlands. The European market is particularly important in two technology areas: biotechnology and aerospace. The Netherlands, Belgium, and the UK are the top customers for U.S. biotechnology products, together consuming more than half of all U.S. exports within this technology area. Germany is the leading European consumer of U.S. life science technologies and optoelectronics, whereas France and the UK are the leading European consumers of U.S. aerospace technology products.

Top Suppliers by Technology Area

The United States is not only an important exporter of technologies to the world but also a major consumer of imported technologies. The leading economies in Asia, Europe, and North America are important suppliers to the U.S. market in each of the 11 technology areas examined. Together, they supply about 97% of all U.S. imports across all classes of advanced technology products (table 6-14; appendix table 6-21). In 2006, Asia supplied more than 60%, Europe about 21%, and North America about 16%.

China is by far the largest supplier of technology products to the United States, as the source for 25% of U.S. imports in 2006, followed by Mexico with 11% (table 6-14; appendix table 6-21). By comparison, Japan, the third largest supplier, was a distant second among all Asian sources, supplying 9% of U.S. technology imports in 2006. Malaysia, South Korea,

Table 6-13
Three largest export markets for U.S. technology products: 2006
(Percent)

	Largest market		Second largest market		Third largest market	
Export	Country	Percent	Country	Percent	Country	Percent
All technologies	China	9.6	Canada	9.3	Japan	7.7
Computer software	Canada	41.6	Mexico	8.6	China	6.5
Advanced materials	Mexico	14.1	China	11.5	Japan	11.1
Aerospace	Japan	8.7	France	8.5	China	8.1
Biotechnology	Netherlands	28.8	Belgium	13.1	UK	12.6
Electronics	China	16.9	Malaysia	11.1	Mexico	10.6
Flexible manufacturing	South Korea	15.4	Taiwan	13.7	Japan	13.0
Information/communications	Canada	16.2	Mexico	13.7	China	8.0
Life sciences	Japan	12.6	Germany	10.9	Canada	8.6
Nuclear technology	Japan	36.9	UK	15.0	Taiwan	9.8
Optoelectronics	Japan	15.4	Germany	10.6	Taiwan	9.7
Weapons	UK	16.4	Japan	14.4	South Korea	10.0

UK = United Kingdom

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

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Table 6-14
Three largest foreign suppliers of technology products to United States: 2006
(Percent)

	Largest supplier		Second largest supplier		Third largest supplier	
Import	Country	Percent	Country	Percent	Country	Percent
All technologies	China	25.3	Mexico	10.6	Japan	8.9
Advanced materials	Japan	44.2	Mexico	11.3	Germany	10.1
Aerospace	France	24.7	Canada	22.9	UK	13.0
Biotechnology	Germany	25.6	Ireland/UK	11.1	Belgium	9.3
Computer software	Mexico	23.7	China	17.0	Canada	16.6
Electronics	Taiwan	16.2	South Korea	11.1	Malaysia	10.8
Flexible manufacturing	Japan	43.4	Netherlands	10.2	Germany	9.5
Information/communications	China	40.5	Malaysia	13.4	Mexico	10.1
Life sciences	Ireland	35.3	Germany	10.6	Mexico	6.6
Nuclear technology	UK	29.9	Russia	27.8	Netherlands	14.9
Optoelectronics	Mexico	51.9	China	22.8	Japan	6.8
Weapons	Canada	15.8	UK	15.0	China	13.4

UK = United Kingdom

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

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and Taiwan are other major Asian suppliers. In the electronics technology area, the top three suppliers are all in Asia and supply about 38% of total U.S. imports.

Among European countries, Germany, the UK, and France are major suppliers of technology products to the United States. Many smaller European countries also have become important sources for technology products, although they tend to specialize. Ireland was among the top suppliers of life science and biotechnology products to the United States in 2006, as the source for 35% and 11%, respectively, of U.S. imports in these categories (table 6-14; appendix table 6-21). Belgium supplied 9% of U.S. biotechnology imports, and the Netherlands supplied 10% of U.S. flexible manufacturing technology imports in 2006.

U.S. Royalties and Fees Generated From Intellectual Property

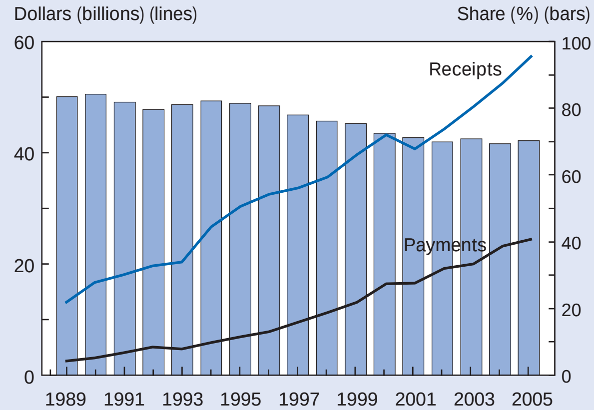
Companies trade intellectual property when they license or franchise proprietary technologies, trademarks, and entertainment products to entities in other countries. Trade in intellectual property can involve patented and unpatented techniques, processes, formulas, and other intangible assets and proprietary rights; broadcast rights and other intangible rights; and the rights to distribute, use, and reproduce general-use computer software. These transactions generate revenues in the form of royalties and licensing fees.[26] The exception is contract manufacturing, which may permit the use of intellectual property without a licensing fee.

U.S. Royalties and Fees From All Transactions

In contrast to the country's merchandise trade position, the United States runs a surplus from its trade of intellectual property (figure 6-24; appendix table 6-22). U.S. receipts from licensing of intellectual property have grown every year since 1986 (except for 2001) and in 2005 reached $57.4 billion, 9% higher than in 2004 (appendix table 6-22). U.S. payments for foreign intellectual property were $24.5 billion in 2005, 6% higher than 2004 and more than 20% higher than in 2003. The slowdown in 2005 primarily resulted from a falling off of U.S. company payments to unaffiliated foreigners. In 2004, U.S. payments to foreign companies spiked because of payments to broadcast the summer Olympic Games in Greece (BEA 2006).

In 2005, U.S. trade in intellectual property produced a surplus of $32.9 billion, up 12% from the $29.3 billion surplus recorded a year earlier (figure 6-24; appendix table 6-22). About three-quarters of transactions involved exchanges of intellectual property between U.S. companies and their foreign affiliates.[27] Companies with marketable intellectual property may prefer affiliated over unaffiliated transactions to exercise greater control over the distribution and use of this property, especially when the intellectual property is

Figure 6-24
U.S. receipts and payments of trade for intellectual property and receipts share of trade volume: 1989–2005



SOURCE: Bureau of Economic Analysis, *Survey of Current Business* 86(10):50–54 (2006). See appendix table 6-22.

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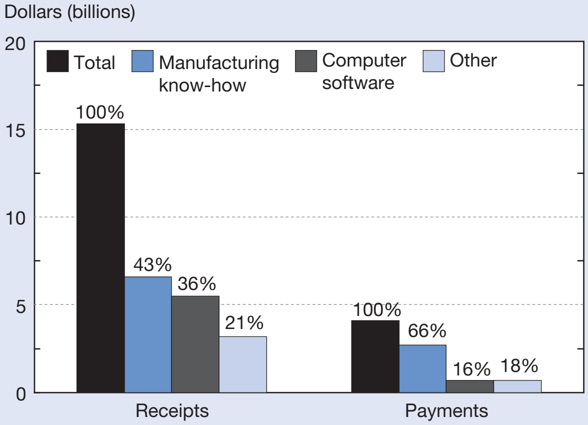
instrumental to the company's competitive position in the marketplace (Branstetter, Fisman, and Foley 2005). Despite the greater value of transactions among affiliated companies, both affiliated and unaffiliated transactions have grown at the same pace during the past two decades (appendix table 6-22). These trends suggest a greater internationalization of U.S. business activity and a growing reliance on intellectual property developed overseas.[28]

U.S. Royalties and Fees From U.S. Trade Between Unaffiliated Companies

Data on intellectual property transactions between unaffiliated companies, in which prices are set through market-based negotiation, may better reflect the value of U.S. intellectual property than data on exchanges between affiliated companies. About 80% of receipts and payments from trade of U.S. intellectual property with unaffiliated foreign companies are generated by licenses for manufacturing know-how and computer software (figure 6-25; appendix table 6-23).

Trade in manufacturing know-how as described above consists of U.S. trade in industrial processes (including patents and trade secrets) used in the production of goods. Trade in computer software consists of cross-border software licensing agreements, such as on-site licensing. When receipts (sales of manufacturing know-how and software license agreements) consistently exceed payments (purchases), these data may indicate a comparative advantage in the creation of industrial technology and licensing of computer software. These data also provide an indicator of trends in the production and diffusion of these technologies as intellectual property.

Figure 6-25
U.S. trade in intellectual property between unaffiliated companies: 2005



NOTE: Percentage of share shown above each component.

SOURCE: Bureau of Economic Analysis, *Survey of Current Business* 86(10):50–54 (2006). See appendix tables 6-23 to 6-25.

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U.S. Royalties and Fees From Trade in Manufacturing Know-How

The United States is a net exporter of manufacturing know-how sold as intellectual property (table 6-15; appendix tables 6-23 and 6-24). In 2005, the surplus from trade in manufacturing know-how was $3.9 billion, which was $1 billion greater than the 2004 surplus because of strong growth in receipts and a flat trend for payments.

The U.S. surplus from trade in manufacturing know-how is driven largely by trade with Asia (BEA 2007) (table 6-15; appendix table 6-24).[29] Asia has been the single largest consumer of U.S. manufacturing know-how for the past 20 years, led primarily by Japan.[30] With a 39% share of total receipts in 2005, Japan has historically spent more to purchase U.S. manufacturing technology than any other country. South Korea, a major consumer of U.S. manufacturing know-how since the early 1990s, had the second highest share of any country, accounting for 19% of total U.S. receipts in 2005.

China's and Taiwan's shares of total receipts are much smaller than those of Japan or South Korea, although they have increased over the past decade (table 6-15; appendix table 6-24). China's and Taiwan's shares were 3% and 6% of total receipts in 2005, respectively, at least double their levels in 1995. Asia was also an important supplier of manufacturing know-how to U.S. companies during this period, although U.S. purchases from Asia largely consisted of trade with Japan. In 2005, Asia supplied nearly 16% of U.S. manufacturing know-how licensed from foreign sources, of which close to 90% came from Japan.

Unlike trade with Asia, U.S. trade with the EU in manufacturing know-how is much more balanced (table 6-15; appendix table 6-24). Receipts from the EU were $1.3 billion in 2005, accounting for 20% of all U.S. receipts from U.S. intellectual property trade in manufacturing know-how. France, Germany, and the UK accounted for more than half

Table 6-15
U.S. royalties and fees generated from trade in manufacturing know-how between unaffiliated companies, by share of selected region/country/economy: 1995 and 2005
(Percent distribution)

Region/country/economy	Receipts		Payments	
	1995	2005	1995	2005
All royalties and fees ($billions)	3.5	6.6	0.9	2.7
All royalties and fees	100.0	100.0	100.0	100.0
Asia	69.0	69.8	34.7	15.6
China	1.5	3.0	D	0.8
Japan	44.1	38.9	32.4	14.0
South Korea	17.3	18.8	D	0.3
Taiwan	2.3	6.1	0.0	D
EU	21.5	20.2	48.6	60.9
France	2.4	2.3	12.8	19.1
Germany	4.9	5.8	11.6	7.9
United Kingdom	3.3	3.4	13.3	10.4
Other	9.5	10.0	16.6	23.5

D = suppressed to avoid disclosure of confidential information

EU = European Union

NOTES: Industrial processes (or manufacturing know-how) include patents and other proprietary inventions and technology. Affiliate refers to business enterprise located in one country directly or indirectly owned or controlled by entity in another country. Controlling interest must equal ≥10% of voting stock or equivalent. Asia includes China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, Thailand, and other unspecified Asian countries. China includes Hong Kong. Percents may not add to total because of rounding.

SOURCES: Bureau of Economic Analysis, *Survey of Current Business* 86(10):50–54 (2006). See appendix tables 6-23 and 6-24.

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of the receipts from the EU in 2005, with Germany having the largest single share among EU countries. Payments to the EU were about $1.6 billion in 2005, accounting for 61% of total payments. France, Germany, and the UK received more than half of U.S. payments to the EU to license its manufacturing know-how.

U.S. Royalties and Fees From Licensing of Computer Software

The United States is also a net exporter when licensing computer software (table 6-16; appendix tables 6-23 and 6-25). The trade surplus from computer software licensing transactions reached a record high of $4.8 billion in 2005, driven by much faster growth in receipts relative to payments. Although 2005 receipts from transactions involving manufacturing know-how ($6.6 billion) were greater than those involving computer software ($5.5 billion), U.S. companies paid almost four times as much for foreign manufacturing know-how ($2.7 billion) than for foreign computer software ($0.7 billion).

Incomplete data suggest that Asia is a large licensor of U.S. computer software (table 6-16; appendix table 6-25). Asia was responsible for more than half of all licensing fees paid to U.S. companies for computer software in 2005. Since 1998, the first year that data were collected on computer software licensing, Asia's share has steadily increased, surpassing the EU's share in 2001. Japan is the largest purchaser of U.S. computer software of any country, accounting for 31% of total U.S. receipts in 2005, which is more than 8 percentage points higher than in 1998. South Korea, the only other Asian country from which data are consistently available, had a 5% share in 2005.

The EU accounted for 30% of U.S. receipts from licensing of computer software in 2005. About three-fourths of the EU's receipts originated from France, Germany, and the UK (table 6-16; appendix table 6-25). Even so, the EU licenses more computer software to U.S. companies than any other region. In 2005, U.S. companies purchased more than 85% of the $0.7 billion spent worldwide on computer software from the EU. The EU, however, spends considerably more on licensing computer software from U.S. companies; as a result, the EU's deficit in 2005 for this trade area was $1.1 billion.

New High-Technology Exporters

Several nations are rapidly becoming more competitive in international high-technology trade. Large ongoing investments in S&T, education, and R&D[31] have supported their progress, but other factors, such as political stability, access to capital, and an infrastructure that can support technological and economic advancement, are likely to affect their ability to advance in the future.

This section presents four indicators that may be relevant to the long-term potential of developing economies to maintain or improve their competitiveness in international high-technology markets. National scores on each indicator are computed using both statistical data and systematic expert assessments (Porter et al. 2005).[32] The indicators are:

Table 6-16
U.S. royalties and fees generated from trade in computer software between unaffiliated companies, by share of selected region/country/economy: 1998 and 2005
(Percent distribution)

Region/country/economy	Receipts 1998	Receipts 2005	Payments 1998	Payments 2005
All royalties and fees ($billions)	3.2	5.5	0.5	0.7
All royalties and fees	100.0	100.0	NA	NA
Asia	37.0	51.1	NA	NA
China	2.0	D	NA	D
Japan	22.7	31.1	5.2	0.4
South Korea	D	4.9	NA	0.0
Taiwan	6.7	D	0.2	0.0
EU	42.2	30.3	89.6	86.2
France	4.8	2.0	D	D
Germany	13.9	13.3	15.3	2.7
United Kingdom	10.0	7.2	7.6	10.0
Other	20.8	18.6	NA	NA

NA = not available; D = suppressed to avoid disclosure of confidential information

EU = European Union

NOTES: Computer software includes rights to distribute and use general-use software. Affiliate refers to business enterprise located in one country directly or indirectly owned or controlled by entity in another country. Controlling interest must equal ≥10% of its voting stock or equivalent. EU includes 25 member countries following May 2004 enlargement. Bulgaria and Romania, which joined in January 2007, not included. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and other unspecified Asian countries. China includes Hong Kong.

SOURCES: Bureau of Economic Analysis, *Survey of Current Business* 86(10):50–54 (2006). See appendix tables 6-23 and 6-25.

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- **Technological infrastructure.** This term refers to the social and economic institutions that help a nation develop, produce, and market new technology. This indicator combines statistical data on the number of scientists employed in R&D and electronic data processing purchases with expert assessments of technical training and education, industrial R&D, and technological mastery.
- **Socioeconomic infrastructure.** This term refers to the social and economic institutions necessary to sustain and advance technology-based development. This indicator combines statistical data on educational attainment with expert assessments of national policies toward multinational investment and capital mobility.
- **Productive capacity.** This term refers to the physical and human resources devoted to manufacturing products and the efficiency with which these resources are used. This indicator combines statistical data on electronics production with expert assessments of the management capability and indigenous supply of skilled labor and component parts for high-technology manufactured goods.
- **National orientation.** This term refers to national policies, institutions, and public opinion that help a nation become technologically competitive. This indicator combines a statistical measure of investment risk with expert assessments of national strategy, implementation, entrepreneurship, and attitudes toward technology.

In their present form, these four indicators have been tracked for a relatively stable set of developing and industrialized countries since the early 1990s. Because these indicators were designed to forecast long-term changes in national high-technology competitiveness, especially among developing nations, analyses of whether and how they predict future competitiveness and how they compare to other measures remain preliminary and inconclusive (Porter et al. 2001).[33] As a result, the primary value of these indicators at this stage is that they synthesize a large amount of potentially relevant data in a way that enables systematic comparisons and lays the groundwork for more probing analyses in the near future.

This section examines composite scores of the four indicators in 2007 for 14 developing countries, classified as middle or low income by the World Bank. The developing countries were divided into groups of larger and smaller economies according to their 2004 GDP in 1990 purchasing power parities: larger being economies that are greater or equal to $750 billion and smaller being less than $750 billion).

According to its 2007 composite score, China is the highest ranked of the six large developing economies examined (table 6-17; appendix table 6-26). Ranked fourth a decade ago, China moved to second in 1999, then to first in 2002, overtaking India, the previous leader. China's ascent was largely driven by a near doubling of its productive capacity indicator score over the last decade. The high rankings of both China and India in part result from advantages associated with size: a large and rapidly growing domestic market, a big population, and a growing number of scientifically and technically trained graduates.

Russia's ranking has fluctuated over the last decade (table 6-17; appendix table 6-26). In 2007, it was third, ahead of Mexico and Brazil. Mexico's 2007 ranking was higher than in past cycles as a result of rising scores for all four indicators. Brazil continued a decade-long decline resulting from low or negative growth for all four indicators. Indonesia has been ranked last among the six large developing economies for much of the decade.

Among the eight smaller developing economies examined, Malaysia ranks first in future high-technology export potential, followed by Poland and Hungary (table 6-18; appendix table 6-26). Thailand, ranked fourth, improved from its seventh rank in 1999 and 2002 as a result of growth for all four indicators. South Africa, Argentina, the Philippines, and Venezuela occupy the bottom half of this group. Among these countries, the Philippines has exhibited the most change in its position during the last decade, dropping from first in 1996 to seventh in 2007. Venezuela has been the lowest-ranked of the eight countries for the last decade. Although higher-ranked than Venezuela, the remaining two countries,

Table 6-17
Ranking of future high-technology export potential for larger developing countries: Selected years, 1996–2007

Country	1996	1999	2002	2005	2007
China	4	2	1	1	1
India	2	1	3	2	2
Russia	1	4	2	4	3
Mexico	5	6	5	5	4
Brazil	3	3	4	3	5
Indonesia	6	5	6	6	6

NOTES: Countries grouped by 2007 ranking. Developing countries classified as low or middle income by World Bank. Larger economies have 2004 gross domestic product ≥$750 billion expressed in 1990 purchasing power parities. Overall indicator is simple average of raw scores of four component indicators scaled to U.S. overall score. National orientation composed of an investment risk index, and questions addressing national strategy, implementation, entrepreneurship, and attitudes toward technology. Socioeconomic infrastructure composed of educational attainment and questions on national policies toward multinational investment and capital mobility. Technological infrastructure composed of number of scientists employed in R&D, electronic data processing purchases, and questions on technical training and education, industrial R&D, and technological mastery. Productive capacity composed of electronics production, and questions on supply of skilled labor and indigenous component supply and management capability.

SOURCES: Georgia Institute of Technology, Technology Policy and Assessment Center, High Tech Indicators: Technology-Based Competitiveness of 33 Nations. 2007 Final Report to National Science Foundation, Division of Science Resources Statistics (2007); Conference Board and Groningen Growth and Development Centre, Total Economy Database (January 2007), http://www.ggdc.net/dseries/totecon.shtml; and World Bank, http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20420458~menuPK:64133156~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html.

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Table 6-18
Ranking of future high-technology export potential for smaller developing countries: Selected years, 1996–2007

Country	1996	1999	2002	2005	2007
Malaysia	2	2	3	1	1
Poland	3	3	2	3	2
Hungary	4	1	1	2	3
Thailand	5	7	7	6	4
South Africa	6	5	5	5	5
Argentina	7	6	6	7	6
Philippines	1	4	4	4	7
Venezuela	8	8	8	8	8

NOTES: Countries grouped by 2007 ranking. Developing countries classified as low or middle income by World Bank. Larger economies have 2004 gross domestic product ≥$750 billion expressed in 1990 purchasing power parities. Overall indicator is simple average of raw scores of four component indicators scaled to U.S. overall score. National orientation composed of an investment risk index, and questions addressing national strategy, implementation, entrepreneurship, and attitudes toward technology. Socioeconomic infrastructure composed of educational attainment and questions on national policies toward multinational investment and capital mobility. Technological infrastructure composed of number of scientists employed in R&D, electronic data processing purchases, and questions on technical training and education, industrial R&D, and technological mastery. Productive capacity composed of electronics production, and questions on supply of skilled labor and indigenous component supply and management capability.

SOURCES: Georgia Institute of Technology, Technology Policy and Assessment Center, High Tech Indicators: Technology-Based Competitiveness of 33 Nations. 2007 Final Report to National Science Foundation, Division of Science Resources Statistics (2007); Conference Board and Groningen Growth and Development Centre, Total Economy Database (January 2007), http://www.ggdc.net/dseries/totecon.shtml; and World Bank, http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20420458~menuPK:64133156~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html.

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South Africa and Argentina, have consistently ranked in the bottom half of this group.

S&E Publications in Peer-Reviewed Journals

Output indicators in the form of articles appearing in the research literature are discussed in Chapter 5 because academic researchers account for most of those articles. This section focuses on trends first in the number and share of S&E articles produced by authors affiliated with industry, then in their collaboration patterns with other U.S. sectors and internationally.[34]

Number of Articles

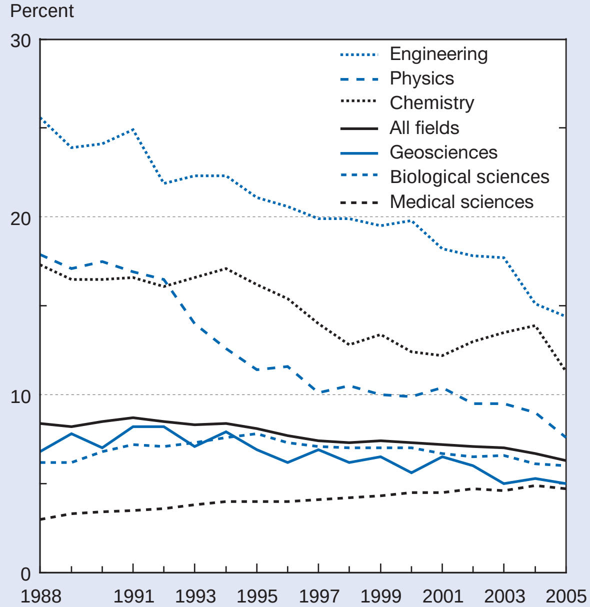
Trends in the number of S&E articles written by industrial researchers that appear in peer-reviewed journals, while not a direct indicator of innovation, are a rough indicator of outputs from research being carried out in industrial settings. This section examines the total number of articles authored by industry researchers as an indicator of overall industrial research activity, and the number of articles by these researchers published in basic research journals as an indicator of the volume of basic research carried out in industrial laboratories.[35]

Articles With an Industrial Author

The number of scientific articles with at least one author in U.S. private industry fluctuated between about 13,000 and 16,000 per year between 1988 and 2005, peaking at slightly more than 16,000 in 1991, then falling to its lowest level just below 13,000 in 2004. During this same period, however, the total number of U.S. S&E articles increased from 169,000 to 215,000 (appendix table 6-27). Consequently, industry's overall share of U.S. article output declined from just below 9% to about 6% (figure 6-26).

Six broad fields accounted for about 90% of the S&E literature by U.S. industry authors from 1988 to 2005: biological sciences, medical sciences, engineering, chemistry, physics, and the geosciences. With one exception, the number of industry articles peaked in 1995 or earlier for all of

Figure 6-26
U.S. S&E articles by authors in private industry as share of all U.S. S&E articles, by selected field: 1988–2005



NOTES: Fields are those in which authors from private industry made significant contribution (500+ articles/year). Percentages based on fractional counts and an expanding journal set.

SOURCES: Thomson Scientific, Science Citation Index and Social Sciences Citation Index, http://www.scientific.thomson.com/products/categories/citation/; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix table 6-27.

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these fields. The exception is medical sciences, for which articles increased throughout the period, peaking in 2005. In four of these broad fields, industry's share of all U.S. articles in the field declined between 1988 and 2005, from 26% to 14% in engineering, 18% to 8% in physics, 17% to 11% in chemistry, and 7% to 5% in the geosciences. Industry's share of articles in the biological sciences remained stable throughout the period (between 6% and 8%), whereas its share of articles in the medical sciences increased (from 3% to 5%) (figure 6-26).

Articles in Basic Research Journals

Between 1988 and 1995, the total number of basic research articles having authors in U.S. private industry fluctuated between 3,400 and 4,200 per year (appendix table 6-28). However, after peaking in 1995, the number declined by 30% through 2005. In contrast, the total number of basic research articles by authors from all sectors grew between 1995 and 2005. As a result, industry's share of this output declined, from slightly more than 6% to 4% (figure 6-27).

Five broad fields accounted for about 95% of the basic research literature by U.S. industry authors during the entire 18-year period: biological sciences, chemistry, physics, the geosciences, and the medical sciences. The trend in the number of basic research articles by U.S. industry researchers in the biological, medical, and geosciences, as a percentage of basic research articles in those fields, generally mirrored the trend for all fields, with gradual declines in share of about 1 percentage point.

Article output by U.S.-industry authors in physics and chemistry showed notably different patterns. In physics, the total number of these articles decreased sharply from nearly 1,000 in 1988 to about 300 in 2005. As a result, industry's share of basic research articles in physics dropped by more than 7 percentage points (figure 6-27). Most of this decline is accounted for by widespread restructuring of a few large corporations during this period, including closure, downsizing, or reorientation of large central research laboratories. Increased globalization, intensified competition, and commercial priorities may have contributed to the decline in publishing by companies and their researchers.

The pattern in chemistry has been different. U.S.-industry authors' share of basic research articles in chemistry fluctuated between 9% and 13% over the period. Researchers at large pharmaceutical companies continued or increased their already strong publishing traditions in chemistry basic research journals despite consolidation within the industry. The pharmaceutical industry's far greater reliance on patents and exclusivity for intellectual property protection relative to other industries may have played a role in its continued strong publishing record. Beyond pharmaceuticals, some of the same companies that saw declines in physics basic research articles also declined in chemistry.

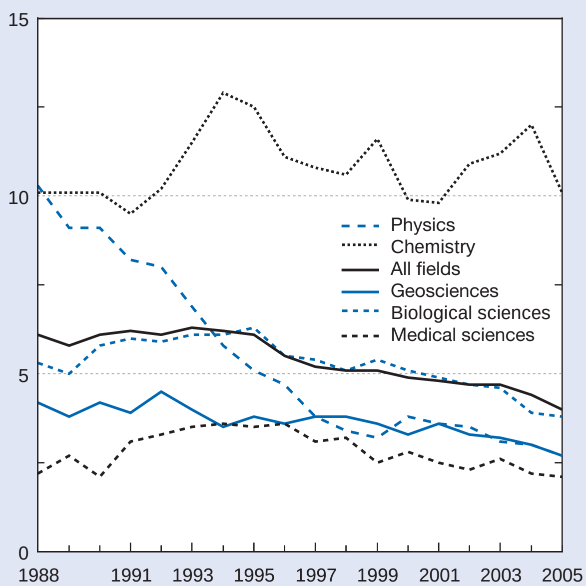
Changing Emphasis on Basic Research

Industrial publications tended to shift away from basic research between 1988 and 2005. After peaking at 26% in 1995, the percentage of articles with an industrial author published in basic research journals declined to 22% by 2005 (figure 6-28).[36] This declining emphasis on basic research in industry publications has been especially strong in the biological sciences (from around 50% in the early 1990s to 39% in 2005), in physics (from 31% in 1988 to 20% in 2005), and in the medical sciences (from 10% in the early- to mid-1990s to 5% in 2005). Again, however, the pattern in chemistry has been quite different. The basic research share of industrially authored articles in chemistry increased from around 30% during the late 1980s to 46% in 2005.

Industry Collaboration in Publications

Both in the United States and worldwide, a major increase in collaboration across sectors and countries on S&E publications has been evident during the past decade. (For a more complete discussion of collaboration patterns, see "Coauthorship and Collaboration" and "Trends in Output and Collaboration Among U.S. Sectors" in chapter 5.)

Figure 6-27
U.S. S&E basic research articles by authors in private industry as share of all U.S. S&E basic research articles, by selected field: 1988–2005



NOTES: Fields have basic research journals to which authors from private industry make significant contribution (100+ articles/year). Percentages based on fractional counts and an expanding journal set.

SOURCES: Thomson Scientific, Science Citation Index and Social Sciences Citation Index, http://www.scientific.thomson.com/products/categories/citation/; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix table 6-28.

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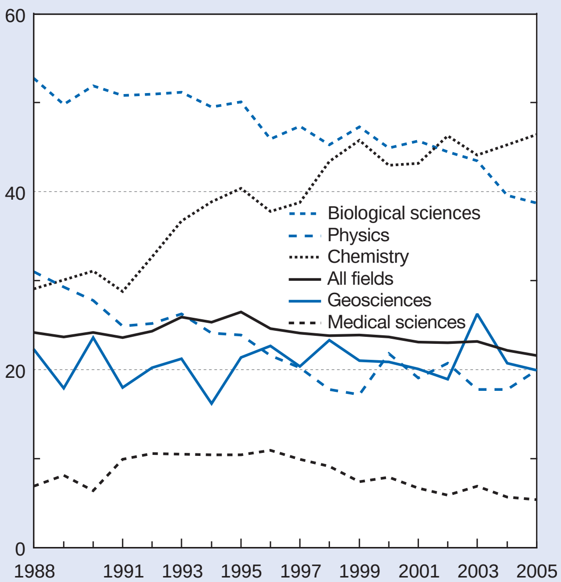
Figure 6-28
Industry S&E basic research articles as share of all industry S&E articles, by selected field: 1988–2005



NOTES: Fields have basic research journals to which authors from private industry make significant contribution (100+ articles/year). Percentages based on fractional counts and an expanding journal set.

SOURCES: Thomson Scientific, Science Citation Index and Social Sciences Citation Index, http://www.scientific.thomson.com/products/categories/citation/; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix table 6-28.

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Articles by Institutional Author Type

Articles with one or more authors in private industry can be broken down into five unique types:

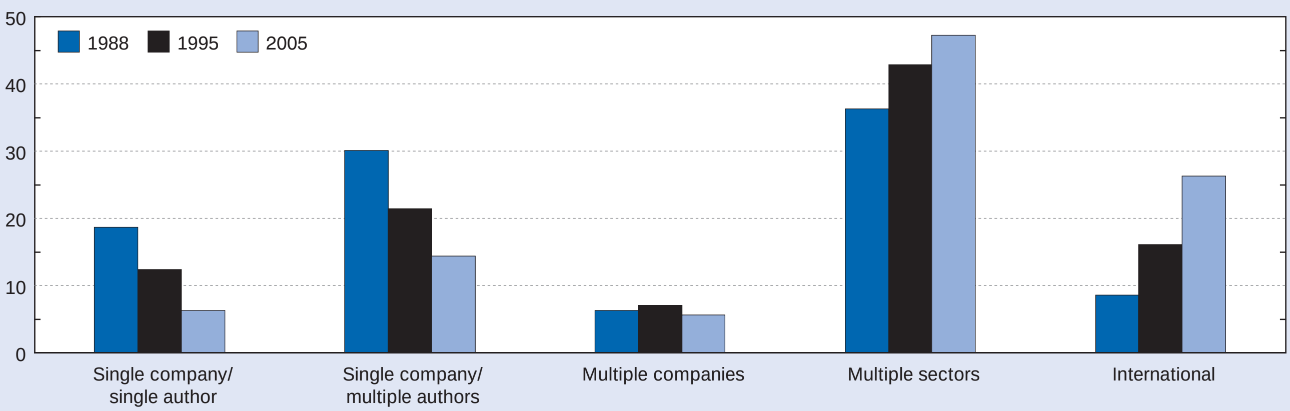
- Single company-single author[37]
- Single company-multiple authors
- Multiple companies, with authors from more than one U.S. company
- Multiple sectors, with U.S. authors from more than one sector[38]
- International, with at least one foreign author.

Between 1988 and 2005, single company-single author articles declined by almost 60% (to about 2,000) and single company-multiple author articles declined by almost 40% (also to about 2,000) (appendix table 6-29). Multiple-company articles increased by 20% during this period. In contrast, multiple-sector articles and international articles increased by about 70% and 300%, respectively (about 5,000 in both cases). The net result of these trends were drops from 19% to 6% in the proportion of single company-single author articles and from 30% to 14% for single company-multiple author articles. During the period, international articles increased from 9% to 26% and multiple-sector articles increased from 36% to 47% (figure 6-29).

Industry Collaboration Across U.S. Sectors

Coauthorship data indicate that U.S. industry collaborates more frequently with the academic sector than with other U.S. sectors.[39] Since 1988, more than 60% of the articles that industry authors have coauthored with someone outside their company have had an academic coauthor (appendix table 6-30). This is

Figure 6-29
S&E articles with industry authors, by institutional author type: 1988, 1995, and 2005



NOTE: Percentages based on whole counts and an expanding journal set.

SOURCES: Thomson Scientific, Science Citation Index and Social Sciences Citation Index, http://www.scientific.thomson.com/products/categories/citation/; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix table 6-29.

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not unexpected, because the vast majority of S&E articles with a U.S. author include an author from academia.

Although the number of industry articles not limited to a single company increased substantially between 1988 and 2005, collaboration patterns between industry and other sectors changed very little during that period (figure 6-30). The only sector in which a large change in collaboration has occurred is the private nonprofit sector. The proportion of industry articles coauthored with the private nonprofit sector steadily increased from 9% to 15% from 1988 to 2005.

Global Trends in Patenting

To foster inventiveness, nations assign property rights to inventors in the form of patents. These rights allow the inventor to exclude others from making, using, or selling the invention for a limited period of time in exchange for publicly disclosing details and licensing the use of the invention.[40] Inventors obtain patents from government-authorized agencies for inventions judged to be "new…useful…and…nonobvious."[41]

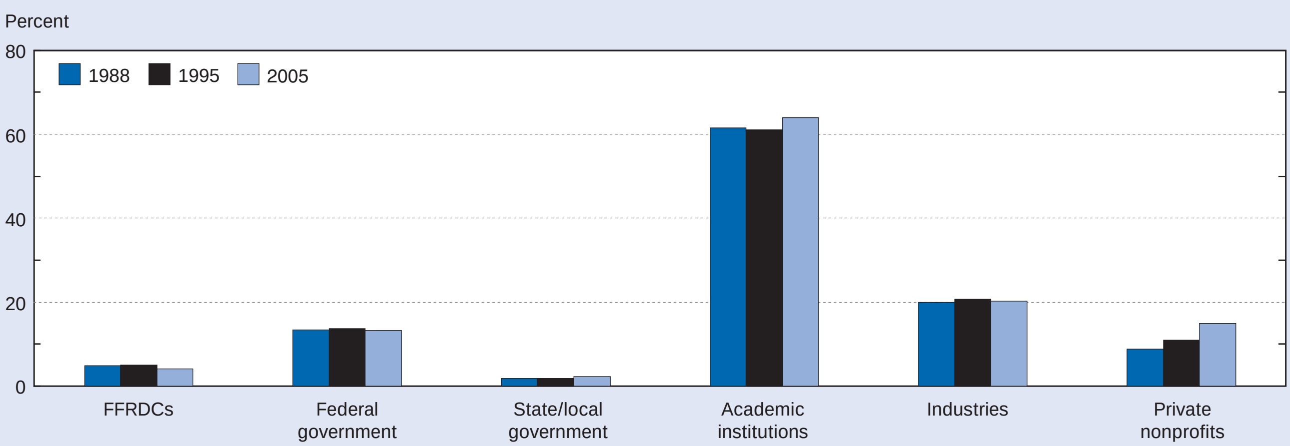
Patented inventions are of great economic importance when they result in new or improved products or processes or even entirely new industries, and, as is increasingly the case, when their licensing provides an important source of revenue. Worldwide revenues from patent licensing increased from $15 billion in 1990 to $110 billion in 2000 (Idris 2003).

This discussion focuses on patent activity at the U.S. Patent and Trademark Office (USPTO) and the European Patent Office (EPO).[42] These two patent offices are among the largest in the world in terms of volume of patents and have a significant share of applications and grants from foreign inventors.[43] The size and openness of the U.S. and EU markets offer potentially higher returns than smaller markets. Therefore, many domestic and foreign companies sell new products and services there and have a strong incentive to patent their inventions in both the United States and the EU.

These market attributes make data on patenting in the United States and Europe informative for the purpose of identifying trends in global inventiveness. Patenting indicators have several well-known drawbacks, however, including:

- **Incompleteness.** Many inventions are not patented at all, in part because laws in some countries already protect industrial trade secrets.
- **Inconsistency across industries and fields.** The propensity to patent and the type and intensity of R&D differ by industry and technology area. For example, pharmaceutical companies patent more heavily and engage in years of costly R&D before achieving a fundamental breakthrough, whereas computer software companies patent less heavily and achieve more rapid but generally more incremental breakthroughs.
- **Inconsistency in importance.** The importance of patented inventions can vary considerably. Inventors may use other methods to protect their inventions, such as secrecy and product lead time. In addition, entities with large patent portfolios manage these carefully to control the cost of filing, maintaining, and defending their patents, including assessing the marginal benefits of potential new patents.
- **Varying motivations for patenting.** Inventors may patent for reasons other than commercialization or licensing,

Figure 6-30
Industry-coauthored S&E articles, by sector of coauthorship: 1988, 1995, and 2005



FFRDC = federally funded research and development center

NOTES: Percentages based on whole counts and an expanding journal set. Percents do not add to 100 because an article can have coauthors from multiple sectors.

SOURCES: Thomson Scientific, Science Citation Index and Social Sciences Citation Index, http://www.scientific.thomson.com/products/categories/citation/; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix table 6-30.

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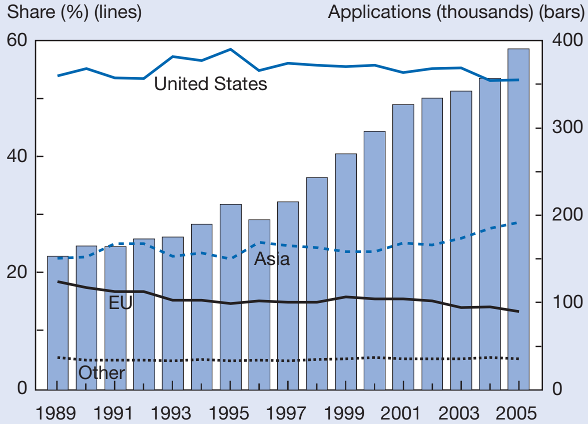
Figure 6-31
USPTO patent applications and share of total, by inventors from selected regions/countries/economies: 1989–2005



EU = European Union; USPTO = U.S. Patent and Trademark Office

NOTES: Patent applications assigned to region/country/economy based on residence of first-named inventor. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCES: USPTO, Number of Utility Patent Applications Filed in the United States, By Country of Origin, Calendar Years 1965 to Present (1), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.htm, accessed 15 December 2006; and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix tables 6-29 to 6-31 and 6-35.

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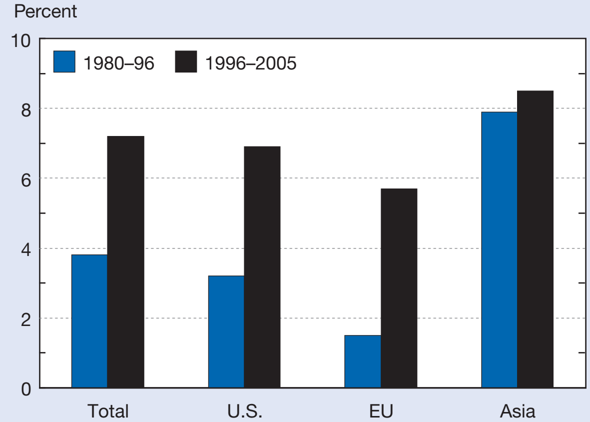
Figure 6-32
Average annual growth rate of USPTO patent applications for inventors from selected regions/countries/economies: 1980–2005



EU = European Union; USPTO = U.S. Patent and Trademark Office

NOTES: Patent applications assigned to region/country/economy based on residence of first-named inventor. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCES: USPTO, Number of Utility Patent Applications Filed in the United States, By Country of Origin, Calendar Years 1965 to Present (1), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.htm, accessed 15 December 2006; and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix tables 6-29 and 6-30.

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including blocking rivals from patenting related inventions, using patents as a tactic to negotiate with competitors, and helping to prevent infringement lawsuits (Cohen, Nelson, and Walsh 2000).

This discussion of patenting trends somewhat mitigates the above limitations by: (1) presenting data from two major markets, the United States and Europe; (2) looking at trends in key technology and industry areas, information and communications technology (ICT), and biotechnology; and (3) looking at trends in triadic patents, which are inventions valuable enough to patent in the three largest world markets, i.e., the United States, Europe, and Japan. With these adjustments, patent data may serve as an approximate indicator of inventiveness over time. In addition, information about foreign inventors seeking patents in the United States and Europe may offer some insights into inventiveness in and new technological competition from foreign countries (see sidebar, "Comparison of Data Classification Systems Used"). The discussion also examines data on U.S. patents granted to U.S. inventors by type of ownership and by state.

Applications for Patents in the United States and Europe

Trends in the number and sources of patent applications provide indicators of new sources of high-technology competition. Because the time from patent application to grant has grown rapidly in the United States and now averages 2–4 years in both the United States and Europe, data on patent filings provide a more instantaneous look at inventive trends than data on patents granted.[44] However, patent applications provide a less-definitive indicator of inventiveness compared with patent grants because some applications are rejected by the patent office or withdrawn by the inventor.

Applications for U.S. Patents

Applications filed for U.S. patents numbered more than 390,000 in 2005, a 9% increase from 2004, continuing the trend of strong growth over the past decade (figure 6-31; appendix tables 6-31 and 6-32). Starting in the mid-1990s, the growth rate of USPTO applications doubled compared with the 1980s and the early 1990s (figure 6-32). The acceleration of U.S. patent applications coincided with a strengthening of the patent system and extension of patent protection into new technology areas through policy changes and judicial decisions during the 1980s and 1990s (NRC 2004).

Inventors residing in the United States filed 208,000 applications in 2005, a little more than half of all U.S. patent applications filed that year.[45] Again starting in the mid-1990s, the growth rate for patent filings by U.S. inventors accelerated, but not as fast as the growth rate for filings by foreign inventors; the U.S. share dropped from 55% in 1996 to 53% in 2005 (appendix table 6-33). This may be indica-

U.S. Patents Granted by State and Type of Ownership

Examination of USPTO-issued patents provides information on patenting activity by U.S. states and type of ownership. More than half of USPTO patents issued to the United States come from seven states: California, Texas, New York, Michigan, Massachusetts, New Jersey, and Illinois (table 6-19; appendix tables 6-34 and 6-35). These seven top patenting states are among the top 10 states that accounted for almost two-thirds of U.S. R&D expenditures (see Chapter 4). California, which has the largest single share of any state, has showed a steady increase in its share from 15% in 1993 to 24% in 2005.

When patent output by U.S. states is adjusted for their population, however, the rankings change considerably. Two states with small populations, Idaho and Vermont, are ranked first and second, respectively, in their per capita output of U.S. patents in 2005 (figure 6-33; appendix table 6-36). Two of the six top patenting states, California and Massachusetts, however, remain highly ranked on a per capita basis.

Patents granted to U.S. inventors can be further analyzed by patent ownership at the time of the grant. Ownership is assigned on the basis of the first-named organization listed on the patent. Corporations own the majority of patents granted to U.S. entities, and their share has been steadily increasing since the early 1990s (figure 6-34). The PTO defines the corporate sector to include U.S. corporations, small businesses, and educational institutions. U.S. universities and colleges owned about 4% of U.S. utility patents granted to corporations in 2003. (For further discussion of academic patenting, see chapter 5.)

Almost all patents are issued to either corporations or individuals. In 2005, U.S. corporations owned 86% of patents issued to U.S. inventors, with individuals owning 14%; in 1992, the respective shares were 74% and 24%. Corporations also own the majority of U.S. patents issued to the rest of the world, and that share also has been increasing over the past decade. The share of individual ownership in patents issued to the rest of the world, which is about half of the level in the United States, has also fallen since the early 1990s.

Table 6-19
USPTO patents granted to inventors of selected states: Selected years, 1993–2005
(Percent)

State	1993	1995	1997	1999	2001	2003	2005
U.S. patents issued to all states (number)	53,231	55,739	61,708	83,905	87,600	87,893	74,637
Total of seven states	50.9	51.0	51.6	52.3	52.9	52.9	53.2
California	15.3	16.6	18.3	20.0	21.2	22.4	24.1
Texas	6.4	7.0	6.7	7.2	7.3	6.9	7.1
New York	8.8	8.4	7.8	7.3	7.2	7.1	6.3
Michigan	5.4	5.0	4.6	4.4	4.4	4.4	4.5
Massachusetts	4.1	3.9	4.2	4.2	4.2	4.4	4.2
New Jersey	5.5	4.9	5.2	4.8	4.4	4.0	3.4
Illinois	5.3	5.2	4.9	4.5	4.2	3.8	3.7

USPTO = U.S. Patent and Trademark Office

NOTE: Patents assigned to state based on residence of first-named inventor.

SOURCES: Patents By Country, State, and Year-Utility Patents (December 2006), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utl.htm, accessed 15 February 2007. See appendix tables 6-34 and 6-35.

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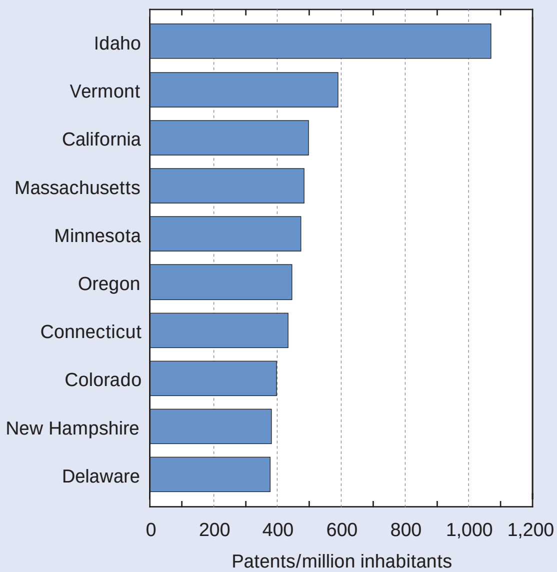
tive of increased globalization and increased recognition by developing countries of the potential value of intellectual property. Most USPTO patents credited to the United States are owned by corporations and granted to inventors in six states (see sidebar, "U.S. Patents Granted by State and Type of Ownership").[46]

Asia and the EU are the main sources of inventors outside of the United States filing for U.S. patent applications. Inventors residing in these two regions filed nearly 90% of applications filed by foreign inventors. Asia was the first-ranked foreign source in 2005, filing 112,000 U.S. patent applications (figure 6-31; appendix tables 6-31 and 6-32). Applications from Asia increased at a faster rate than those from the United States and the EU between 1985 and 2005 (figure 6-32), and Asia's share of U.S. patent filings increased from 19% to 29% during this period (appendix table 6-33). Japan, which produced much of the increase in Asia's share prior to the early 1990s, showed slower growth than the rest of Asia between 1996 and 2005 (table 6-20; appendix table 6-33). The three Asian economies of China, South Korea, and Taiwan drove the increase in Asia's share of U.S. patent filings between 1996 and 2005:

- ♦ China's applications grew eightfold, and its share of U.S. patent filings quadrupled from 0.2% to 0.8%. China's share ranking moved from 20th place in 1995 to 12th place in 2005 (appendix tables 6-37 and 6-38).

Figure 6-33
USPTO patents granted per capita for inventors from selected U.S. states: 2005



USPTO = U.S. Patent and Trademark Office

NOTES: Patents assigned to state based on residence of first-named inventor. States ranked by number of 2005 patents per million inhabitants in 2005.

SOURCES: USPTO, Patents By Country, State, and Year - Utility Patents, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utl.htm (December 2006); and Census Bureau, Annual Estimates of the Population for the United States, Regions, and States and for Puerto Rico: April 1, 2000 to July 1, 2006 (NST-EST2006-01), http://www.census.gov/popest/states/NST-ann-est.html, accessed 15 December 2006. See appendix table 6-34.

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- South Korea's applications quadrupled, doubling its share of U.S. patent filings from 2.2% to 4.4%. South Korea's rapid growth caused its share ranking to move from eighth in 1995 to fourth in 2005, moving past France, the UK, and Canada (appendix tables 6-37 and 6-38).
- Taiwan's applications more than tripled, and its share of U.S. patent filings advanced from 2.4% to 4.3%. Taiwan's share ranking moved from seventh to fifth place, moving past the same countries overtaken by South Korea (appendix tables 6-37 and 6-38).
- India's applications grew more than 12-fold, but from an extremely low base, and its share of U.S. patent filings rose from 0.1% to 0.4%. India's share ranking moved from 29th to 17th during this period (appendix tables 6-37 and 6-38).

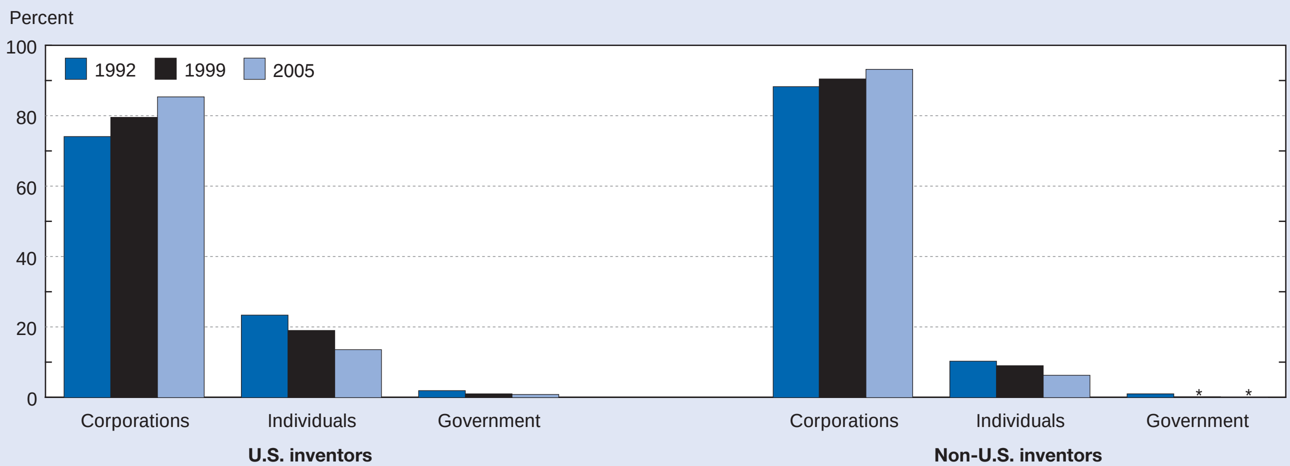
From 1996 to 2005, USPTO applications from the EU rose at the slowest rate of the three major world economies, and the EU's share of U.S. patent filings fell from 15% to 13% (figure 6-31; appendix tables 6-31 and 6-32).[47] The share of U.S. patent applications from inventors in France, Germany, and the UK, as a group, declined from 11% to 9% during this period.

A comparison of shares of USPTO patents granted among the three major world economies, the United States, Asia, and the EU, reveals trends similar to those observed concerning their applications (appendix tables 6-39 and 6-40).

Applications for European Patents

Applications for EPO patents reached nearly 114,000 in 2004, a 1% increase from 2003 (figure 6-35; appendix tables 6-41 and 6-42). The growth rate of EPO applications

Figure 6-34
USPTO patents granted, by type of ownership: 1992, 1999, and 2005



* = < 0.5

USPTO = U.S. Patent and Trademark Office

NOTES: Corporations refer to private, nonprofit, and educational institutions. Bulk of corporate patents originate from private companies.

SOURCE: USPTO, All Technologies (Utility Patents) Report, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/all_tech.htm, accessed 15 December 2006.

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Table 6-20
USPTO patent applications for inventors from selected Asian regions/countries/economies: 1996, 2001, and 2005

Region/country/economy	1996		2001		2005	
	Number	World share (%)	Number	World share (%)	Number	World share (%)
Asia	49,249	25.2	81,966	25.1	111,620	28.6
China	364	0.2	1,252	0.4	2,943	0.8
India	115	0.1	643	0.2	1,463	0.4
Japan	39,510	20.2	61,238	18.8	71,994	18.4
South Korea	4,248	2.2	6,719	2.1	17,217	4.4
Taiwan	4,766	2.4	11,086	3.4	16,617	4.3

USPTO = U.S. Patent and Trademark Office

NOTES: Patent applications assigned to region/country based on residence of first-named inventor. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCES: USPTO, Utility Patent Applications by Country of Origin, Calendar Years 1965–2005, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.htm, accessed 15 December 2006. See appendix tables 6-32, 6-33, and 6-37.

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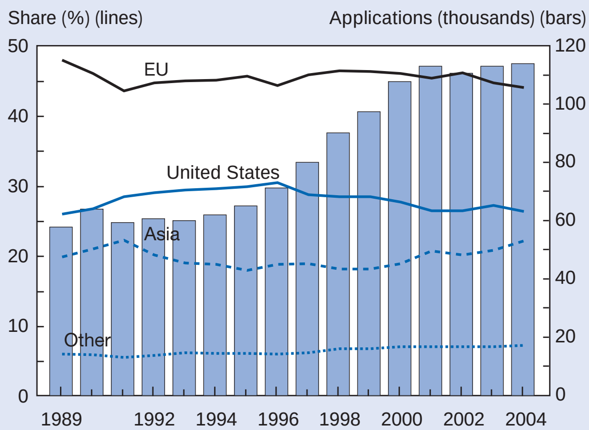
Figure 6-35
EPO patent applications and share of total, by inventors from selected regions/countries/economies: 1989–2004



EPO = European Patent Office; EU = European Union

NOTES: Patent applications assigned to year based on application date to EPO. Patent applications on fractional-count basis. For patent applications with multiple inventors from different countries, each country receives fractional credit based on proportion of its participating inventors. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Organisation for Economic Co-operation and Development, Patent database, http://stats.oecd.org/wbos/default.aspx?DatasetCode=PATS_IPC, accessed 15 February 2007. See appendix tables 6-31, 6-39, and 6-40.

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picked up in the mid-1990s, which is similar to the trend for USPTO applications except that EPO applications began to flatten starting in 2001.

The EPO received 30,000 patent applications from U.S. inventors in 2004, making the United States the first-ranked foreign source of EPO filings (appendix table 6-42). The growth rate of U.S. applications to the EPO picked up in the mid-1990s but leveled off starting in 2001, paralleling the growth trend of EPO applications by all countries (appendix tables 6-41 and 6-42).[48] Comparing U.S. applications to the EPO with those filed by inventors from the EU and Asia, the U.S. number grew at the slowest rate between 1996 and 2004, resulting in a decline of the U.S. share of filings at the EPO from 31% to 26% during this period (figure 6-35).

As expected, EU inventors have the largest share at the EPO with 44% of total applications in 2004 (figure 6-35; appendix table 6-33). The EU's EPO share remained flat between the mid-1990s and 2004, although the shares of some EU countries changed. The combined EPO share of France and the UK fell from 13% to 11% between 1996 and 2004, offset by small gains by Germany, the Netherlands, Spain, and several other countries.

Asia's EPO applications grew faster than those from the EU or the United States, and Asia's share of total patent filings at the EPO rose from 19% in 1996 to 22% in 2004 (figure 6-35; appendix table 6-33). During this same period, the share gap between the United States and Asia narrowed from 12 percentage points to 4. The same Asian economies that led Asia's patent filings at the USPTO, which were China, South Korea, and Taiwan, drove the rise in Asia's share of EPO patent applications.

A comparison of shares of EPO patents granted among the three major world economies, the United States, Asia, and the EU, reveals trends similar to those observed in their applications (appendix tables 6-43 and 6-44). Gains in EPO patents granted to China, India, South Korea, and Taiwan, however, have been lower than gains in EPO applications.

Patents Granted for Information and Communications Technology and Biotechnology

When inventions result in new or improved products or processes, patent owners can reap economic benefits that, in turn, typically spill over to users and consumers. Inventions that lead to the creation of entire new industries, however, have a more profound impact on national and global economies. Two examples of the latter are ICT and biotechnology patents.

ICT patents have helped to create new industries and products such as home computers, cellular phones, and wireless devices. ICT technology has revolutionized and improved productivity in non-ICT industries and services, such as the health, finance, and retail sectors.

Biotechnology research and patents have led to entirely new industries that closely collaborate with and rely on basic research from the academic, government, and nonprofit sectors. Biotechnology patents have led to fundamental breakthroughs such as mapping the human genome and creating new diagnostic and therapeutic products. This section examines recent trends in ICT and biotechnology patenting in the United States and Europe and identifies countries that are the source for most of the ICT and biotechnology patenting in these two major markets.[49]

ICT Patenting

The numbers of ICT patents granted by the USPTO and EPO have increased rapidly over the past decade and a half (table 6-21; appendix tables 6-45 and 6-46). Between 1993 and 2006, the number of ICT patents granted by USPTO tripled, and the ICT share of all USPTO patents almost doubled from 26% to 49% (table 6-22; figure 6-36). ICT patents granted by the EPO grew less dramatically. Even so, they almost doubled, and the ICT share of EPO patents rose from 24% in 1993 to 28% in 1996, then flattened out before increasing to 29% in 2006.

Table 6-22

ICT and biotechnology patents share of total USPTO and EPO patents granted: Selected years, 1993–2006

Industry/agency	1993	1996	2000	2003	2005	2006
ICT						
EPO	23.6	28.1	27.3	25.3	27.2	29.2
USPTO	26.3	31.6	34.9	39.9	45.6	49.3
Biotechnology						
EPO	3.2	2.9	3.1	2.9	3.9	4.6
USPTO	2.0	2.8	3.6	3.1	2.9	3.3

EPO = European Patent Office; ICT = information and communications technology; USPTO = U.S. Patent and Trademark Office

NOTES: ICT includes telecommunications, consumer electronics, computers and office machinery, and other ICT as defined by Organisation for Economic Co-operation and Development (OECD). Biotechnology defined by OECD. Patent counts on fractional-count basis. For patent grants with multiple inventors from different countries, each country receives fractional credit based on proportion of its participating inventors.

SOURCES: OECD, Patent database, http://stats.oecd.org/wbos/default.aspx?DatasetCode=PATS_IPC, accessed 15 February 2007. See appendix tables 6-39, 6-40, and 6-43 to 6-45.

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Table 6-21

Share and activity index of ICT patents granted by USPTO and EPO, by inventors from selected regions/countries: 1993, 1999, and 2006

	1993		1999		2006	
Agency and region/country	Share (%)	Activity index	Share (%)	Activity index	Share (%)	Activity index
USPTO						
All regions (number)	25,830	na	51,258	na	77,982	na
United States	48.0	0.89	51.5	0.95	50.4	0.98
Asia	37.9	1.52	35.4	1.39	34.6	1.17
EU	11.4	0.68	10.0	0.64	10.8	0.76
EPO						
All regions (number)	8,643	na	9,803	na	17,256	na
United States	27.1	1.20	28.4	1.14	25.5	1.13
Asia	31.1	1.49	33.5	1.60	29.2	1.38
EU	38.5	0.76	34.2	0.71	40.1	0.80

na = not applicable

EPO = European Patent Office; EU = European Union; ICT = information and communications technologies; USPTO = U.S. Patent and Trademark Office

NOTE: ICT includes telecommunications, consumer electronics, computers and office machinery, and other ICT as defined by Organisation for Economic Co-operation and Development (OECD). Patent counts on fractional-count basis. For patent grants with multiple inventors from different countries, each country receives fractional credit based on proportion of its participating inventors. ICT activity index is region/country's share of ICT patents adjusted for its share of all patents. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCES: OECD, Patent database, http://stats.oecd.org/wbos/default.aspx?DatasetCode=PATS_IPC, accessed 15 February 2007. See appendix tables 6-45 to 6-47.

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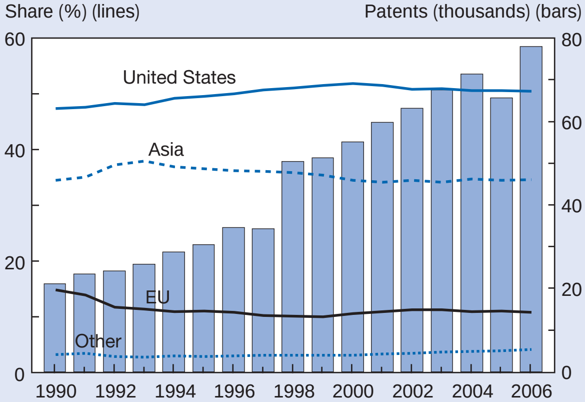
Figure 6-36
USPTO ICT patents granted and share of total, by inventors from selected regions/countries/economies: 1990–2006



EU = European Union; ICT = information and communications technologies; USPTO = U.S. Patent and Trademark Office

NOTES: ICT consists of telecommunications, consumer electronics, computers and office machinery, and other ICT as defined by Organisation for Economic Co-operation and Development (OECD). Patent counts on fractional-count basis. For patent grants with multiple inventors from different countries, each country receives fractional credit on basis of proportion of its participating inventors. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCES: OECD, Patent database, http://stats.oecd.org/wbos/default.aspx?DatasetCode=PATS_IPC, accessed 15 February 2007; and Compendium of Patent Statistics 2006,www.OECD.org/sti/ipr-statistics. See appendix tables 6-43 and 6-44.

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The United States has the largest share of ICT patents granted by the USPTO (figure 6-36; appendix tables 6-45 and 6-46). The U.S. activity index in USPTO ICT patents (the U.S. share of USPTO ICT patents compared with its share of all USPTO patents) is an indicator of U.S. patenting intensity in ICT compared with other technology areas. The U.S. activity index is around 1.0, which indicates that U.S.-resident inventors show about the same propensity to patent in ICT as in other technology areas (table 6-21; appendix table 6-47). In Europe, the United States is ranked third in share of EPO ICT patents granted. The U.S. inventor activity index at the EPO (1.13 in 2006), however, unlike its activity index at the USPTO, indicates that U.S. inventors have a higher propensity to patent ICT compared with other technologies.

Asia is ranked second in ICT at both patent offices among the three major economic areas (table 6-21; appendix tables 6-45 and 6-46). Asia's inventors also patent more intensively in ICT compared with other technology areas, according to its activity indexes (table 6-21; appendix table 6-47). A decline in its index for ICT over the past decade, however, indicates that Asia may be expanding its patenting activity to other technology areas. Japan has the largest share of world ICT patents of any Asian economy, although its share has fallen as South Korea and Taiwan have increased their patenting of ICT. ICT patents issued by the United States and the EPO to China and by the United States to India have sharply increased recently, although from very low levels.

The EU has a significantly lower presence in ICT patents compared with the United States and Asia (figure 6-36; appendix tables 6-45 and 6-46). The EU's activity index (0.76 in the USPTO and 0.80 in the EPO) indicates that the EU patents less intensively in ICT compared with other technology areas in both patent offices (appendix table 6-47). Five EU countries, however, do patent more intensively in ICT compared with the rest of the EU. In the USPTO and EPO, Finland and Ireland emphasize ICT compared with other technology areas, and the UK patents at about the same level of intensity in ICT as for other technology areas. Sweden and the Netherlands patent with the EPO more intensively in ICT than for other technology areas.

Biotechnology Patents

The number of biotechnology patents granted by the USPTO accelerated rapidly in the mid-1990s, almost doubling its share of all patents granted between 1993 and 2000 (figure 6-37; table 6-22; appendix tables 6-48 and 6-49).[50] The growth trend stopped and turned negative starting in 2001, however, and the biotechnology share of USPTO patents declined from 4% to 3% from 1998 to 2006. Biotechnology patents issued by the EPO, on the other hand, grew in volume between 2001 and 2006.[51] In 2004, the biotechnology share of all patents granted by the EPO surpassed that granted by the USPTO.

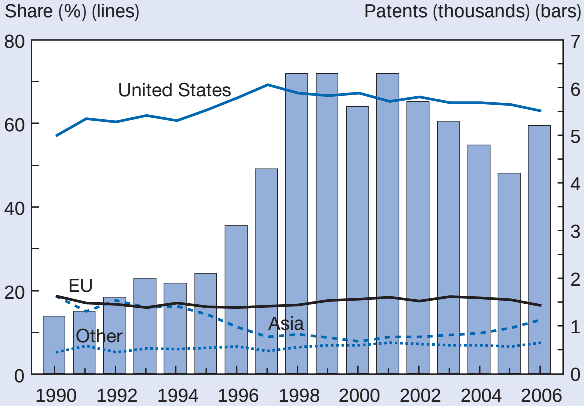
U.S. resident inventors have the largest share of biotechnology patents granted by the USPTO and EPO (table 6-23; appendix tables 6-48 and 6-49). The U.S. activity index in biotechnology patenting indicates that inventors residing in the United States patent more intensively in biotechnology compared with other technology areas within both patent offices. Asia has the smallest share of biotechnology patents from both patent offices compared with those of the United States and the EU. Asia's activity index in biotechnology patents also shows less emphasis on biotechnology than is evident within the United States and the EU.

The EU, on the other hand, ranks second to the United States in its share of biotechnology patents from both patent offices, although its activity index in EPO biotechnology patents indicates less-intensive patenting in biotechnology compared with other technology areas. The EU's activity index in USPTO, however, indicates a higher level of intensity in biotechnology compared with other technology areas (table 6-23).

Patenting of Valuable Inventions: Triadic Patent Families

One limitation of using patent counts as an indicator of national inventive activity is that such counts cannot differentiate between minor inventions and highly important inventions. A database has been developed that helps to address this problem by counting only those inventions for which patent protection is sought in the world's three largest

Figure 6-37
USPTO biotechnology patents granted and share of total, by inventors from selected regions/countries: 1990–2006



EU = European Union; USPTO = U.S. Patent and Trademark Office

NOTES: Biotechnology patents defined by Organisation for Economic Co-operation and Development (OECD). Patent counts on fractional-count basis. For patent grants with multiple inventors from different countries, each country receives fractional credit on basis of proportion of its participating inventors. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: OECD, Patent database, http://stats.oecd.org/wbos/default.aspx?DatasetCode=PATS_IPC, accessed 15 February 2007. See appendix tables 6-46 and 6-47.

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markets: the United States, the EU, and Japan. These inventions are called *triadic patent families*.[52] The high cost of filing for patents from three separate patent offices and the need to manage patent costs in competitive industries make triadic patent families a more accurate measure of inventions deemed economically valuable than simple patent counts.

The number of triadic family patents was estimated to be almost 54,000 in 2003 (the last year for which data are available), a 3% increase compared with 2002 (figure 6-38; appendix tables 6-50 and 6-51). Since 2001, growth in triadic patent families has flattened compared with most of the previous decade. The same three sources that file the majority of U.S. and European patents (the United States, the EU, and Asia) account for the majority (more than 90%) of triadic patent families.[53] The United States has been the leading source of filings (37% of estimated world share) since 1989, when it surpassed the EU. Between 1996 and 2003, the gap between the U.S. share and the EU's share widened from less than 1 to 7 percentage points as the U.S. world share edged up and the EU's world share declined.

Asia's share (estimated at 28% in 2003) has stayed relatively constant since the early 1990s (figure 6-38; appendix tables 6-50 and 6-51). China, India, South Korea, and Taiwan, which are the same Asian countries that have increased their share in USPTO patents, also gained world share in triadic patent families, although on a more limited basis. Japan continues to have by far the dominant share of Asian countries, accounting for more than 90% of triadic patent families credited to Asia.

Table 6-23
Share and activity index for biotechnology patents granted by USPTO and EPO, by inventors from selected regions/countries: 1993, 1999, and 2006

	1993		1999		2006	
Agency and region/country	Share (%)	Activity index	Share (%)	Activity index	Share (%)	Activity index
USPTO						
All regions (number)	1,969	na	6,290	na	5,194	na
United States	61.9	1.15	66.6	1.22	62.9	1.22
Asia	15.9	0.64	8.8	0.35	13.0	0.44
EU	16.0	0.97	17.7	1.14	16.5	1.17
EPO						
All regions (number)	1,176	na	934	na	2,695	na
United States	33.2	1.47	42.7	1.71	38.7	1.71
Asia	23.2	1.00	13.0	0.62	15.0	0.71
EU	38.8	1.11	35.7	0.74	37.9	0.76

na = not applicable

EPO = European Patent Office; EU = European Union; USPTO = U.S. Patent and Trademark Office

NOTES: Biotechnology defined by Organisation for Economic Co-operation and Development (OECD). Patent counts on fractional-count basis. For patent grants with multiple inventors from different countries, each country receives fractional credit based on proportion of its participating inventors. Biotechnology activity index is region/country's share of biotechnology patents adjusted for its share of all patents. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCES: OECD, Patent database, http://stats.oecd.org/wbos/default.aspx?DatasetCode=PATS_IPC, accessed 15 February 2007; and Compendium of Patent Statistics 2006, www.OECD.org/sti/ipr-statistics. See appendix tables 6-48 and 6-49.

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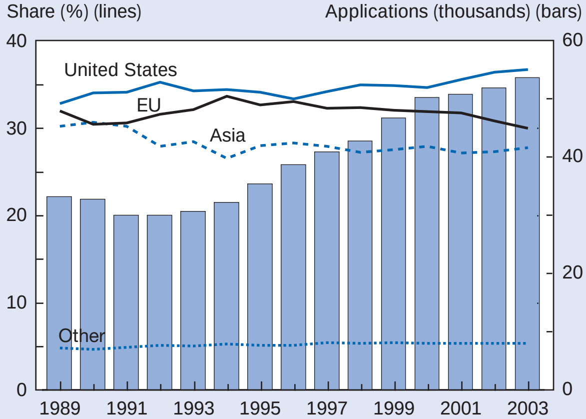
Figure 6-38
Triadic patent applications and share of total, by inventors from selected regions/countries: 1989–2003



EU = European Union

NOTES: Triadic patent families on fractional-count basis. For patent families with multiple inventors from different countries, each country receives fractional credit based on proportion of its participating inventors. Year on patent is first priority filing. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Organisation for Economic Co-operation and Development, Patent database, http://stats.oecd.org/wbos/default.aspx?DatasetCode=PATS_IPC, accessed 15 February 2007. See appendix tables 6-48 and 6-49.

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If triadic patents are normalized for either the size of the economy or for population, the rankings of the three regions (the United States, the EU, and Asia) do not change (table 6-24). The differences are considerably larger, however, when normalized by population. Four European countries (Finland, Switzerland, Germany, and Sweden) and Japan have a higher per capita and size-of-economy triadic patent family output than the United States.

U.S. High-Technology Small Businesses

Many of the new technologies and industries seen as critical to U.S. economic growth are also closely identified with small businesses, i.e., those employing fewer than 500 people. Biotechnology, the Internet, and computer software are examples of industries built around new technologies that were initially commercialized by small businesses. Operating within commercial environments characterized by fast-moving technology and rapidly changing consumer needs, small businesses learn from their customers, suppliers, and government labs and universities, and innovate based on what they have learned. This agility makes high-technology small businesses a key sector for developing, adopting, and diffusing new technologies within the U.S. economy.

Table 6-24
Triadic patents, by size of economy (GDP) and population for inventors from selected regions/countries/economies: 2003

Region/country/economy	GDP (1990 PPP $billions)	Population (millions)
Finland	5.94	121.83
Switzerland	5.43	120.82
Japan	5.02	106.57
Germany	4.51	86.02
Sweden	4.20	90.19
Israel	3.53	58.03
Netherlands	2.85	62.81
United States	**2.28**	**66.20**
EU	**1.91**	**36.93**
France	1.81	39.15
Denmark	1.60	37.08
United Kingdom	1.57	33.68
South Korea	1.09	17.40
Asia	**1.08**	**5.01**
Canada	0.95	22.04
Norway	0.95	24.81
Australia	0.93	21.84
Singapore	0.89	19.53
Italy	0.76	14.55
Ireland	0.61	15.04
Hungary	0.28	2.29
Taiwan	0.27	4.77
South Africa	0.20	0.85
Spain	0.17	2.86
Czech Republic	0.15	1.46
Russian Federation	0.06	0.39
India	0.04	0.09
Brazil	0.04	0.19
China	0.04	0.17
Mexico	0.02	0.16

EU = European Union; GDP = gross domestic product; PPP = purchasing power parity

NOTES: Triadic patent families on fractional-count basis. For patent families with multiple inventors from different countries, each country receives fractional credit based on proportion of its participating inventors. Year on patent is first priority filing. Asia includes China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCE: Organisation for Economic Co-operation and Development, Patent database, http://stats.oecd.org/wbos/default.aspx?DatasetCode=PATS_IPC, accessed 15 February 2007.

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This section covers patterns and trends that characterize small businesses operating in high-technology industries, based on data from the Census Bureau and Corporate Technology Information Services, Inc. (Corptech). The section reports on the number of companies, their formation, and employment figures. Two sources of financing for high-technology small businesses are examined, using data from the National Venture Capital Association and the University of New Hampshire's Center for Venture Research.

Employment in High-Technology Small Businesses

According to Census Bureau data, U.S. small businesses employed slightly more than half of the total labor force and accounted for one-third of employment in high-technology industries[54] in 2004 (table 6-25). Small businesses operating in high-technology industries numbered nearly one-half million firms and employed 5 million workers in 2004.[55]

In 2004, most workers in high-technology small businesses (67%) were in the service sector (table 6-26; appendix table 6-52). Service-sector employment is concentrated within six industries: architecture, computer systems design, consulting, management, commercial equipment and services, and R&D. These service industries collectively employed more than four-fifths of workers employed by all small businesses in high-technology service industries in 2004. The manufacturing sector employs most of the remainder of workers in high-technology small businesses (31% in 2004).

Employment in manufacturing is similarly concentrated within a relatively small number of industries: motor vehicle parts, metal working, semiconductors, other machinery, fabricated metals, and navigational and measurement tools. These six industries collectively employed more than half of all workers employed by all manufacturing high-technology small businesses and 16% of the entire high-technology small business labor force in 2004.

Table 6-26
Leading types of employers of high-technology small businesses, by industry: 2004

Industry	Employment (thousands)	Share (%)
All industries	5,045	100.0
Services	3,374	66.9
Top six combined	2,844	56.4
All others	530	10.5
Manufacturing	1,553	30.8
Top six combined	801	15.9
All others	752	14.9
Other	118	2.3

NOTES: Small businesses are firms with <500 employees. Firms include those reporting no employees on their payroll. Firm is an entity that is either in a single location with no subsidiaries or branches or is topmost parent of a group of subsidiaries or branches. High-technology industries defined by Bureau of Labor Statistics on basis of employment intensity of technology-oriented occupations. Other consists of agriculture, mining, and utilities.

SOURCES: Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/csd/susb/susb.htm; and Hecker DE. 2006. High-technology employment: A NAICS-based update. *Monthly Labor Review* 128(7):57–72, http://www.bls.gov/opub/mlr/2005/07/art6full.pdf, accessed 19 September 2007.

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Formation of High-Technology Small Businesses

Corptech has created a database on the formation of high-technology businesses by technology area. Corptech identifies 17 industry areas as high technology (using a classification that is not comparable to the Bureau of Labor Statistics definition of high-technology businesses used in the previous section).[56] Formations of U.S. high-technology small businesses sharply increased in the mid-1990s, rising from around 1,000 annually to an annual average of about 1,400 from 1995 to 1999 (figure 6-39). Coinciding with the end of the dot.com boom in 2000, formations declined steeply and have remained at half or less of 1990s levels.

Changes in the share of high-technology small business formations by technology area may indicate emerging areas of technologies. Factory automation accounted for the largest share of formations (15%) between 2003 and 2004, which was 9 percentage points higher than during the 2000–02 period (figure 6-40; appendix table 6-53). Computer software had the second highest share during the period 2003–04 (10%), sharply down compared with its 25% share from 1997 to 2002. The shares of three industries that

Table 6-25
Firms and employment in U.S. small businesses versus all businesses: 2004

Technology	All businesses	Small businesses	Small business share (%)
High-technology			
Firms (thousands)	497	482	97.0
Employment (millions)	15.1	5.0	33.5
All technologies			
Firms (thousands)	5,886	5,869	99.7
Employment (millions)	115.1	58.6	50.9

NOTES: Small businesses are firms with <500 employees. Firms include those reporting no employees on their payroll. Firm is an entity that is either a single location with no subsidiary or branches or topmost parent of a group of subsidiaries or branches. High-technology industries defined by Bureau of Labor Statistics on basis of employment intensity of technology-oriented occupations.

SOURCES: Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/csd/susb/susb.htm; and Hecker DE. 2006. High-technology employment: A NAICS-based update. *Monthly Labor Review* 128(7):57–72, http://www.bls.gov/opub/mlr/2005/07/art6full.pdf, accessed 19 September 2007.

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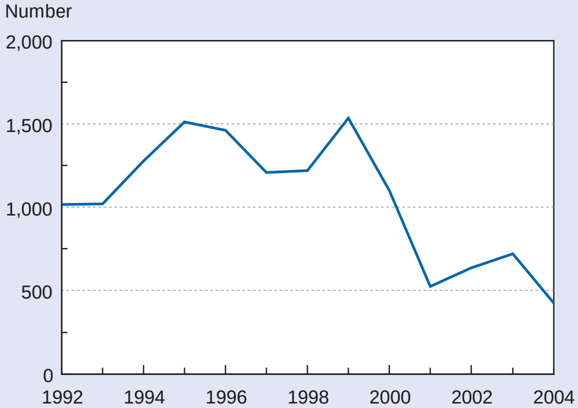
Figure 6-39
U.S. high-technology small business formation: 1992–2004



NOTE: High-technology areas defined by Corporate Technology Information Services, Inc. (Corptech).

SOURCE: Corptech, http://www.corptech.com/index.php, special tabulations (15 June 2007). See appendix table 6-53.

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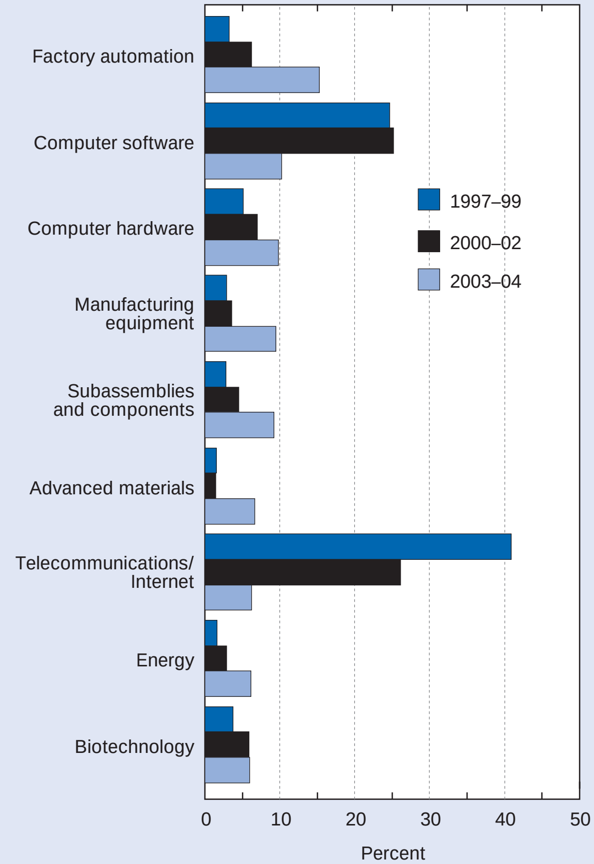
Figure 6-40
U.S. high-technology small business formation, by share of selected technology areas: 1997–2004



NOTE: High-technology areas defined by Corporate Technology Information Services, Inc. (Corptech).

SOURCE: Corptech, http://www.corptech.com/index.php, special tabulations (15 June 2007). See appendix table 6-53.

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rank just below computer software, i.e., computer hardware, manufacturing equipment, and subassemblies, have at least doubled compared with their shares from 1997 to 1999. The most dramatic change was the decline in new telecommunications and Internet-related small businesses. This industry's share from 2003 to 2004 was 6%, which is 20 percentage points lower compared with the period from 2000 to 2002, and down 35 percentage points compared with the period from 1997 to 1999.

Financing of High-Technology Small Businesses

Entrepreneurs seeking to start up or expand a small firm with new or unproven technology may not have access to public or credit-oriented institutional funding. Two types of financing, *angel* and *venture*, are often critical to financing nascent and growing high-technology and entrepreneurial businesses. (In this section, *business* denotes anything from an entrepreneur with an idea to a legally established operating company.)

Angel investors tend to be wealthy individuals who invest their own funds in entrepreneurial businesses, either individually or through informal networks, usually in exchange for ownership equity. Venture capitalists manage the pooled investments of others, typically wealthy investors, investment banks, and other financial institutions in a professionally managed fund. In return, venture capitalists receive ownership equity and almost always a say in managerial decisions.

Venture capital firms have categorized their investments into four broad financing stages, which are also relevant for discussion of angel investment:

- **Seed and startup funding,** referred to as *seed-startup* throughout this section, provides financing at the earliest stage of business development. Seed funding develops proof of a concept, and startup funding supports product development and initial marketing.
- **Early funds** provide financing to companies that have exhausted their initial capital and need funds to initiate commercial manufacturing and sales.
- **Expansion financing** includes working capital for the initial expansion of a company, funds for major growth expansion (involving plant expansion, marketing, or development of an improved product), and financing for a company expecting to go public within 6–12 months.
- **Later-stage funds** include acquisition financing and management and leveraged buyouts. Acquisition financing provides resources for the purchase of another company, and a management and leveraged buyout provides funds to enable operating management to acquire a product line or business from either a public or private company.

Angel investor funds are concentrated in the seed-startup and early stages. During the period 2005–06, they provided 92% of investment for these stages compared with 8% in later stages. Venture capital, however, is provided primarily in the expansion and later stages (figure 6-41).

This section examines angel and venture capital investment patterns in the United States, focusing on the period from 2001 to the present and examining: (1) changes in the overall level of investment, (2) investment by stage of financing, and (3) the technology areas that U.S. angel and venture capitalists find attractive.

U.S. Angel Capital Investment

According to data from the Center for Venture Research, angel investors provided $25.6 billion in financing in 2006, an 11% increase compared with 2005 and the fourth consecutive annual increase since 2002 (figure 6-42; appendix table 6-54).[57] An estimated 51,000 businesses received financing from angel investors in 2006, 1,500 more compared with 2005, and 3,000 more compared with 2004. The average investment per business from 2004 to 2005 increased from about $470,000 to $500,000 in 2006 (table 6-27).

Although angel investors continue to concentrate on the riskier stages of business development, they have become more conservative in their investment patterns. Slightly more than half of all angel investment financing was seed-startup financing in 2006, down from nearly 60% in 2002 (figure 6-43). Conversely, angel investment financing in the early stage grew from 41% to 47% during this period.

Changes in the technology areas that attract angel investment may indicate changes in the parts of the economy that offer future growth opportunities. Healthcare and medical devices received the largest share of angel investment in 2006 (21%), 5 percentage points higher than its 2004 share (figure 6-44). Biotechnology received 18% of total angel investment in 2006, 8 percentage points higher than its 2004 share. Software also received 18% share of total angel investment during the same period, 4 percentage points lower than its share in 2004.

Businesses receiving angel investment in 2006 employed about 200,000 workers. This figure is about the same as employment in 2005, but 60,000 jobs greater compared with the 2004 level (appendix table 6-54). Each business employed an average number of four workers from 2005–06, up from three workers in 2003.

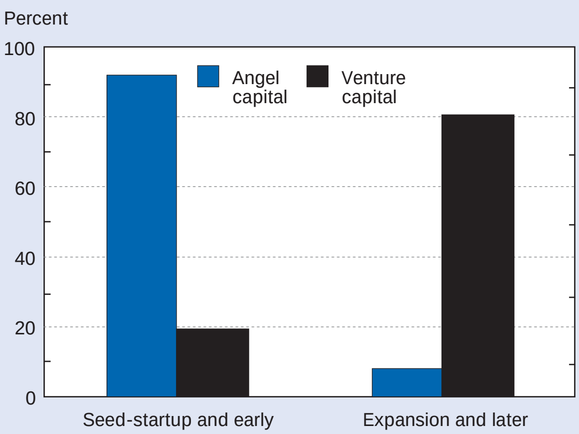
U.S. Venture Capital Investment

U.S. venture capitalists invested $26 billion in 2006, a 14% gain compared with the level in 2005 (figure 6-42; appendix table 6-55). The amounts of angel and venture capital investment have been very similar for the last 5 years. Since declining sharply in 2002 following the end of the dot.com boom, angel and venture capital investment have been strengthening.

Venture capitalists financed 2,910 firms in 2006, far fewer than the number of businesses financed by angel investors (51,000). The average venture capital investment was $8.9 million per firm, much larger than the corresponding figure for angel investors (table 6-27; appendix table 6-56).

The number of businesses funded by venture capital and the average amount of investment have been increasing during the

Figure 6-41
Share of angel and venture capital investment, by financing stage: 2005–06



NOTES: Seed-startup includes proof of concept (seed), research, and product development. Early includes financing for activities such as initial expansion, commercial manufacturing, and marketing. Expansion includes major expansion of activities, or to prepare a company expecting to go public within 6–12 months. Later includes acquisition financing and management and leveraged buyout.

SOURCES: Center for Venture Research, University of New Hampshire, http://wsbe2.unh.edu/center-venture-research; and Thomson Financial, National Venture Capital Association Yearbook 2007 (2007). See appendix table 6-56.

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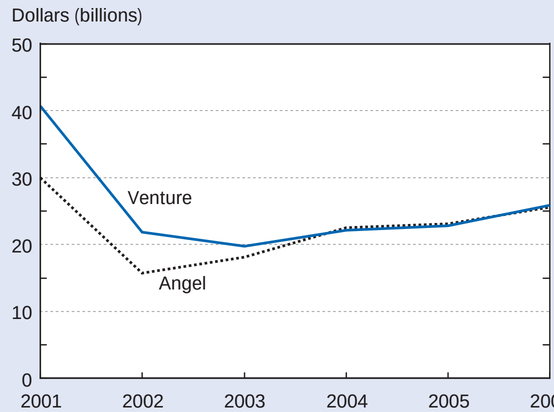
Figure 6-42
Angel and venture capital investment: 2001–06



SOURCES: Center for Venture Research, University of New Hampshire, http://wsbe2.unh.edu/center-venture-research; and Thomson Financial, National Venture Capital Association Yearbook 2007 (2007). See appendix tables 6-54, 6-55, and 6-56.

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Table 6-27
Average investment of angel and venture capital per business: 2002–06

	Angel			Venture		
Year	Businesses (number)	Total investment ($billions)	Average investment/business ($thousands)	Businesses (number)	Total investment ($billions)	Average investment/business ($thousands)
2002.........	36,000	15.7	436	2,619	21.8	8,324
2003.........	42,000	18.1	431	2,416	19.7	8,154
2004.........	48,000	22.5	469	2,574	22.1	8,586
2005.........	49,500	23.1	467	2,646	22.8	8,617
2006.........	51,000	25.6	502	2,910	25.9	8,900

NOTE: Business includes anything from an entrepreneur with an idea to a legally established operating company.

SOURCES: Center for Venture Research, University of New Hampshire, http://wsbe2.unh.edu/center-venture-research; and Thomson Financial, National Venture Capital Association Yearbook 2007 (2007).

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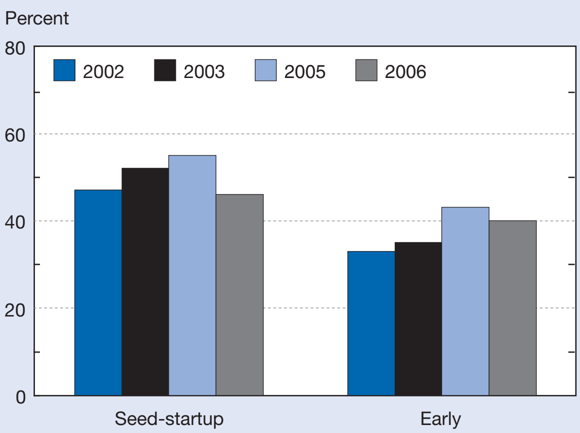
last several years. The number of businesses in 2006 was 10% higher than in 2005 and 13% higher than the 2004 level. Average investment per business in 2006 was about $300,000 higher compared with 2005 and 2004, and approximately $750,000 higher compared with 2003.

Like angel investment, venture capital investment has become generally more conservative and moved toward later stages of business development. As noted previously, the bulk of venture capital is provided for expansion and later-stage financing; from 2002 to 2006 these stages accounted for a combined share of 80% (figure 6-45; appendix table 6-56). Expansion financing has typically been the single largest stage financed by venture capital funds, accounting for approximately half or more of all venture investment from 1996 through 2004. Expansion financing's share, however, declined to 41% between 2005 and 2006. Later-stage investment, on the other hand, more than doubled from 15% during the mid-1990s to 31% from 2002 to 2004, before rising to 39% between 2005 and 2006, a level nearly equal to the share of expansion financing.

As the venture capital industry has consolidated, venture capitalists have largely abandoned the seed-startup stage and invested almost exclusively in early, expansion, and later stages. The share of venture capital devoted to seed-startup financing peaked at 19% in 1994 and then declined precipitously, bottoming out just above 1% in 2002 (figure 6-45; appendix table 6-56). Three factors help explain this shift:

Figure 6-43
Angel investment, by share of seed-startup and early activities: 2002–06



NOTES: 2004 data not available. Seed-startup includes proof of concept (seed), research, product development, or initial marketing. Early provides funding for initiating commercial manufacturing and sales.

SOURCE: Center for Venture Research, University of New Hampshire http://wsbe2.unh.edu/center-venture-research.

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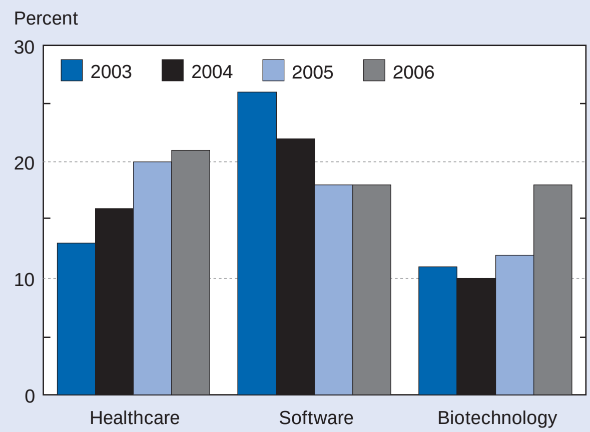
Figure 6-44
Share of top three technology areas receiving angel capital investment: 2003–06



NOTES: Technology areas ranked by 2006 share. Healthcare includes medical devices and equipment. Healthcare definition for 2003 slightly different from definition for 2004–06.

SOURCE: Center for Venture Research, University of New Hampshire, http://wsbe2.unh.edu/center-venture-research.

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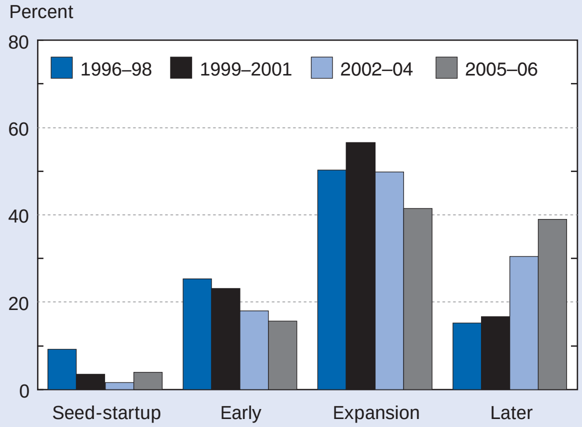
Figure 6-45
U.S. venture capital investment, by stage of investment: 1996–2006



NOTES: Seed-startup includes proof of concept (seed), research, product development, or initial marketing. Early includes financing for activities such as initial expansion, commercial manufacturing, and marketing. Expansion includes major expansion of activities, or to prepare a company expecting to go public within 6–12 months. Later includes acquisition financing and management and leveraged buyout.

SOURCE: Thomson Financial, National Venture Capital Association Yearbook 2007 (2007). See appendix table 6-56.

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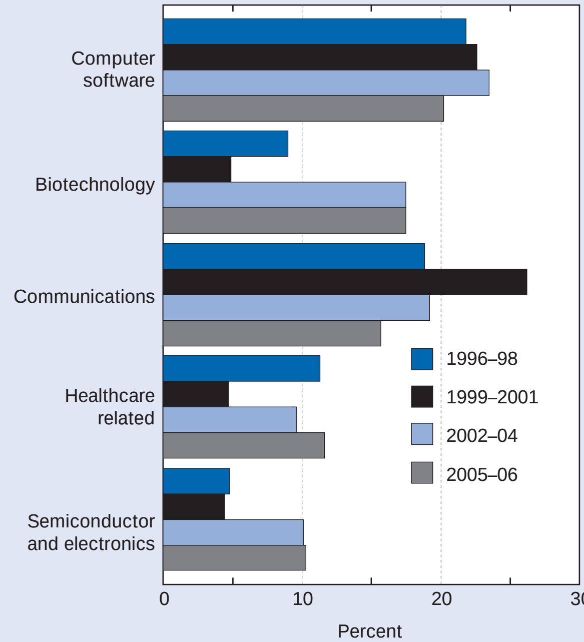
Figure 6-46
U.S. venture capital investment, by share of selected industry: 1996–2006



SOURCE: Thomson Financial, National Venture Capital Association Yearbook 2007 (2007). See appendix table 6-55.

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- Investment in early, expansion, and later stages is usually less risky compared with the seed-startup stage.
- Venture capital funds in the 21st century generally have a shorter time horizon for closing out their investments compared with the longer time required by seed-startup investments.
- The amount of investment required for seed-startup is typically below the minimum threshold of venture capital funds.

In 2003, however, the percentage of venture capital invested in the seed-startup stage began to inch up, reaching 4% by 2006. This recent increase has been attributed to two factors: the need for venture capitalists to find new investments after closing out their holdings in mature companies and the emergence of promising new opportunities that spurred investment in new businesses (NVCA 2007a).

Venture Capital Financing by Industry

Computer software had the largest share of venture capital funding of any industry from 2005 to 2006 (20%), a slight decline compared with 2002–04 levels (figure 6-46; appendix table 6-55). Biotechnology had the second highest share from 2005 to 2006 (18%), more than triple its share during the period 1999–2001. The growth in venture capitalist financing of biotechnology parallels rising interest by angel investors (figure 6-44). Communications, which had the largest share between 1999 and 2001, slipped to second place from 2002 to 2004 and fell slightly below biotechnology from 2005 to 2006. The healthcare and semiconductor industries each received 10%–12% of venture capital investment, about double their levels from 1999 to 2001.

During the late 1990s, the Internet emerged as a business tool, and companies developing Internet-related technologies drew venture capital investments in record amounts. The share of Internet-related companies more than doubled from 35% in 1996 to peak at more than 70% from 1999 to 2000 before falling sharply to a level of about 40% or less in 2004 (appendix table 6-55). Internet-related companies continue to command a substantial share of venture capital, however, especially in several high-technology industries. For example, in 2006, the share of Internet-related companies in the computer software and communications industries exceeded 65% (table 6-28). In retailing and media, Internet-related companies amounted to three-quarters of all companies financed by venture capital. Other sectors have far smaller shares of Internet-related companies, including semiconductors (9%), healthcare (3%), and industrial/energy (1%).

Venture Capital Investment by U.S. States

Venture capital is invested disproportionately in a few states that also perform most of the R&D conducted in the United States and that receive most U.S. patents (table 6-29; appendix table 6-57). California alone received nearly one-half of total venture capital investment in 2006; its 48% share that year was 8 percentage points higher than its share a decade earlier. Massachusetts has the second highest share of investment (11% in 2006); this share has remained steady

Table 6-28
Share of Internet-related venture capital investments, by industry: 2006

Industry	Share (%)
All industries	38.1
Communications	83.2
Retailing and media	75.2
Computer software	65.6
Computer hardware	62.7
Business/financial	43.3
Semiconductor and electronics	8.9
Healthcare related	2.9
Industrial/energy	1.3
Biotechnology	0.0

NOTE: Industries ranked by their Internet-related share of venture capital investment.

SOURCE: Thomson Financial, National Venture Capital Association Yearbook 2007 (2007).

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during the last decade. The remaining top-10 states receiving venture capital have shares between 2% and 5%. These 10 states collectively account for 86% of total U.S. venture capital investment (see Chapter 8).

Venture Capital Financing and Employment

According to the National Venture Capital Association, firms that received venture financing employed an estimated 10 million workers in 2005, more than half of whom worked in R&D and technology-intensive industries including computer hardware (19%), industrial/energy (12%), financial services (9%), and software (9%) (table 6-30). Two other R&D-intensive industries, which have close ties to scientific research and academia, employed a combined 4% of the workers in venture capital-financed firms. In 2005, employment in firms with venture capital support was 9% higher than in 2003 and 16% higher than 2000 levels (NVCA 2007b).

Table 6-29
Top 10 U.S. states receiving venture capital investment: 1996, 2001, and 2006
(Percent share)

State	1996	2001	2006
All states ($billions)	11.3	40.7	26.0
All states (% share)	100.0	100.0	100.0
California	40.4	41.0	48.0
Massachusetts	9.6	11.8	10.9
Texas	4.7	7.2	5.3
New York	3.6	5.2	4.9
Washington	3.6	2.8	3.9
New Jersey	3.6	3.7	3.1
Pennsylvania	2.7	2.4	2.9
Maryland	1.2	2.4	2.6
Colorado	2.7	3.1	2.5
North Carolina	1.6	1.4	1.8
All others	26.3	18.9	14.0

NOTES: Data includes Puerto Rico and Washington, DC. States ranked by share in 2006.

SOURCE: Thomson Financial, National Venture Capital Association Yearbook 2007 (2007).

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Table 6-30
Employment in venture capital-backed firms, by industry: 2005

Industry	Number (thousands)	Share distribution (%)
All industries	10,000	100.0
Media, entertainment, and retail	2,006	20.1
Computers and peripherals	1,886	18.9
Industrial/energy	1,180	11.8
Financial services	897	9.0
Software	858	8.6
Biotechnology and medical devices/equipment	425	4.3
Other	2,748	27.5

SOURCE: Global Insight, Venture Impact: The Economic Importance of Venture Capital Backed Companies to the U.S. Economy. 4th ed. National Venture Capital Association (2007). http://www.nvca.org/pdf/NVCA_VentureCapital07-2nd.pdf, accessed 11 August 2007.

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Conclusion

The U.S. economy continues to be a leading competitor and innovator in the global economy as measured by its overall performance, market position in S&T industries, and trends in patenting of new technologies at home and abroad. The U.S. economy has grown relatively rapidly and become more productive while sustaining a high and rising per capita income. The U.S. gap with Asia on many of these measures is narrowing, however, because of rapid progress by China and several other countries. Although the EU's economic position is relatively strong, its market position in S&T industries has either flattened out or slipped.

The strong competitive position of the U.S. economy is tied to continued U.S. global leadership in many industries that have extensive ties to S&T. With the service sector increasingly dominating global economic activity, the United States continues to hold the dominant market position in service industries that rely on S&T. The U.S. trading position in technology-oriented services remains strong, as evidenced by the continued U.S. surplus in trade of computer software and manufacturing know-how.

The U.S. position in high-technology manufacturing industries, however, is not quite as strong as in services. The United States continues to be a leading innovator and producer in many high-technology manufacturing industries, but the historically strong U.S. trade position has decreased. Although in surplus for the prior two decades, the U.S. trade balance moved to a deficit during the late 1990s because of faster growth of imports, primarily in computer and communications equipment. The U.S. trade balance in advanced-technology goods has similarly moved from surplus to deficit during this period.

Led by China, South Korea, and Taiwan, Asia is challenging the U.S. market position in S&T industries and reducing the gap on technological innovation. China has rapidly risen to become a leading producer and exporter of high-technology manufacturing goods, as measured by world market share. This rapid ascent shows signs of continuing. South Korea, Taiwan, and other Asian economies have also become leading producers and exporters in S&T-intensive industries.

Various patenting indicators suggest that the United States will remain a leader in technological development within its domestic and foreign markets. The leading source of economically valuable patents known as triadic patents, the United States also leads in U.S. patent applications and is the leading foreign source of European patent applications. Asia shows a strengthening of technological development, however; its share of U.S. and European patents has risen markedly, led by Japan, South Korea, and Taiwan.

In sum, the United States continues to be a world-class competitive and technologically innovative country with a leading position in most high-technology industries. Several Asian economies, however, including China, South Korea, Taiwan, and India, have become global players in some high-technology industries, and their technological capabilities are strengthening. The EU, on the other hand, has lost market share in high-technology industries.

Notes

1. Educating a workforce that can fully participate in an S&T-oriented economy is critical to its success. Three chapters of this report track trends in education: Elementary and Secondary Education (chapter 1), Higher Education in Science and Engineering (chapter 2), and Science and Engineering Labor Force (chapter 3).

2. This chapter presents data from various public and private sources. Consequently, the countries included vary by data source.

3. The Bureau of Economic Analysis (BEA) estimates that treating R&D as an investment increased the level of current-dollar GDP by an average of 2.5% per year during the period 1959 to 2002 (Okubo et al. 2006). The BEA estimate measures the direct impact of R&D and does not include the indirect (spillover) impact of R&D.

4. GDP per capita does not reveal anything about comparative distribution of income across countries, for which data are not readily available.

5. Extensive literature exists on the impact of IT on U.S. economic growth in the mid-1990s. For example, see Stiroh K 2001. What drives productivity growth? *Economic Policy Review* 7(1):39–59; http://www.newyorkfed.org/research/epr/01v07n1/0103stir.html. Accessed 26 June 2007.

6. See OECD (2001) for discussion of classifying economic activities according to degree of "knowledge intensity."

7. In designating these high-technology manufacturing industries, OECD took into account both the R&D done directly by firms and R&D embedded in purchased inputs (indirect R&D) for 13 countries: the United States, Japan, Germany, France, the UK, Canada, Italy, Spain, Sweden, Denmark, Finland, Norway, and Ireland. Direct intensities were calculated as the ratio of R&D expenditure to output (production) in 22 industrial sectors. Each sector was weighted according to its share of the total output among the 13 countries, using purchasing power parities as exchange rates. Indirect intensities were calculated using the technical coefficients of industries on the basis of input-output matrices. OECD then assumed that, for a given type of input and for all groups of products, the proportions of R&D expenditure embodied in value added remained constant. The input-output coefficients were then multiplied by the direct R&D intensities. For further details concerning the methodology used, see OECD (2001). It should be noted that several non-manufacturing industries have equal or greater R&D intensities. For additional perspectives on OECD's methodology, see Godin B. 2004. The new economy: What the concept owes to the OECD. *Research Policy* 33:679–90.

8. Data are extracted from the Global Insight World Industry Service database, which provides information for 70 countries that account for more than 97% of global economic activity. The Global Insight data on international country activity within the service and manufacturing industries are expressed in 2000 constant dollars. Constant dollar data for foreign countries are calculated by deflating industry data valued in each country's nominal currency.

9. Compared with the extensive data available for the manufacturing industries, national data that track activity in many rapidly growing service sectors are limited in the level of industry aggregation and types of data collected. For example, export and import data are currently not available for many services.

10. Gross revenue includes inputs or supplies purchased from other industries or services. Knowledge-intensive service and high-technology manufacturing industry data are expressed in 2000 constant dollars. Constant-dollar data for foreign countries is calculated by deflating nominal domestic currency with a sector-specific price index constructed for that country, then converting the result to U.S. dollars based on average annual market exchange rates.

11. Asia is defined in this section as consisting of China, India, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

12. One of the earliest quantitative analyses of R&D was done in 1955 by R.H. Ewell, supported by the National Science Foundation. This study showed a definite correlation between research and productivity. Also see Godin B. 2004. The obsession for competitiveness and its impact on statistics: The construction of high-technology indicators. *Research Policy* 33:1217–29.

13. This conclusion is derived from an examination of weighted U.S. data from the Bureau of Labor Statistics Occupational Employment Survey concerning average annual pay during the period 1997–2001.

14. Global Insight's data show that U.S. high-technology industry manufacturers' share of value added to total output was 20% higher than the share of all other U.S. manufacturing industries.

15. This conclusion is derived from an examination of weighted U.S. data from the Bureau of Labor Statistics Occupational Employment Survey on average annual pay from 1997–2001.

16. Europe's success in growing its aerospace industry and China's efforts to develop a semiconductor industry are two examples.

17. In February 1996, the Telecommunications Act became U.S. law. This Act was the first major telecommunications reform in more than 60 years. It facilitated competition between cable companies and telephone companies and may have contributed to increased U.S. manufacturing activity in both the communications and computer hardware industries.

18. In 1999, the State Department's responsibilities under the International Traffic in Arms Regulation were expanded to include research activity formerly covered under the Commerce Department's export regulations. The transfer placed scientific satellites, related data, and certain computer components and software on the U.S. Munitions List. Related research activities and the country of origin of researchers working on related research activities also became subject to many of the same regulations controlling exports of sensitive products.

19. Like the United States, other national governments usually have strong ties to their aerospace industries, often supporting and funding R&D and serving as major customers.

20. Unlike the previous section that examined data on industry manufacturing value added (domestic content), the value of exports reported in this section reflects the final value of industry shipments exported, not just the value resulting from domestic production. Exported shipments will, therefore, often include the value of purchased foreign inputs.

21. EU exports exclude intra-EU exports.

22. The U.S. trade balance is affected by many other factors including currency fluctuations, differing fiscal and monetary policies, and export subsidies between the United States and its trading partners.

23. U.S. trade in software products is not a separate National Institute of Standards and Technology Advanced Technology Program (ATP) category in the official statistics but is included in the ATP category covering information and communications products. For this report, trade in software products is examined separately, in effect creating an 11th category (see figure 6-23).

24. The U.S. dollar rose against other major currencies in the late 1990s and continued to rise until early 2002. The sharp rise in the dollar was a contributing factor in the broad-based decline in exports by U.S. manufacturers from 2000 to 2003. The U.S. export decline was also affected by slower rates of GDP growth experienced by some U.S. trading partners during that time, including the EU and Japan.

25. Data on U.S. trade balance in advanced technology products during the 1990s is available at appendix table 6-3 in volume 2 of NSB (2002), accessible at http://www.nsf.gov/statistics/seind02/append/c6/at06-03.pdf.

26. The U.S. government and U.S. corporations have long advocated the establishment and protection of intellectual property rights. The Office of the U.S. Trade Representative monitors countries with reported violations and reports on the status of intellectual property protection in its annual report, Foreign Trade Barriers.

27. An affiliate refers to a business enterprise located in one country that is directly or indirectly owned or controlled by an entity in another country. The controlling interest for an incorporated business is 10% or more of its voting stock; for an unincorporated business, it is an interest equal to 10% of voting stock.

28. In addition, data on the destination of multinational corporate sales to foreign affiliates also suggest that market access is an important factor in the firms' decisions to locate production abroad. See Borga and Mann (2004).

29. The Bureau of Economic Analysis (BEA), the source of U.S. royalty and fees data, collects data on the following Asian countries/economies: China, Hong Kong, India, Indonesia, Japan, Malaysia, the Philippines, Singapore, South

Korea, Taiwan, Thailand, and other unspecified Asian countries. See BEA (2007).

30. Asia has purchased more manufacturing know-how than the EU since 1987, the first year data were collected on manufacturing know-how. See BEA (2007).

31. See chapter 2 for a discussion of international higher education trends and chapter 4 for a discussion of trends in U.S. R&D.

32. For details on survey and indicator construction, see Porter et al. (2005).

33. For information on the validity and reliability testing the indicators have undergone, see Porter et al. (2001, 2005) and Roessner, Porter, and Xu (1992).

34. These articles are identified by at least one author having a private, for-profit institutional address.

35. In this section, article counts were reported on a fractional-count basis. In the following section's discussion of collaboration trends, articles are reported on a whole-count basis. See the sidebar "Bibliometric Data and Terminology" in chapter 5 for a description of these methods of counting articles and how they are generally used.

36. In contrast to the decline in emphasis on basic research in industry publications, about one-third of U.S. publications overall were published in basic research journals from 1988 to 2005.

37. All addresses for a company and its subsidiaries are unified into a single code for the parent company.

38. Other U.S. sectors in which researchers produced articles are academia, the federal government, state and local governments, federally funded R&D centers, and the private nonprofit sector.

39. The base for the percentages discussed in this section is the number of industry articles with one or more industry authors minus the number of single company articles.

40. Rather than granting property rights to the inventor as is the practice in the United States and many other countries, some countries grant property rights to the applicant, which may be a corporation or other organization.

41. U.S. patent law states that any person who "invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent." The law defines "nonobvious" as "sufficiently different from what has been used or described before [so] that it may be said to be nonobvious to a person having ordinary skill in the area of technology related to the invention." These terms are part of the criteria in U.S. patent law. For more information, see USPTO, "What is a patent?" at http://www.uspto.gov/web/offices/pac/doc/general/index.html#patent, accessed 28 June 2007.

42. Although the USPTO grants several types of patents, this discussion is limited to utility patents, commonly known as patents for inventions. They include any new, useful, or improved-on method, process, machine, device, manufactured item, or chemical compound.

43. The Japan Patent Office (JPO) is also a major patent office but has much smaller share of foreign patents compared with the USPTO and EPO.

44. USPTO reports that average time to process an application (pendancy) was 31.1 months for utility, plant, and reissue patent applications in FY 2006, compared with 18.3 months in FY 2003. Applications for utility patents account for the overwhelming majority of these requests. The EPO reports that the average pendancy was 45.3 months in 2005.

45. Unless otherwise noted, USPTO patents are assigned to countries on the basis of the residence of the first-named inventor.

46. U.S. patenting data on type of ownership and by state is available only for U.S. patents granted.

47. Some of the decline in U.S. patenting by inventors from the EU and other leading industrialized nations may be because of movement toward European unification, which has encouraged wider patenting within Europe.

48. EPO patents are assigned to countries on a fractional-count basis. For patents with inventors from different countries, each country receives credit on basis of proportion of its participating inventors.

49. The data source for EPO and USPTO patents is the OECD. USPTO data drawn from the OECD database are not directly comparable with data reported by the USPTO because of methodological differences and consequent OECD adjustments.

50. A seminal court decision opening the floodgate for biotechnology-related patents is the 1980 Supreme Court decision *Diamond* v. *Chakrabarty*, which ruled that genetically engineered living organisms can be patented.

51. The EU issued a directive that harmonized the laws of member states on biotechnology patenting, which may explain the lag and subsequent growth of EU biotechnology patents compared with the United States.

52. The database is housed at the OECD and produced as a collaborative project among the OECD, the National Science Foundation, the EU, the World Intellectual Property Organization, the USPTO, the JPO, and the EPO. Until March 2001, only patents granted in the United States were published in the database. Technically, the dataset counts those inventions for which patent protection is sought in Europe and Japan and obtained in the United States.

53. Triadic patent families with coinventors residing in different countries are assigned to their respective countries on a fractional count basis. Patents are listed by priority year, which is the year of the first patent filing. Data for 1998–2003 are estimated by the OECD.

54. The high-technology definition used here is from the Bureau of Labor Statistics and differs from that used in earlier sections.

55. See Hecker (2005) for their definition and methodology for determining high-technology industries. Several industries identified by the Bureau of Labor Statistics as high technology are not available in the Census Bureau's data prior to 2003.

56. Corptech classifies 17 fields as high technology: factory automation, biotechnology, chemicals, computer hardware, defense, energy, environmental, manufacturing equipment, advanced materials, medical, pharmaceuticals, photonics, computer software, subassemblies and components, testing and measurement, telecommunications and the Internet, and transportation. For more information, see www.corptech.com.

57. Comparable data on angel capital investment is not available prior to 2001.

Glossary

Activity index: A country's (based on residence of the inventor) world share of patents within a particular technology area, divided by a country's world share of all patents. The activity index is used to determine the propensity to patent within a particular technology area compared with other technology areas.

Affiliate: A company or business enterprise located in one country but owned or controlled (10% or more of voting securities or equivalent) by a parent company in another country; may be either incorporated or unincorporated.

Angel investment: Financing from affluent individuals for business startups, usually in exchange for ownership equity. Angel investors typically invest their own funds or organize themselves into networks or groups to share research and pool investment capital.

Asia-10: China (including Hong Kong), India, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand.

Basic research journals: Scientific journals covered by the Institute of Scientific Information that are classified as "basic scientific research," one of the four categories of a research level classification system for scientific journals developed by ipIQ, Inc. (formerly CHI). Journals assigned to the other three categories publish science at a research level that is applied, developmental, or more targeted, as defined by ipIQ.

Company or firm: A business entity that is either a single location with no subsidiary or branches or the topmost parent of a group of subsidiaries or branches.

EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the UK.

EU-20: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, and the UK.

EU-25: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and the UK.

Gross domestic product (GDP): The market value of all final goods and services produced within a country within a given period of time.

Gross revenues (sales): The value of the industry's shipments or services, equivalent to the industry's sales, including domestic and imported supplies and inputs from other industries.

Harmonized code, harmonized system (HS): Developed by the Customs Cooperation Council, the Harmonized System, or Harmonized Commodity Description and Coding System, is used to classify goods in international trade.

High-technology manufacturing industries: Those that spend a relatively high proportion of their revenue on R&D, consisting of aerospace, pharmaceuticals, computers and office machinery, communications equipment, and scientific (medical, precision, and optical) instruments.

Intellectual property: Intangible property resulting from creativity that is protected in the form of patents, copyrights, trademarks, and trade secrets.

Intra-EU exports: Exports from EU countries to other EU countries.

Knowledge-intensive industries: Those that incorporate science, engineering, and technology into their services or the delivery of their services, consisting of business, communications, education, financial, and health services.

Market-oriented knowledge-intensive [services]: Knowledge-intensive services that are generally privately owned and compete in the marketplace without public support. These services are business, communications, and financial services.

Normalizing: To adjust to a norm or standard.

Not obvious: One criterion (along with "new" and "useful") by which an invention is judged to determine its patentability.

Productivity: The efficiency with which resources are employed within an economy or industry, measured as labor or multifactor productivity. Labor productivity is measured by GDP or output per unit of labor. Multifactor productivity is measured by GDP or output per combined unit of labor and capital.

Purchasing power parity (PPP): The exchange rate required to purchase an equivalent market basket of goods.

R&D intensity: The proportion of R&D expenditures to the number of technical people employed (e.g., scientists, engineers, and technicians) or the value of revenues.

Small business: A company or firm with less than 500 employees.

Triadic patent: A patent for which patent protection has been applied within the three major world markets: the United States, Europe, and Japan.

Utility patent: A type of patent issued by the U.S. Patent and Trademark office for inventions, including new and useful processes, machines, manufactured goods, or composition of matter.

Value added (value-added revenue): Gross revenue (sales) excluding purchases of domestic and imported inputs and materials.

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