Chapter 6
Industry, Technology, and the Global Marketplace

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Highlights

Knowledge- and Technology-Intensive Industries in the World Economy

The U.S. economy had the highest concentration among major economies of knowledge- and technology-intensive (KTI) industries, a key part of the global economy.

- KTI industries, including knowledge-intensive (KI) service and high-technology (HT) manufacturing industries, have become a major part of the global economy, providing almost 30% of global economic output in 2007.
- The U.S. economy had the highest concentration of KTI industries among major economies. These industries accounted for 38% of U.S. gross national product (GDP) in 2007. China's KTI industries created 23% of GDP in 2007, up from 21% in 1992.
- Labor productivity growth has been higher in China and the Asia-9 than in the developed economies. (The Asia-9 includes India, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam.) Despite China's 8% annual growth over the past 15 years and 4% growth in the countries and economies of the Asia-9, their absolute productivity levels remain far below those of their developed counterparts.
- U.S. per capita income in 2007 was about 25% higher than that of Japan and 40% higher than the European Union (EU) average. The per capita income of China and the Asia-9 has grown far faster than that of the three developed economies—the United States, the EU, and Japan.

Trends in Knowledge- and Technology-Intensive Industries

The United States is the largest producer of privately provided KTI service and manufacturing industries.

- KTI industries contributed $15.7 trillion to the world economy: $5.0 trillion in largely location-bound education and health services, $9.5 trillion in tradable services, and $1.2 trillion in HT manufacturing.
- The United States is the largest provider of commercial KI service industries (business, financial, and communications). The U.S. world share edged up from 32% in 1995 to 34% in 2007.
- China's share of global commercial KI service industries rose from 2% in 1995 to 5% in 2007, led by nearly 20% average annual growth of its communications industry. India's communications industry also grew rapidly.
- In HT manufacturing industries, 90% of global value added was accounted for by the United States (30%), the EU (25%), China (14%), and Japan and the Asia-9 (about 10% each).
- China's share of HT manufacturing industries more than quadrupled, rising from 3% in 1997 to 14% in 2007, surpassing the Asia-9 in 2006 and Japan in 2007.

Information and Communications Services and Manufacturing

The United States is the largest provider of information and communications technology (ICT) service and manufacturing industries.

- The United States and the EU are the largest producers of ICT service and manufacturing industries (27% share each of global value added).
- China's share of ICT global value added rose sharply from 4% to 12% between 1995 and 2007. Japan's share declined steeply from 22% to 9% over the decade.

U.S. and Global Trade in Knowledge- and Technology-Intensive Goods and Services

The United States lost market share in global HT exports, whereas China became the largest single country exporting HT goods.

- The U.S. share of global HT exports declined from 21% in 1995 to 14% in 2008, largely because of a fall in ICT goods exports.
- China's share of global HT goods exports more than tripled, from 6% in 1995 to 20% in 2008, making it the single largest exporting country for HT products.
- The U.S. trade balance of HT products shifted from surplus to deficit, starting in the late 1990s. In 2000, the deficit was $32 billion in current dollars; in 2008, the deficit widened to $80 billion. The deficit in ICT goods alone was almost $120 billion in 2008.
- China's trade position in HT products moved from balance to surplus, starting in 2001, and rapidly increased from less than $13 billion in 2003 to almost $130 billion in 2008, driven by trade in ICT goods. The Asia-9's trade surplus also increased over the past decade from less than $50 billion to more than $220 billion, an increase entirely due to an expansion of its surplus in information technology (IT) goods.
- China's rise as the world's major assembler and exporter of many electronic goods is reflected by a sharp increase in China's share of imports of ICT goods from the United States, the European Union, and Japan.
- Trade data indicate that assembly of ICT goods has shifted to China and that the Asia-9 has become a major supplier of components and inputs. Its share of China's ICT imports jumped from 40% to 70% in a decade; China's share of the Asia-9's exports nearly quadrupled,

intra-Asia trade is up, and Japan's export data also show a pronounced shift toward China.

U.S. Trade Positions

The United States has maintained a surplus in trade of commercial KI services, but its surplus in advanced technology products turned into a deficit earlier in this decade.

- U.S. trade in commercial KI service industries has been in surplus for the past decade and grew from $21 billion in 1997 to $47 billion in 2007.
- U.S. trade in advanced technology products generated an initial deficit in 2002 that widened to $56 billion by 2008. The deficit in the manufacturing component of ICT alone reached more than $100 billion, with smaller deficits in the life sciences and optoelectronics. Aerospace and electronics generated surpluses of $55 billion and $25 billion, respectively.
- The largest U.S. trade deficit in advanced technology products was $66 billion with China, its largest trading partner country, followed by $19 billion with the Asia-9 and $8 billion with Japan. ICT deficits were higher: $75 billion with China, $44 billion with the Asia-9, and $9 billion with Japan.
- The United States had a $7-billion surplus with the EU in 2008; aerospace, the life sciences, and ICT manufacturing constituted the largest share of advanced technologies trade with this region.

Foreign Direct Investment

U.S. overseas investment in KTI industries was more than $900 billion, and direct investment in the United States in these industries was almost $600 billion.

- U.S. overseas investment in commercial KI service industries stood at $834 billion and HT manufacturing industries at $121 billion by 2008.
- Financial services had the largest share of commercial KI service industries by far (76%), followed by business services (22%) and communications (2%). Among HT manufacturing industries, communications and semiconductors (44%) and pharmaceuticals (30%) had the largest shares.
- Direct investments in the United States in commercial KI service industries stood at $390 billion in 2008; direct investment in U.S. HT manufacturing industries stood at $187 billion.
- Financial services had the largest share (64%) of foreign direct investment in commercial KI service industries, followed by business services (23%) and communications (13%). Among HT manufactures, the largest shares were in pharmaceuticals and in communications and semiconductors.

Trade in Intangible Assets

The United States runs a surplus with the rest of the world in trade of intangible assets, including patent licensing fees and use of trade secrets.

- Investment and trade in intangible assets such as copyrights, trademarks, and patents is sizeable. In 2007, the United States had a surplus of nearly $60 billion in trade of intangible assets, which has grown steadily over the past two decades.
- An important component of the surplus in U.S. intangible assets is generated by industrial processes ($19 billion), which include licensing fees for patents and use of trade secrets. U.S. exports in this category were $37 billion in 2007.
- The EU is the United States' largest trading partner for industrial processes (nearly 50% share), followed by Japan (19%). More than half of the U.S. surplus is with the EU ($10 billion), and it has smaller surpluses with the Asia-9, China, and Latin America. The U.S. has a deficit of $3 billion with Japan.

Patents

The United States, the EU, and Japan have similar shares of economically valuable patents, accounting for a combined 90% share of the total.

- Inventions for which patent protection is sought in three of the world's largest markets—the United States, the EU, and Japan—are presumed to be of higher-than-average value. The United States, the EU, and Japan have similar shares of high-value patents, accounting for nearly 90% of the total. The Asia-9's share increased from 1% in 1997 to 6% in 2006, accounted for almost entirely by South Korea.
- The United States is the leading source of U.S. Patent and Trademark Office (USPTO) patent applications; however, foreign-based inventors, attracted by the size and openness of the U.S. market, have traditionally provided almost half of these applications.
- In 2008 the U.S. share of patent applications declined to 51%, with gains for second- and third-ranked Japan and the EU. The Asia-9's share in 2008 was flat at 10% compared to 2007, but double its level of a decade ago, driven by growth in applications from South Korea and Taiwan. India's and China's patent applications grew but remained modest, with India's share below and China's share barely above 1%. Trends are similar in patents granted.

Angel and Venture Capital Funding in the United States

Investment in angel and venture capital, an important source of financing for HT small businesses, fell in 2008 after several years of increases.

- Angel investors provided $19 billion in financing in 2008, compared with $26 billion in 2007—the first decline since 2002. Health services received the largest share of investment (16%), followed by software (13%), retail (12%), and biotechnology (11%).
- U.S. venture capitalists invested $28.1 billion in 2008—an 8% decline, compared with the level in 2007. Computer software had the largest share of investment from 2007 to 2008 (18%), followed by biotechnology (16%) and industrial/energy (13%), possibly reflecting opportunities in green and renewable energy.

Introduction

Chapter Overview

Economists increasingly emphasize the central role of knowledge, particularly R&D and other activities to promote science and technology, in a country's economic success. Information and communications technology (ICT), for example, is widely regarded as a transformative technology that has altered lifestyles and the way business is conducted across a wide range of sectors.

This chapter examines some of the downstream effects of R&D on the United States and the global marketplace. One key area is the creation of knowledge- and technology-intensive (KTI) industries and the diffusion and application of new technologies throughout other industries. Technology-intensive manufacturing and knowledge-intensive service industries have become an important and growing part of the United States' and other economies.

The globalization of the world economy and the vigorous pursuit of national innovation policies by developing countries have led to the rise of new centers of high-technology manufacturing and knowledge-intensive service industries. The United States continues to be a world leader in both, but Asian and other developing countries have become major producers and exporters and are building up their indigenous capability. The rise of these new centers of activity and the increasing fragmentation of production across borders and firms have stimulated foreign investment and trade.

Innovation is closely associated with technologically led economic growth, and observers regard it as important for advancing living standards. The measurement of innovation is an emerging field, and current data and indicators are limited. However, activities related to the commercialization of inventions and new technologies are regarded as important components of innovation indicators. Such activities include patenting, the creation and financing of new high-technology firms, and investment in intangible goods and services.

Chapter Organization

This chapter is organized into four sections. The first section discusses the increasingly prominent role of KTI industries in regional/national economies around the world. The focus is on the United States, the European Union (EU), Japan, China, and a set of emerging Asian countries/economies (the Asia-9).[1] The time span starts in the early 1990s, roughly from the end of the Cold War, to the present.

The second section describes the global spread of KTI industries and analyzes regional and national shares of worldwide production. It discusses shares for the KTI industry groups as a whole and for particular services and manufacturing industries within them. Because technology is increasingly essential for non-high-technology industries, some data on the latter are presented as well.

The third section examines indicators of increased interconnection of KTI industries in the global economy. Data on patterns and trends in global trade in KTI industries make up the bulk of this section. It presents bilateral trade data to provide a rough indication of the internationalization of the supply chains of high-technology manufacturing industries, with a special focus on the Asian region. The section also presents data on U.S. trade in advanced technology products, examining trends in U.S. trade with major economies and in key technologies. Domestic and foreign production and employment of U.S. multinationals in KTI industries are presented as indicators of the increasing involvement of these economically important firms in cross-border activities. To further illustrate the effects of globalization on the United States, the section presents data on U.S. and foreign direct investment abroad, showing trends by region and by KTI industries.

The last section presents innovation indicators and examines U.S. trade in intangible goods. It next examines patterns in country shares of high-value patents. A discussion of U.S. high-technology small businesses includes data on the number of high-technology small business startups and existing firms, employment, and venture and angel capital investment by industry. The last section also presents World Bank indicators of the knowledge capability of the United States and other major economies, which may have bearing on their current ability and future capacity to innovate.

Data Sources, Definitions, and Methodology

This chapter uses a variety of data sources. Although several are thematically related, they have different classification systems. The sidebar, "Comparison of Data Classification Systems Used," shows the classification systems used in this chapter in tabular format.

Knowledge- and Technology-Intensive Industries in the World Economy

Science and technology are widely regarded as important for the growth and competitiveness of all industries and for national economic growth. The Organisation for Economic Co-operation and Development (OECD 2001 and 2007) has identified 10 categories of service and manufacturing industries—collectively referred to as *KTI industries*—that have a particularly strong link to science and technology.[2] Although a number of other taxonomies exist, they do not allow examination of worldwide production and trade data.

- Five knowledge-intensive service industries incorporate high technologies either in their services or in the delivery of their services. They include financial, business, and communications services (including computer software development and R&D), which are generally commercially traded. They also include education and health services, which are primarily government provided and location bound.
- The five high-technology manufacturing industries include aerospace, pharmaceuticals, computers and office

Comparison of Data Classification Systems Used

System	Type of data	Basis	Coverage	Data source	Data preparation
High-technology manufacturing industries	Production and value added	Industry by International Standard Industrial Classification	Aerospace, pharmaceuticals, office and computing equipment, communications equipment, scientific instruments	United Nations Commodity Trade Statistics and IHS Global Insight	IHS Global Insight, proprietary special tabulations
Knowledge-intensive service industries	Industry production (revenues from services), in current dollars	Industry by International Standard Industrial Classification	Business, financial, communications, health, and education services	United Nations Commodity Trade Statistics and IHS Global Insight	IHS Global Insight, proprietary special tabulations
Trade in high-technology products	Product exports and imports, in current dollars	Product by technology area, harmonized code, country of origin and destination	Aerospace, pharmaceuticals, office and computing equipment, communications equipment and scientific instruments	United Nations Commodity Trade Statistics and IHS Global Insight	IHS Global Insight, proprietary special tabulations
U.S. trade in advanced technology products	U.S. product exports and imports, in current dollars	Product by technology area, harmonized code, country of origin and destination	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
U.S. trade in commercial knowledge-intensive services	U.S. exports and imports, in current dollars	Type of service, country of origin	Business, financial, and communications services	U.S. Bureau of Economic Analysis	U.S. Bureau of Economic Analysis
Globalization of U.S. multinationals	Value added and direct investment position, in current dollars	North American Industry Classification, in country of origin and destination	Business, financial, and communications services, aerospace, pharmaceuticals, office and computing equipment, communications equipment, scientific instruments manufacturing	U.S. Bureau of Economic Analysis	U.S. Bureau of Economic Analysis
U.S. trade in intangibles	U.S. receipts and payments, in current dollars	Type of intangibles and industrial processes	Total intangibles and industrial processes	U.S. Bureau of Economic Analysis	U.S. Bureau of Economic Analysis
Patents	Number of patents for inventions, triadic patents (invention with patent granted or applied for in U.S., European, and Japanese 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 (USPTO) and Organisation for Economic Co-operation and Development (OECD)	USPTO, The Patent Board, and OECD
Angel capital	Funds invested by U.S. angel investors	Technology	Biotechnology, electronics, financial services, health care, 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

machinery, communications equipment, and scientific (medical, precision, and optical) instruments.[3] These industries spend a high proportion of their revenues on R&D, and their products contain or embody technologies developed from R&D. Aerospace comparisons will reflect, in part, government funding for military aircraft, missiles, and spacecraft and differences in national commercial and civilian flight regulations. Global comparisons of pharmaceuticals gross domestic product (GDP) shares or market revenues may be influenced by differing national regulations covering foreign pharmaceuticals.

- Information and communications technology (ICT) is a subset of KTI industries. It consists of two high-technology manufacturing industries—(1) computers and office machinery and (2) communications equipment and semiconductors—and two knowledge-intensive service industries—(1) communications and (2) computer services—that are classified under business services. ICT is used in a wide variety of economic sectors and is considered an important driver of economic growth.

The OECD classification of knowledge-intensive service and high-technology manufacturing industries is an imprecise measure for a number of reasons. For example, high-technology manufacturing and knowledge-intensive service industries may produce non-high-technology products or non-knowledge-intensive services, and technologically advanced manufacturing industries are excluded if they do not spend a high proportion of their revenues on R&D.

This section examines the prominence of KTI industries in the global economy. The value added of these industries as a share of GDP is presented as an indicator of their relative importance in the major and world economies (see sidebar, "Industry Data and Terminology," for a discussion of value added and other measures). Selected data are presented on the economic wealth and productivity growth of these economies, with particular focus on the United States and other economies that are knowledge and technology intensive.

KTI industries have become a major part of the global economy. Value added of these industries was almost $16 trillion in 2007, representing 29% of world GDP compared with a 26% share 15 years ago (figure 6-1; appendix tables

Industry Data and Terminology

The industry production and trade data used in this chapter come from a proprietary data set developed by IHS Global Insight that covers a consistent set of industries across 70 countries. IHS Global Insight's data set uses data from the United Nations, the Organisation for Economic Co-operation and Development, and other sources, combined with IHS Global Insight's proprietary forecasting and estimation for missing data in some developing countries.

Two measures of industry activity are used in this chapter: *value added* and *exports and imports*. Value added and exports and imports are expressed in current (not adjusted for inflation) dollars. These measures are not compatible with past editions of this chapter, which expressed value added and exports and imports in constant (adjusted for inflation) dollars.

Value added, a measure of industry production, is the amount contributed by the country, firm, or other entity to the value of the good or service. It excludes the country, industry, firm, or other entity's purchases of domestic and imported supplies and inputs from other countries, industries, firms, and other entities.

Value added is credited to regions or countries on the basis of where the company reported the activity. This is likely to be an imperfect measure because globalization and fragmentation of production may mean that the activity occurred in a different region or country than was reported by the company. In addition, companies have different reporting and accounting conventions for crediting and allocating production performed by their subsidiaries or companies in foreign countries.

Value added of a company's activity is 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 industry.

Exports and imports are valued as the sum (gross) of value added contributed by all countries, firms, or other entities involved in production. This measure is not compatible with the value-added measure of industry production. Exports and imports are credited to the country where the product was "substantially transformed" into final form. This is an imperfect measure for exports produced in multiple countries because the assigned country may not be the same location where the most value added took place.

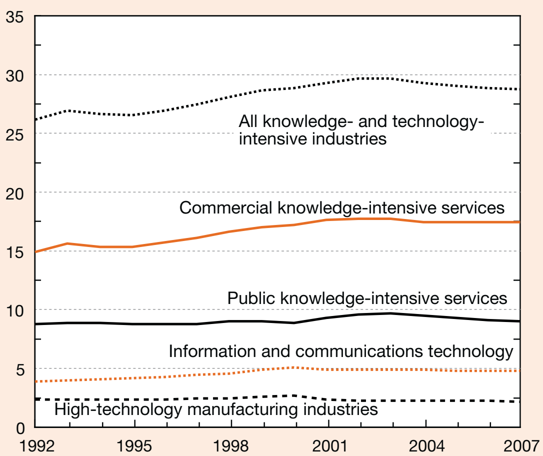
Exports and imports are assigned to a single product category by the exporter or customs agent on the basis of the primary content of the good. This method is imperfect because the product may contain other products. The trade product classification is not directly compatible with the industry classification of company production. For example, exports classified as semiconductor products may have originated from a company classified as being in the computer industry.

6-1 and 6-2). The share increased during the past decade before leveling off in 2002. The increase in the worldwide share of KTI industries was concentrated in five regional/national economies, which conduct nearly 90% of global R&D—the United States, the EU, Japan, the Asia-9, and China.[4]

The United States had the highest concentration of KTI industries (38% of GDP in 2007), 4 percentage points higher compared with its level in 1992 (figure 6-2; appendix tables 6-1 and 6-2). The percentage point increase in the corresponding shares of the EU and Japan was similar, reaching 30% and 28%, respectively, in 2007.

China's KTI industries increased their share of GDP from 21% to 23% (figure 6-2; appendix tables 6-1 and 6-2). The Asia-9's share climbed from 19% to 22% during this period.

Figure 6-1
Global output of knowledge- and technology-intensive industries as a share of global GDP: 1992–2007



GDP = gross domestic product

NOTES: Output of knowledge- and technology-intensive industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge- and technology-intensive industries include knowledge-intensive services and high-technology manufacturing industries classified by Organisation for Economic Co-operation and Development (OECD). Knowledge-intensive services include business, financial, communications, education, and health. Commercial knowledge-intensive services include business, financial, and communications services. Public knowledge-intensive services include education and health. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Information and communications technology, classified by OECD, includes two knowledge-intensive services—communications services and computer and related services (part of business services)—and two high-technology manufacturing industries—communications and semiconductors and computers and office machinery.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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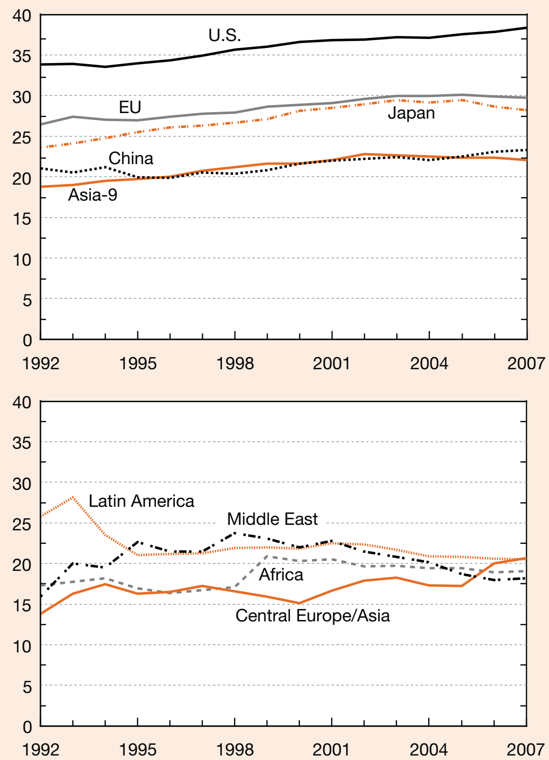
The shares of three Asia-9 countries/economies—the Philippines, South Korea, and Taiwan—rose by about 10 percentage points, reaching a 25% to 30% share of their GDP in

Figure 6-2
Output of knowledge- and technology-intensive industries as a share of GDP, by selected region/country: 1992–2007



EU = European Union; GDP = gross domestic product

NOTES: Output of knowledge- and technology-intensive industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge- and technology-intensive industries classified by Organisation for Economic Co-operation and Development and include knowledge-intensive services and high-technology manufacturing industries. Knowledge-intensive services include business, financial, communications, education; and health. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Africa includes Cameroon, Egypt, Kenya, Morocco, Nigeria, Senegal, South Africa, Tunisia, and Zimbabwe. Central Europe/Asia includes Russia, Turkey, and Ukraine. Latin America includes Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Honduras, Jamaica, Mexico, Panama, Peru, Uruguay, and Venezuela. Middle East includes Iran, Israel, Jordan, Kuwait, and Saudi Arabia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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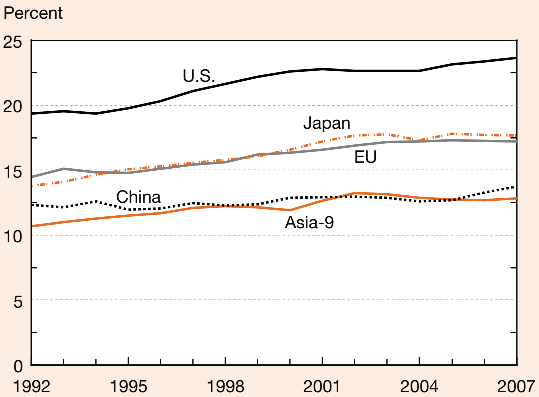
2007, significantly higher than the Asia-9 average. India's share was 18% in 2007, 3 percentage points higher than it was 15 years ago.

An increase in the intensity of the Asia-9 and China's KTI industries coincided with liberalization of their economies, increases in R&D expenditures, and adoption of policies to encourage high-technology industry production and trade. The KTI shares of other developing economies in Latin America, Africa, Central Europe/Asia, and the Middle East have grown little or have stagnated and are comparatively low (appendix tables 6-1 and 6-2).

Value added of commercial knowledge-intensive services amounted to $10 trillion in 2007, representing about 60% of the value added of all KTI industries (appendix table 6-3). Commercial knowledge-intensive services increased their share of world economic activity from 15% to 17% over the 15-year period, driving the increase in the KTI share of world GDP (figure 6-1; appendix tables 6-2 and 6-3). Value added of U.S. commercial knowledge-intensive services increased from 19% of U.S. GDP to 24%, the highest share of the knowledge-based economies (figure 6-3). The EU and Japan experienced a similar percentage point increase in the commercial knowledge-intensive share of their GDP. The share for China and the Asia-9 increased by 1 to 2 percentage points, reaching 14% and 13%, respectively, in 2007. Their considerably lower shares reflect their stage of development.

As a share of the global economy, ICT value added rose from 4% in 1992 to 5% in 2007 (figure 6-1; appendix tables 6-2 and 6-4). ICT shares in the developed economies edged up or remained steady (figure 6-4). China's ICT value-added

Figure 6-3
Output of commercial knowledge-intensive services as a share of GDP, by selected region/country: 1992–2007



EU = European Union; GDP = gross domestic product

NOTES: Output of commercial knowledge-intensive services on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge-intensive services classified by the Organisation for Economic Co-operation and Development and include business, financial, communications, education, and health. Commercial knowledge-intensive services include business, communications, and financial services. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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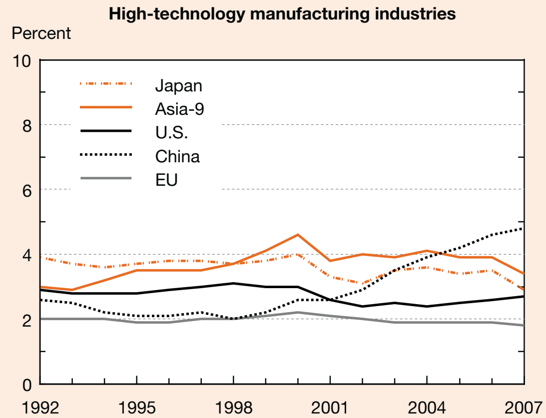
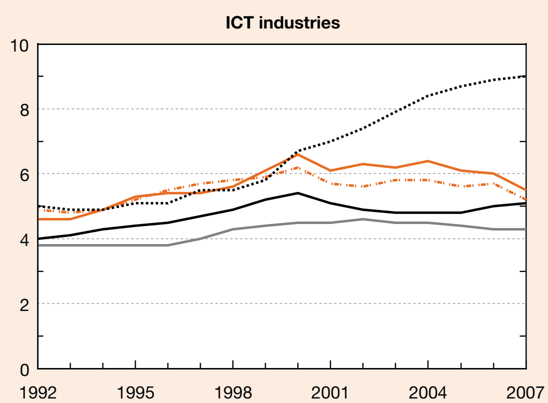
Figure 6-4
Output of high-technology manufacturing and ICT industries as a share of GDP, by selected region/country: 1992–2007





EU = European Union; GDP = gross domestic product;
ICT = information and communications technology

NOTES: Output of high-technology manufacturing and ICT industries on value-added basis. High-technology manufacturing industries and ICT industries classified by Organisation for Economic Co-operation and Development. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. ICT industries include communications services, computer and related services, communications and semiconductors, and computers and office machinery. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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share of its GDP doubled, climbing from 5% in 1992 to 9% in 2007. The Asia-9's share was steady at 5% during this period. A major factor in the rise of China's ICT intensity is that it became a major world exporter of ICT goods. The trend of the high-technology manufactures' share in the five economies was similar to that for ICT (figure 6-4; appendix table 6-5).

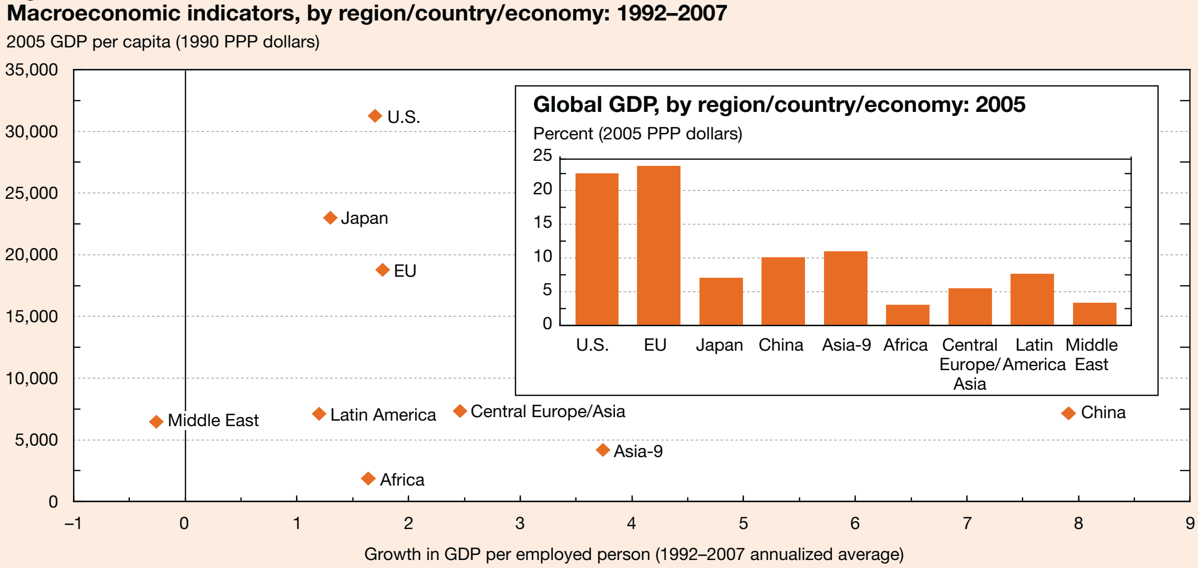
The relatively high and growing intensity of KTI industries in the United States, the EU, Japan, China, and the Asia-9 coincided with elevated living standards, as measured by GDP per capita. The United States, the EU, and Japan account for about half of the world's economic activity and also have the highest living standards (figure 6-5; appendix table 6-6). The United States has the highest per capita income among these economies ($31,260 in 1990 purchasing power parity [PPP][5]), 26% higher than Japan and 40% higher than the EU. The Asia-9 and China, each with economic production approximately the size of Japan's, have far lower per capita incomes. However, per capita income varies widely in the Asia-9. The per capita income of India, Indonesia, the Philippines, and Vietnam is less than $4,500 (1990 PPP), whereas South Korea, Singapore, and Taiwan have standards of living similar to that of the EU.

China and the Asia-9 have made remarkable progress in raising their living standards over the past decade and a half. China's per capita income grew at an annual average rate of almost 8%, resulting in per capita income more than tripling since 1992 (figure 6-6; appendix table 6-6). The Asia-9 economies grew at an annual average rate of 4%, resulting in almost a doubling of per capita income. Singapore, South Korea, and Taiwan grew slightly faster than the Asia-9 average, resulting in living standards rising from middle to high income. India's per capita income doubled from $1,300 to $2,800, propelled by 5% growth during this period. The per capita income of other developing economies has grown at half the rate (or less) of the Asia-9.

Many economists and policymakers regard productivity growth as the single most important factor in maintaining and advancing living standards. Standard productivity measures, such as labor or multifactor output per hour, are not available for many countries. A proxy measure—GDP per employed person—is used here, spanning 1992 to 2007 (appendix table 6-7).[6]

Labor productivity growth was much lower for the developed economies than the developing economies, but productivity levels were much higher (appendix table 6-7). Labor productivity growth rates for the United States, the EU, and Japan averaged less than 2% annually (1.7%, 1.8%, and 1.3%, respectively) (figure 6-5). In contrast, China's labor productivity grew at an estimated 8% annual rate.

Figure 6-5
Macroeconomic indicators, by region/country/economy: 1992–2007



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

NOTES: Africa includes Algeria, Angola, Burkina Faso, Cameroon, Democratic Republic of Congo, Côte d'Ivoire, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Morocco, Mozambique, Niger, Nigeria, Senegal, South Africa, Sudan, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. Central Europe/Asia includes Albania, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyz Republic, Macedonia, Moldova, Russia, Serbia and Montenegro, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. China includes Hong Kong. Latin America includes Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Peru, Puerto Rico, St. Lucia, Trinidad and Tobago, Uruguay, and Venezuela. Middle East includes Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, and Yemen.

SOURCE: The Conference Board, Total Economy Database (January 2009), http://www.conference-board.org/economics, accessed 15 January 2009.

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Productivity growth of the Asia-9 economies averaged roughly 4%, ranging from India's 5% to 3-4% for Singapore, South Korea, and Taiwan.

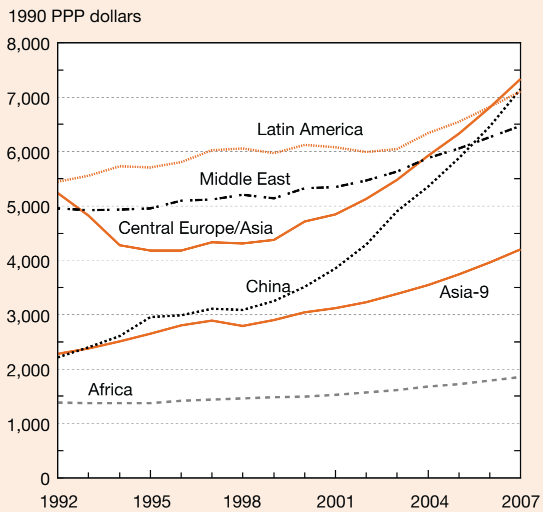
Despite impressive gains, productivity levels in China and the Asia-9 remain far below those of the United States, the EU, and Japan (figure 6-7; appendix table 6-7). China's gap with the United States decreased by 10 percentage points from 1992 to 2007 but remains at one-fifth the U.S. level. The Asia-9's gap narrowed slightly to 16% (from 12%) of the U.S. level. However, the labor productivity levels of Singapore, South Korea, and Taiwan are equivalent to those of the EU and Japan.

ICT has been identified by many economists and policymakers as vital for national economic growth and the competitiveness of all industries.[7] Bresnahan and Trajtenberg (1995) and others have identified ICT as a "general-purpose technology" that has the potential for pervasive use in a wide range of sectors because (1) it can be used with a variety of inputs and technologies and (2) it is subject to falling prices that stimulate further demand and use.[8] ICT is regarded as crucial for the growth of today's knowledge-based economies in much the same way that earlier general-purpose technologies (the steam engine, metal forging, and automatic machinery) were crucial for growth during the Industrial Revolution. Thus, adoption and diffusion of ICT may be an important indicator of future economic and productivity growth and of a country's capacity to innovate.

Three ICT indicators are presented here:

- ♦ **ICT intensity:** ICT spending as a share of GDP
- ♦ **The World Bank's Knowledge Economy Index (KEI):** a measure of per capita diffusion and adoption of ICT[9]

Figure 6-6
GDP per capita for developing economies: 1992–2007



GDP = gross domestic product; PPP = purchasing power parity

NOTES: Africa includes Algeria, Angola, Burkina Faso, Cameroon, Democratic Republic of Congo, Côte d'Ivoire, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Morocco, Mozambique, Niger, Nigeria, Senegal, South Africa, Sudan, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. Central Europe/Asia includes Albania, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyz Republic, Macedonia, Moldova, Russia, Serbia and Montenegro, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. China includes Hong Kong. Latin America includes Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Peru, Puerto Rico, St. Lucia, Trinidad and Tobago, Uruguay, and Venezuela. Middle East includes Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, and Yemen.

SOURCE: The Conference Board, Total Economy Database on Output and Labor Productivity (January 2009), http://www.conference-board.org/economics, accessed 15 January 2009.

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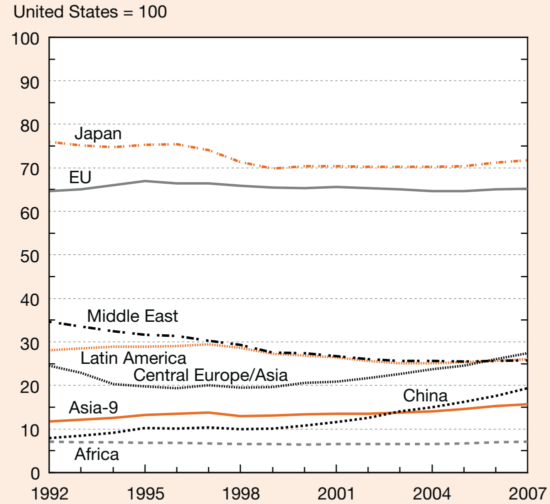
Figure 6-7
GDP per employed person, by region/country/economy: 1992–2007



EU = European Union; GDP = gross domestic product

NOTES: Value for each region expressed as percentage of U.S. value. Africa includes Algeria, Angola, Burkina Faso, Cameroon, Democratic Republic of Congo, Côte d'Ivoire, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Morocco, Mozambique, Niger, Nigeria, Senegal, South Africa, Sudan, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. Central Europe/Asia includes Albania, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyz Republic, Macedonia, Moldova, Russia, Serbia and Montenegro, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. China includes Hong Kong. EU includes all 27 member states. Latin America includes Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Peru, Puerto Rico, St. Lucia, Trinidad and Tobago, Uruguay, and Venezuela. Middle East includes Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, and Yemen.

SOURCE: The Conference Board, Total Economy Database on Output and Labor Productivity (January 2009), http://www.conference-board.org/economics, accessed 15 January 2009.

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- **National share of global ICT spending:** a measure of the scale of the economy's demand for global ICT products and services.

The United States ranks highest in the share of global ICT spending, scores highest in the KEI index, and ties with China in having the highest ratio of ICT spending to GDP (figure 6-8). The EU and Japan score nearly as high in the KEI index but have a lower intensity of ICT spending than the United States. China and the Asia-9 have greater ICT intensity and a higher share of global ICT spending than other developing regional/national economies. However, China and the Asia-9 score lower in the KEI index compared with Latin America, the Middle East, and Central Europe/Asia. ICT index scores vary widely within the Asia-9: The developed economies score at the same level as the United States, but India and other developing economies score at only half the Asia-9 average.

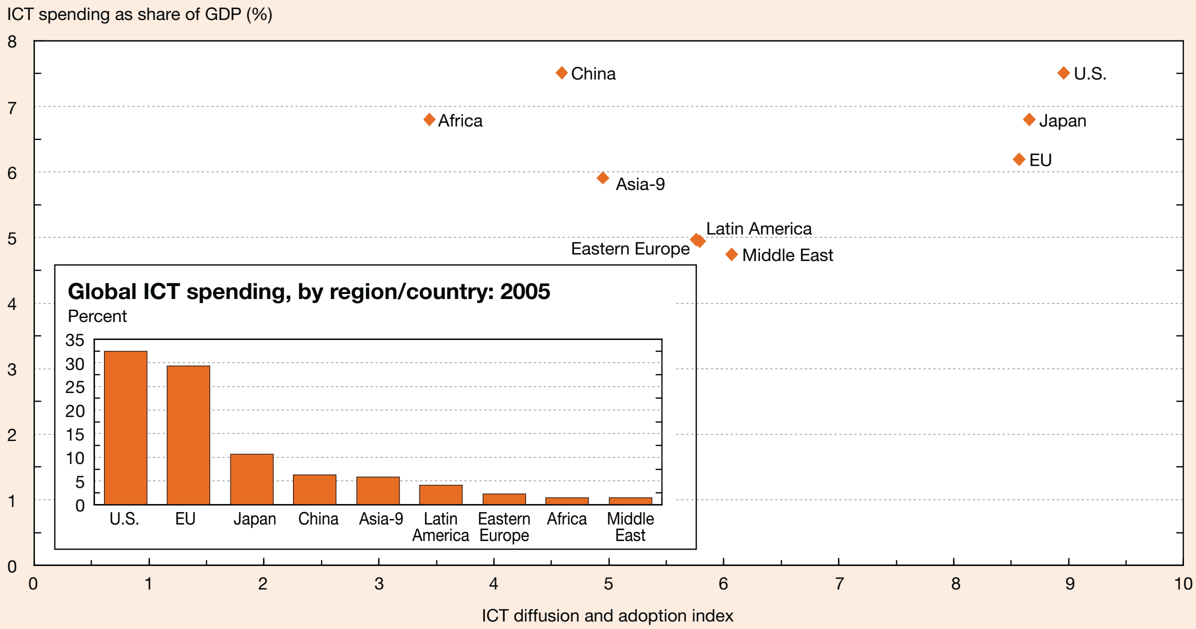
The relatively low standing of China and the Asia-9 in the KEI index, despite their relatively high share of global ICT spending, may be due to China's and India's very large populations and because China and some Asia-9 countries/economies are net exporters of ICT goods. The benefit that China and some of the Asia-9 derive from ICT exports may come at the cost of not using cheaper and more powerful ICT products throughout their domestic economy and populace.[10]

Worldwide Distribution of Knowledge- and Technology-Intensive Industries

As national and regional economies change, the worldwide centers of KTI industries shift in importance. Shifts take place both for this entire group of industries and for individual service and manufacturing industries within the group.

The global value-added output of knowledge-intensive service industries and high-technology manufacturing

Figure 6-8
Indicators of ICT adoption and intensity: 2005



EU = European Union; GDP = gross domestic product; ICT = information and communications technology

NOTES: ICT diffusion and adoption index composed of three variables: telephone, computer, and Internet usage per capita. For more information on key variables, see source World Bank, Knowledge Assessment Methodology. Regions/countries/economies ranked in order of scores on each variable, and scores normalized on 0–10 scale against all regions/countries/economies. Top 10% of performers receive normalized score between 9 and 10, decile receives normalized scores between 8 and 9, and so on. Scores for regions weighted by country/economy share of region's economic activity according to World Bank's GDP on 2005 purchasing power parity basis. Africa includes Angola, Burkina Faso, Cameroon, Egypt, Ghana, Kenya, Madagascar, Malawi, Mali, Morocco, Mozambique, Nigeria, Senegal, South Africa, Tanzania, Tunisia, Uganda, and Zimbabwe. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. Central Europe/Asia includes Albania, Armenia, Azerbaijan, Belarus, Croatia, Georgia, Kazakhstan, Kyrgyz Republic, Macedonia, Moldova, Russia, Tajikistan, Turkey, and Ukraine. China includes Hong Kong. EU excludes Malta. Latin America includes Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay, and Venezuela. Middle East includes Bahrain, Iran, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria, and Yemen.

SOURCE: World Bank, Knowledge Assessment Methodology, http://web.worldbank.org/WBSITE/EXTERNAL/WBI/WBIPROGRAMS/KFDLP/EXTUNIKAM/0,,menuPK:1414738~pagePK:64168427~piPK:64168435~theSitePK:1414721,00.html, accessed 2 October 2009; and World Information Technology and Services Alliance (WITSA), Digital Planet 2008, http://www.witsa.org/v2/, accessed 7 November 2009.

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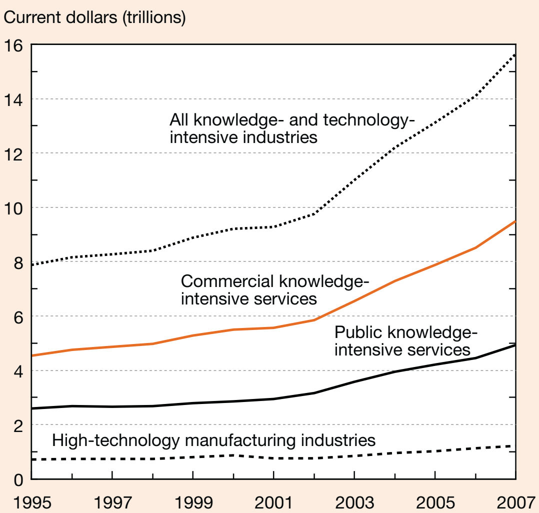
industries accounted for an estimated $15.7 trillion in 2007, of which $5.0 trillion was for the largely location-bound, publicly funded knowledge-intensive services: $2.8 trillion for health and $2.2 trillion for education (figure 6-9; appendix tables 6-8 and 6-9). The total for tradable knowledge-intensive services and high-technology manufactures amounted to $10.7 trillion—$9.5 trillion for services and $1.2 trillion for manufacturing—out of an estimated total world economic output of $54.8 trillion (IMF 2009).

Health and Education Services

The health and education sectors generated an estimated global value added of $2.8 and $2.2 trillion, respectively, in 2007 (appendix tables 6-8 and 6-9). International comparison of these two sectors is complicated by variations in the size and distribution of each country's population and the degree of government involvement and regulation. As a result, differences in market-generated value added may not accurately reflect differences in the relative value of these services.

Figure 6-9
Global value added of knowledge- and technology-intensive industries: 1995–2007



NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge- and technology-intensive industries include knowledge-intensive services and high-technology manufacturing industries classified by Organisation for Economic Co-operation and Development. Knowledge-intensive services include business, financial, communications, education, and health. Commercial knowledge-intensive services include business, financial, and communications services. Public knowledge-intensive services include education and health. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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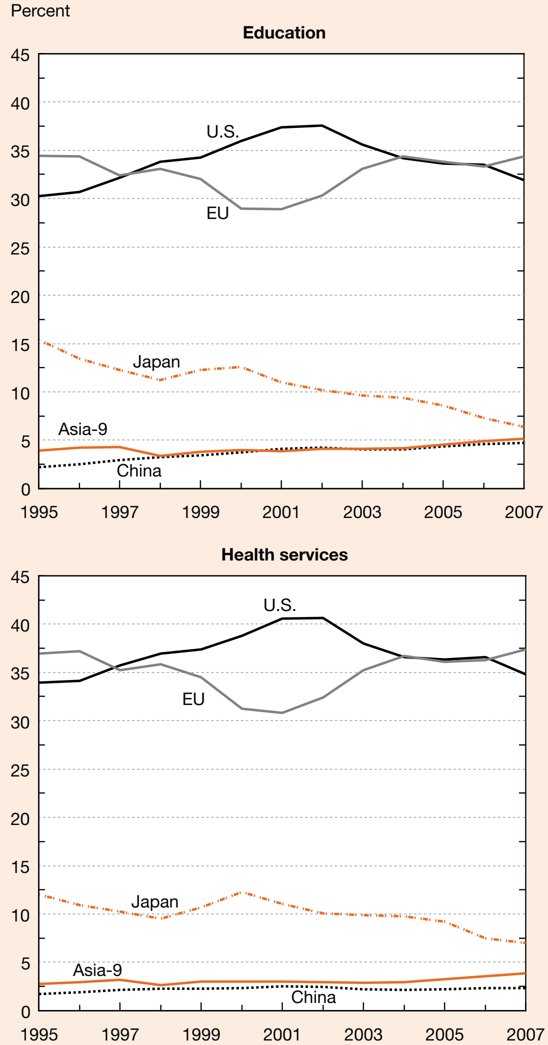
The health sector of the United States, which has more private sector involvement than many countries, is the second largest in the world as measured by share of global value added (35%), behind the EU's 37% share (figure 6-10; appendix table 6-9). The U.S. and EU shares fluctuated considerably over the past decade but were roughly stable at

Figure 6-10
Global value added of education and health services, by selected region/country/economy: 1995–2007



EU = European Union

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-9 Includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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the beginning and end of the period. Japan's world share fell from 12% in 1995 to 7% in 2007. China's share was stable and the Asia-9's share rose from 3% to 4% during this period.

The United States is also the second largest provider of education at a 32% share, placing it behind the EU's 34% share, with little change in these shares over the period (figure 6-10; appendix table 6-8). Third-ranked Japan's share declined from 15% in 1995 to 6% in 2007, China's share rose from 2% to 5%, and the Asia-9's share rose from 4% to 5%, largely because of strong growth in education spending in India, the Philippines, South Korea, Taiwan, and Thailand. Gains by China, India, and other Asian countries coincided with the rapid expansion of university enrollments and graduation of new degree holders. (See "Global Trends in Higher Education in S&E" in chapter 2 for a discussion of trends in S&E higher education in Asia and other regions/countries/economies.)

Commercial Knowledge-Intensive Service Industries

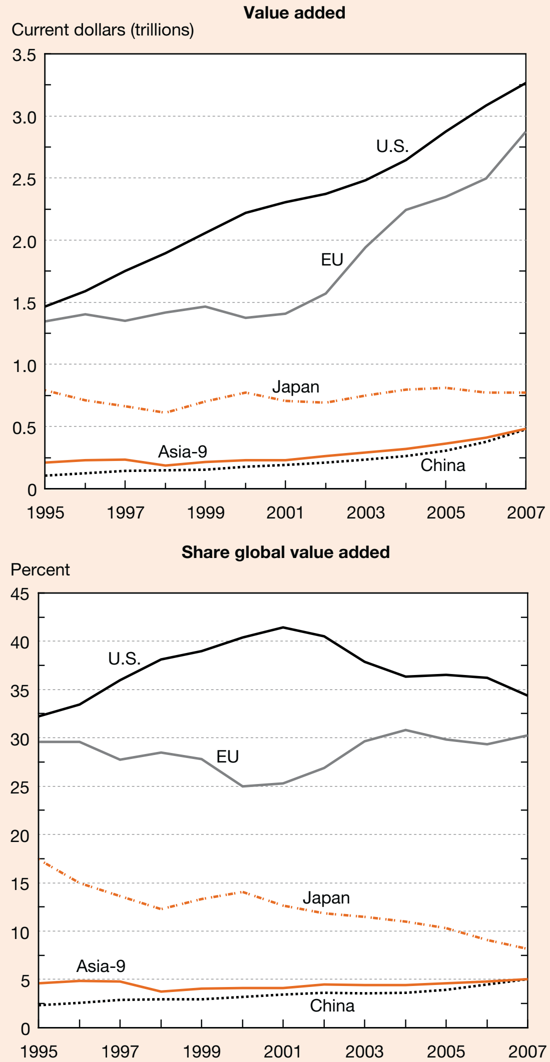
Business services is the largest of the three commercial knowledge-intensive service industries ($5.1 trillion value added); it includes computer and data processing services and commercial R&D services (appendix table 6-10). Financial services, the next largest industry, generated $3.2 trillion (appendix table 6-11). Communications ($1.3 trillion), the smallest of the knowledge-intensive industries, is arguably the most technology driven of the commercial knowledge-intensive services (appendix table 6-12).

Worldwide, the volume of commercial knowledge-intensive services more than doubled over a decade, from $4.5 trillion in 1995 to $9.5 trillion in 2007 (appendix table 6-3). The United States remains the largest provider of commercial knowledge-intensive services, with $3.3 trillion of the value added globally in 2007 (figure 6-11). The EU maintained second place at $2.9 trillion, trailed by Japan with $0.8 trillion. The volume of value added for commercial knowledge-intensive services in China and the Asia-9 is growing but remains low, at half a trillion dollars each.

Three distinct growth patterns marked the commercial knowledge-intensive service industries of these regions. However, trends in these services are probably influenced by the level and growth of per capita income and changing consumption patterns of these economies rather than by advances in technology. The United States, the EU, and the Asia-9 grew at a pace similar to the world average (appendix table 6-3). (Fluctuations in growth for the U.S. and the EU during the past decade may partially reflect fluctuations in the dollar/euro exchange rate.[11]) Japan's output stagnated over the decade, causing its world share to drop from 17% in 1995 to 8% in 2007 (figure 6-11). China's output expanded more than two times the world's average growth rate but began from a low base, reaching 5% of the 2007 world total.

The same patterns can be seen in the individual service industries, with the shares for the United States and the EU consistently near 25% of global value added, steeply

Figure 6-11
Value added of commercial knowledge-intensive services, by selected region/country/economy: 1995–2007



EU = European Union

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge- and technology-intensive industries classified by Organisation for Economic Co-operation and Development and include knowledge-intensive services and high-technology manufacturing industries. Knowledge-intensive services include business, financial, communications, education; and health. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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declining shares for Japan, and modest to rapid growth from low bases for China (moving from 2%–3% to 4%–7% of the world total over the decade) and the Asia-9, depending on the industry (figure 6-12; appendix tables 6-10 through 6-12). Within the EU, the Eastern European countries and Ireland generally grew at least twice as fast as the EU average in all three industries. Among the Asia-9 countries/economies, India was the second largest producer behind South Korea; its share rose from 0.8% to 1.4% as a result of strong growth in all three industries.

In other developing regions, Central Europe/Asia's commercial knowledge-intensive services expanded more than twice as fast as the world's average growth rate, led by growth in Russia and Turkey (appendix table 6-3). Its share of global value added increased from 1% to 3% because of strong growth in business and financial service industries. The Middle East expanded slightly faster than the world average rate, led by very rapid growth by Iran. Although Latin America grew at the world average, Mexico's output expanded 50% faster than the world average and Brazil's output more than doubled between 2003 and 2007 because of strong growth in business services and communications (appendix tables 6-10 through 6-12).

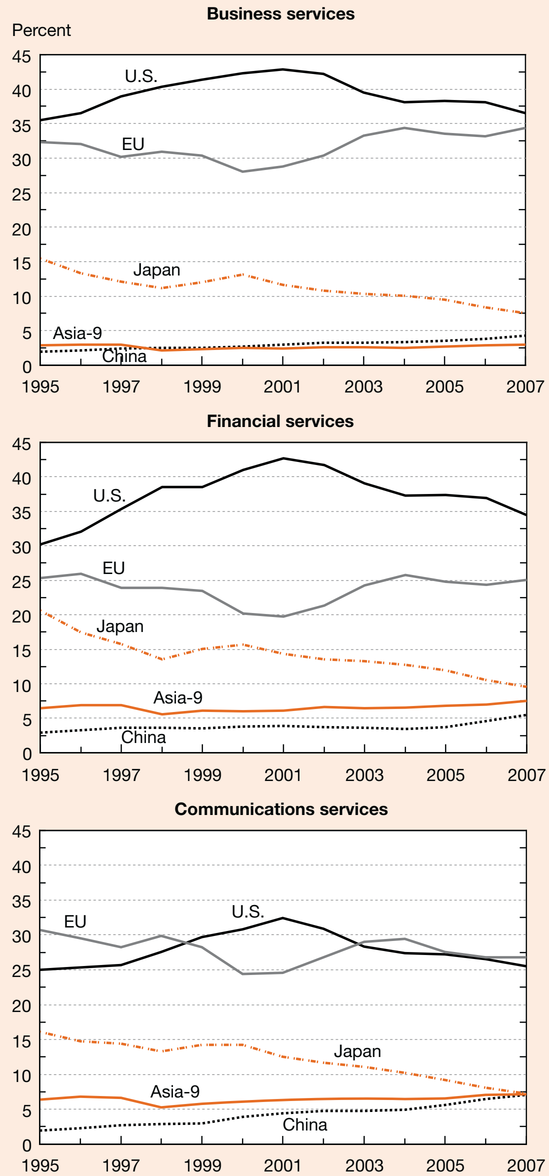
High-Technology Manufacturing Industries

Five manufacturing industries constitute the high-technology manufacturing sector, as defined by the OECD. In decreasing order of 2007 global value added, they are communications and semiconductors ($445 billion), pharmaceuticals ($319 billion), scientific instruments ($189 billion), aerospace ($153 billion), and computers and office machinery ($114 billion) (appendix tables 6-13 through 6-17).

The United States, the EU, Japan, China, and the Asia-9 dominate high-technology manufacturing industries. In 2007, their collective shares accounted for 90% of the $1.2 trillion global total (figure 6-13; appendix table 6-5). U.S. high-technology manufacturers continued to rank first with $374 billion value added, followed by the EU at $306 billion and China at $167 billion. However, the EU ranks first in domestic consumption of high-technology manufactured goods, followed by the United States (see sidebar, "Consumption of High-Technology Manufactured Goods"). Since 1995, the high-technology share of total U.S. manufacturing has increased modestly from 17% to 21% (appendix tables 6-5 and 6-18). In contrast, for all manufacturing industries, the EU is the global leader (29% of value added) and the United States ranks second (20%).

From 1995 to 2007, high-technology manufacturing output rose faster (69%) than total manufacturing (59%) (appendix tables 6-5 and 6-18). The United States, the EU, and the Asia-9 experienced growth in high-technology manufacturing close to the world average, whereas Japan's output declined, resulting in a drop in its world share from 27% to 11% (figure 6-13). China's growth in high-technology manufacturing output greatly exceeded the world average, expanding ninefold over the decade, from $19 billion to $167

Figure 6-12
Global value added of commercial knowledge-intensive services, by selected region/country/economy: 1995–2007



NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge-intensive services classified by Organisation for Economic Co-operation and Development and include business, financial, communications, education, and health. Commercial knowledge-intensive services exclude education and health. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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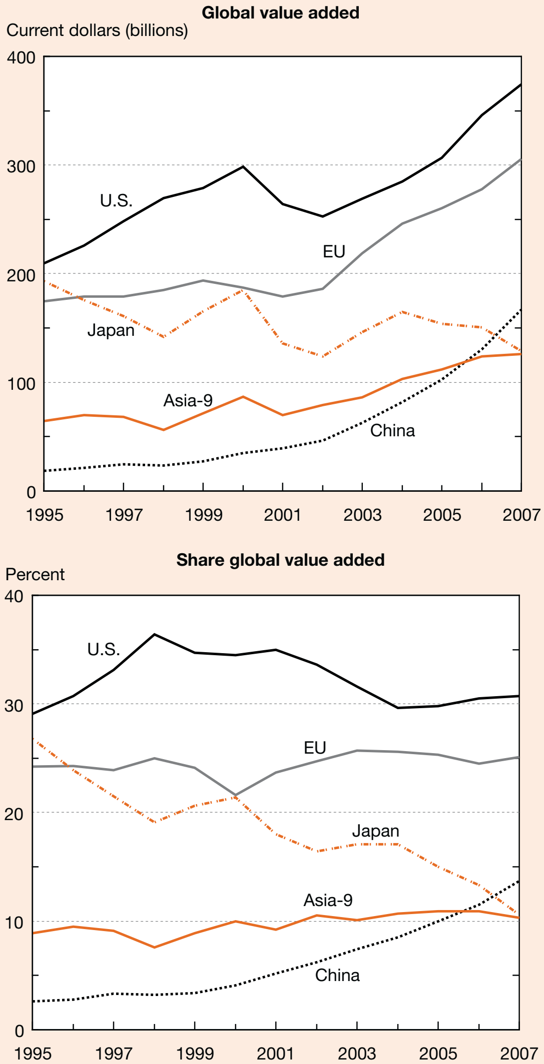
Figure 6-13
Value added of high-technology manufacturing industries, by selected region/country/economy: 1995–2007



EU = European Union

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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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. However, 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 the examination of these two concepts separately.

Patterns of the world's use of high-technology manufactures have changed considerably over the past decade. The U.S. share of domestic use, so defined, fell from 28% in 1995 to 25% in 2004 and has largely stayed at that level (figure 6-A). The EU's share stayed broadly the same at 26%–27% over the decade; it overtook the United States in 2003 to become the leading consumer of high-technology goods. Japan's share declined by more than half, from 21% to 8%; the Asia-9's share stayed essentially stable at 10% during this period.

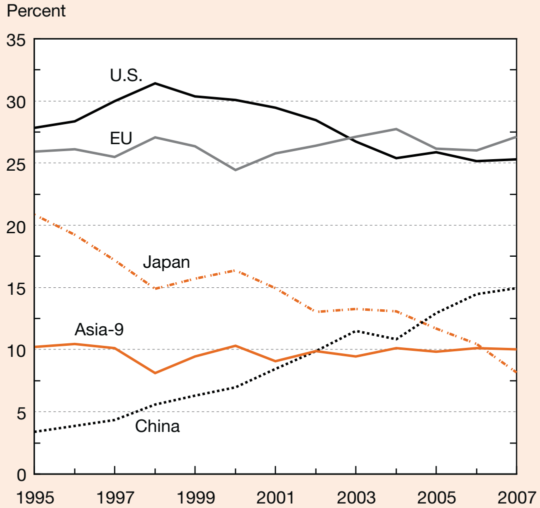
China's share surged from 4% in 1995 to 16% in 2007. The Chinese trend underscores the difficulty of teasing out final consumption from use as intermediate goods. The strong rise in the Chinese trend is considered by many observers to reflect the rising flow of intermediate goods—often previously produced in China—from other Asian manufacturing centers into China for further assembly and ultimate export.

billion, and its world share more than quadrupled from 3% to 14%. The high-technology share of the Chinese manufacturing sector jumped from 7% to 13% during this period. These country patterns were broadly similar to the output growth trends in domestic consumption of high-technology manufactured goods and knowledge-intensive services (figures 6-11 and 6-A).

In 2007, the United States was the world leader in global value added in three high-technology manufacturing industries: communications and semiconductors (29%), pharmaceuticals (32%), and aerospace (52%) (figure 6-14; appendix tables 6-13, 6-14, and 6-16). The United States ranked behind the EU in scientific instruments (19% vs. 44%) and well behind China in computers and office machinery (25% vs. 39%) (appendix tables 6-15 and 6-17).

The U.S. share of global value-added in high-technology manufacturing remained roughly stable over the decade (figure 6-13; appendix tables 6-5 and 6-18). (Fluctuations in U.S. growth may be partially due to changes in the value of the U.S. dollar.) The U.S. share of global value added was relatively stable in the aerospace, communications and

Figure 6-A
Global apparent consumption of high-technology manufacturing industry output, by selected region/country/economy: 1995–2007



EU = European Union

NOTES: Apparent consumption is sum of domestic production and inputs less exports. High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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Output of several Eastern European member countries—the Czech Republic, Hungary, Poland, and the Slovak Republic—grew much more rapidly in these industries than output of other member countries. This is consistent with evidence that these countries have become assembly centers for high-technology industries based in more developed EU economies (Kaminski and Ng 2001).

The communications and semiconductors and computers and office machinery industries drove China's rapid expansion of high-technology manufacturing, coinciding with China becoming the world's low-cost assembler and exporter of these goods. China's communications and semiconductors industry grew nearly sixfold over the decade, its world share climbing from 4% to 15% (figure 6-14 and appendix table 6-13). Its computer industry grew at 45% annually between 1995 and 2007; its world share jumped from 1% to almost 40% over the same period (appendix table 6-17).

China's growth in other high-technology industries was also rapid—China at least quadrupled its world share in pharmaceuticals, scientific instruments, and aerospace (figure 6-14 and appendix tables 6-14, 6-15, and 6-16).

Japan's share loss, driven primarily by the communications and semiconductors and the computers and office machinery industries, also extended to the other three high-technology industries (figure 6-14 and appendix tables 6-13 through 6-17). This broad downward trend may reflect its lengthy economic stagnation and the shift of production to China and other Asian economies. The Asia-9's share of global value added edged up from 9% to 10%, reaching parity with Japan in 2007 (figure 6-13; appendix table 6-5). South Korea had very strong growth in communications and semiconductors, moving its share of global value added from 4% to 10% (appendix table 6-13).

India has a very limited high-technology manufacturing industry, but its value added grew more than twice as fast as the Asia-9's average (appendix table 6-5). India's growth was concentrated in pharmaceuticals, with gains in scientific instruments—industries in which the United States and other multinationals have established a presence in India (appendix tables 6-14 and 6-15).

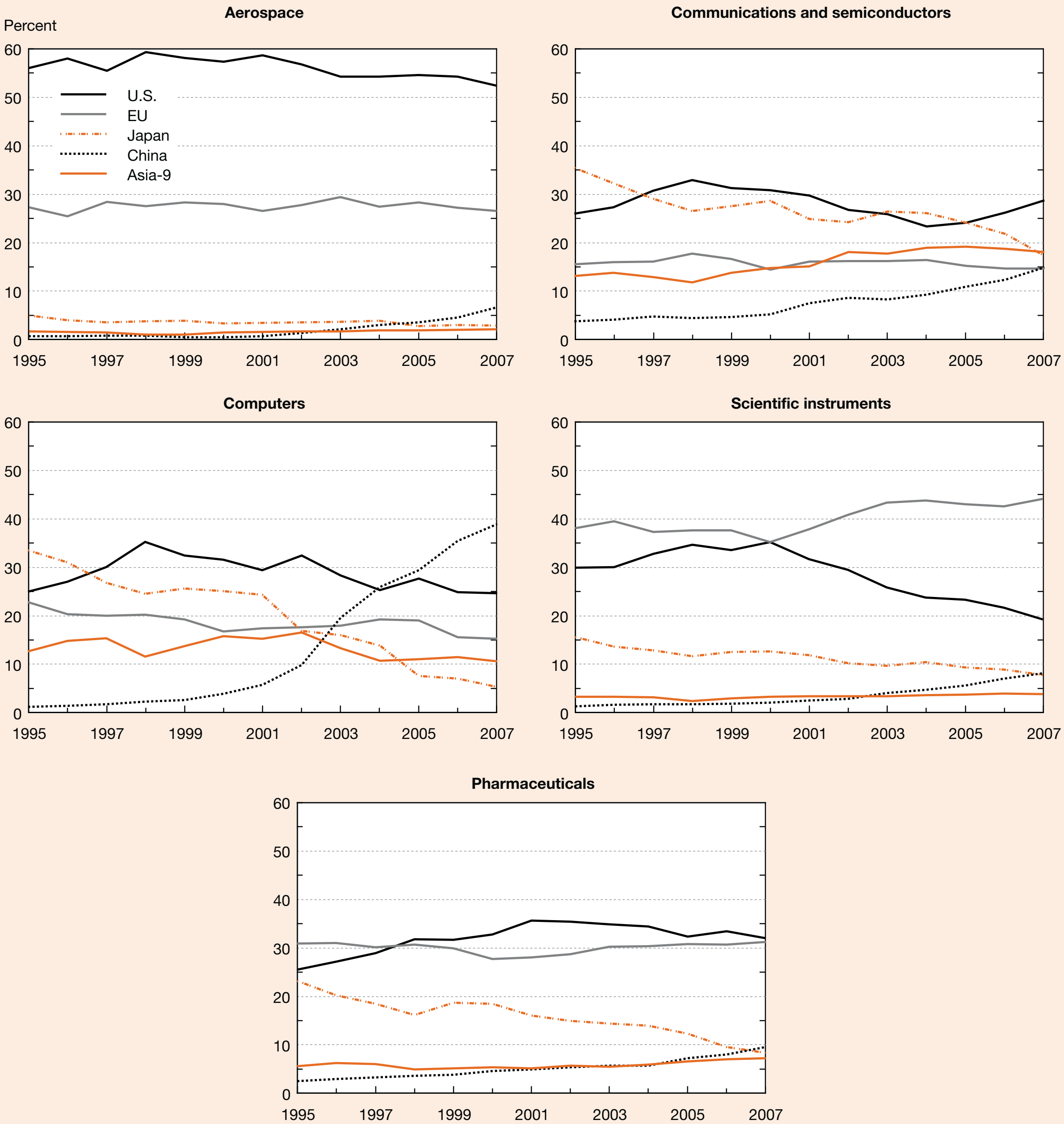
In other developing regions, high-technology manufacturing output in Central Europe/Asia grew more than twice the world average over the 1995–2007 period, led by growth in Russia and Turkey (appendix table 6-5). The Middle East also gained, driven by Israel and Iran. Growth in both of these regions was led by scientific instruments and pharmaceuticals; communications and semiconductors also contributed to the Middle East's gain (appendix tables 6-13, 6-14, and 6-15). Latin America grew at a rate near the world average, the second slowest of the developing regions. However, Mexico, an important assembly center for high-technology goods, grew two times faster than the world average during this period, led by pharmaceuticals and communications and semiconductors. Brazil's growth was stagnant between 1995 and 2003; however, it has grown rapidly since 2003, surpassing Mexico in 2005 to become the

semiconductors, computers and office machinery, and pharmaceutical industries (figure 6-14; appendix tables 6-14 through 6-17). The U.S. share in scientific instruments, however, fell significantly from 29% to 19% during this period.

Anecdotal evidence suggests that assembly of computers and semiconductors shifted from the United States to China and other Asian countries, contributing to China's vigorous expansion of its output in these industries. However, U.S.-based firms such as Dell and Apple continued to grow and to be highly profitable, deriving much of their profits from high-value activities such as logistics, design, and marketing that remained in the United States (see Dedrick, Kraemer, and Linden 2008, and sidebar, "Tracing the Geography of the Value Chain of Products").

The EU's share stayed roughly stable in three industries: pharmaceuticals (31%), communications and semiconductors (15%), and aerospace (27%) (figure 6-14; appendix tables 6-13, 6-14, and 6-16). The EU increased its share of scientific instruments by 6 percentage points to 44% over the decade but experienced a significant decline in computers and office machinery (appendix tables 6-15 and 6-17).

Figure 6-14
Global value added of selected high-technology manufacturing industries, by selected region/country/economy: 1995–2007



EU = European Union

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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Tracing the Geography of the Value Chain of Products

Several studies sponsored by the Sloan Foundation have attempted to estimate the value-added contribution of countries involved in the production of several electronic goods, including the Apple iPod and the Hewlett-Packard laptop computer. These studies essentially show that the big returns accrue to the firms and countries that harbor special design, engineering, and marketing expertise.

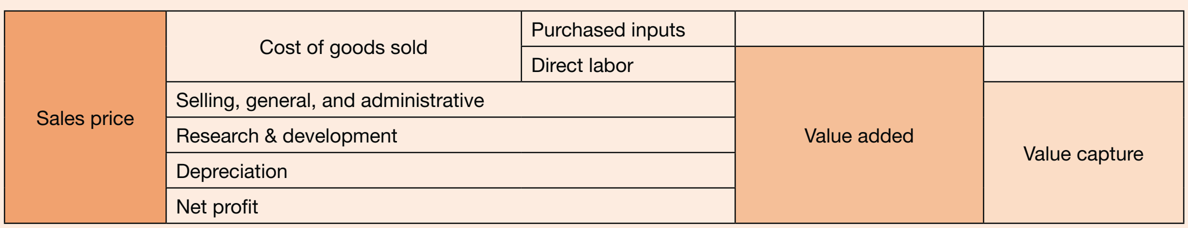
Because value-added data are not readily available at the product or firm level, these studies estimate the *value capture* of these goods. Value capture does not count the cost of direct labor (figure 6-B) which, when included, could raise a country's share (if direct labor was performed in the country) or lower it (if direct labor was performed in another country). Thus, the estimates shown must be regarded as broadly indicative only.

The Apple iPod study estimates that the United States receives the largest share of value capture based on the factory price (39%), largely reflecting Apple's gross profit (36%) (table 6-A). The study sorts iPod components into key and low-cost generic items. Key inputs account for 37% of the wholesale price, and value capture is estimated for their manufacturers. The estimated U.S. share is 3%, raising the total U.S. share to 39%. Asia's key inputs share is estimated at 14%, with Japan capturing 12% because of the expensive hard drive manufactured by Toshiba. (If direct labor costs were available, Japan's share of value added would be arguably lower because Toshiba manufactures its hard drives in China and the Philippines.) The value capture of the generic inputs is estimated at 10%, of which 3% is estimated as the value capture from manufacture of these components.

China, the location of final assembly, receives an estimated 2% share of the Apple iPod's value capture (table 6-A). The study estimates that China's value capture is very small because final assembly of an iPod requires about 10 minutes and the minimum monthly wage for a worker is about $100. Because final assembly of the iPod and other electronic goods yields little value for China, the authors claim that trade statistics are misleading because the U.S. trade deficit with China increases by about $150 plus the cost of shipping for every iPod sold in the United States, whereas the value added by China is estimated at only a few dollars. Table 6-A summarizes similar data for the Hewlett-Packard laptop computer.

(continued on next page)

Figure 6-B
Components of value added and value capture



NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Value capture is value added excluding the cost of direct labor.

SOURCE: Dedrick J, Kraemer KL, Linden G, Who Profits from Innovation in Global Value Chains? A Study of the iPod and notebook PCs, Personal Computing Industry Center, University of California–Irvine (2008), http://pcic.merage.uci.edu/papers.asp., accessed 7 November 2009.

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largest Latin American producer. Brazil's aerospace industry grew by sevenfold and its computer industry registered strong gains.

Information and Communications Technology Industries

ICT as discussed here comprises both the communications and computer services industries and the computer, communications, and semiconductors manufacturing industries. In 2007, ICT generated an estimated total of $2.6 trillion in global value—$2.0 trillion in communications and computer services, and $0.6 trillion in the manufacturing industries (appendix table 6-4).

In 2007, the United States and the EU tied as the largest ICT producers (about $700 billion), followed by second-ranked China ($315 billion). Japan and the Asia-9 converged in a range of approximately $205–$230 billion (figure 6-15; appendix table 6-4).

The U.S. and EU shares fluctuated over the decade but showed little change in 2007 compared with a decade ago (figure 6-15; appendix table 6-4). Japan's share fell steeply during this period, mirroring its downward trends in share in both high-technology and knowledge-intensive industries. China's share tripled from 4% to 12% because of strong gains across all ICT industries. The Asia-9's share was flat during this period, although India's share rose

Table 6-A
Contribution of value capture for Apple iPod and HP laptop computer, by country/economy of origin: 2005
(Percent)

Product, country/economy, and manufacturer	Activity	Share factory price
Apple video iPod		
U.S.	Design/marketing, manufacturing of components	38.7
Apple (gross profit)	Design/marketing	35.7
U.S. contract manufacturer	Manufacturing of components	3.0
Japan	Manufacturing of components	12.0
South Korea	Manufacturing of components	0.4
Taiwan	Manufacturing of components	2.0
China	Final assembly	1.8
Hewlett-Packard laptop computer		
U.S.	Design/marketing, operating system/chip, manufacturing of components	47.0
HP (gross profit)	Design/marketing	28.0
Microsoft and Intel	Operating system and chip	18.0
U.S. contract manufacturer	Manufacturing of components	1.0
Japan	Manufacturing of components	7.0
South Korea	Manufacturing of components	1.0
Taiwan	Manufacturing of components	2.0
NA	Final assembly	NA

NA = not available

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Value capture is value added excluding the cost of direct labor.

SOURCE: Dedrick, J, Kraemer, KL, Linden G, "Who Profits from Innovation in Global Value Chains? A Study of the iPod and notebook PCs," Personal Computing Center, University of California–Irvine (2008), http://pcic.merage.uci.edu/papers.asp., accessed 27 May 2009.

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from 0.5% to 1.1%, driven by gains in communications and computer services.

In other developing regions, Central Europe/Asia and Latin America increased their world share by 1 percentage point over the decade, reaching 4% and 5%, respectively, in 2007 because of strong growth in ICT service industries (appendix table 6-4).

Industries That Are Not Knowledge or Technology Intensive

Science and technology are used in many industries besides high-technology manufacturing and services. Services not classified as knowledge intensive incorporate technology in their services or in the delivery of their services but at a lower intensity compared with the knowledge-intensive services discussed above. Manufacturing industries not classified as high technology by the OECD use advanced manufacturing techniques, incorporate technologically advanced inputs in manufacture, and/or perform or rely on R&D in applicable scientific fields. In addition, some industries not classified as either manufacturing or services use or incorporate science and technology to varying degrees in their products and processes (see sidebar, "Trends in Industries Not Classified as Services or Manufacturing").

Non-Knowledge-Intensive Commercial Services

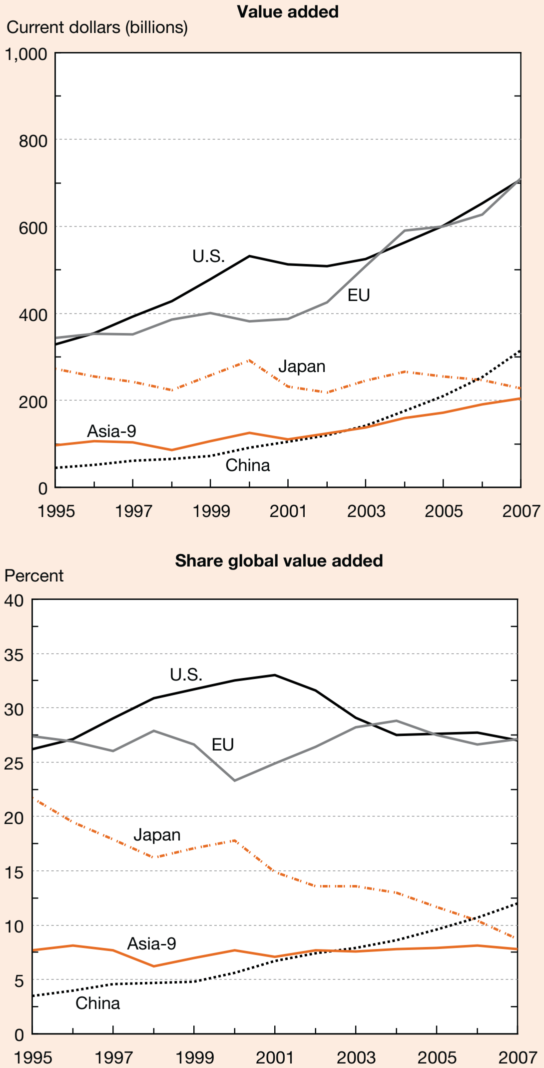
Commercial services not classified as knowledge intensive include the wholesale and retail, restaurant and hotel, transportation and storage, and real estate industries. The United States leads the EU by a slim margin, as measured by share of global value added (29%) in the wholesale and retail industry—the largest of these industries ($5.9 trillion)—and is the second-ranked provider in the other three industries (table 6-1). Allowing for fluctuations, the national/regional shares remained stable or showed slight upward trends except for Japan, whose shares fell in all of these industries.

Non-High-Technology Manufacturing Industries

Non-high-technology manufacturing industries are divided into three categories, as classified by the OECD: medium-high technology, medium-low technology, and low technology. These 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).

The share trends in all of these industry segments are the same as for high technology—share losses for the United States and larger share losses for Japan, stable or slight declines for the EU, stable or slight increases for the Asia-9, and strong share gains across all segments for China.

Figure 6-15
Value added of ICT industries, by selected region/country/economy: 1995–2007



EU = European Union; ICT = information and communications technology

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Information and communications technology classified by Organisation for Economic Co-operation and Development and includes communications services, computer and related services, communications and semiconductors, and computers and office machinery. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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- **Medium-high-technology industries:** These industries produced $2.1 trillion in global value added in 2007. The U.S. share fell from 23% to 17% between 1995 and 2007 (table 6-2), and the EU share remained roughly stable (32%). Japan's share fell from 24% to 13%, China's more than quadrupled from 3% to 13%, and the Asia-9's share rose from 7% to 9%.
- **Medium-low-technology industries:** The U.S. and EU shares of these industries ($2.5 trillion global value added) fell 3 percentage points each over the decade, reaching 16% and 28%, respectively (table 6-2). Japan's share fell from 24% to 10%, its steepest loss among these three segments.
- **Low-technology industries:** These industries produced $2.6 trillion in global value added in 2007. The U.S. and EU shares fell slightly (table 6-2). The Asia-9's share remained stable, as opposed to its small gains in the other two segments.

Trade and Other Globalization Indicators

In the modern world economy, production is more often globalized (i.e., value is added to a product in more than one nation) than in the past and less often vertically integrated (i.e., conducted under the auspices of a single company and its subsidiaries). These trends have affected all industries, but their impact has been particularly strong in electronic, ICT, and other KTI manufacturing and service industries. The broader context is the rapid expansion of these industrial and services capabilities in many developing countries, both for export and internal consumption.

Global high-technology trade volume has risen faster than global production, indicating the growing importance of international suppliers of intermediate goods that are then used in the assembly of the final products purchased by the consumer. Data on multinational companies and cross-border investment likewise indicate growing interconnection among the world's economies.

This discussion of trade trends in high-technology manufactured products focuses on the United States, the EU, Japan, the Asia-9, and China. Europe and East Asia have a substantial volume of intraregional trade that is treated differentially in this section. Intra-EU exports are excluded because the EU is an integrated trading bloc with common external trade tariffs and few restrictions on intra-EU trade. Trade between China and Hong Kong is excluded because it is essentially intracountry trade. The substantial intra-Asia-9 trade is included because the group is not an integrated economy. Analytically, this allows delineation of a developing Asia-9/China supplier and manufacturing zone of high-technology goods that are largely destined for export to the EU, the United States, and Japan.

Trade data are an imperfect indicator of where value is added to a product. When the United States imports an ICT

Trends in Industries Not Classified as Services or Manufacturing

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. However, these industries are dependent on or use science and technology. 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.

The United States ranks first in mining, second in construction and utilities behind the EU, and fourth in agriculture as measured by share of global value added among the five major economies (table 6-B). The U.S. share rose from 18% to 22% in construction over the decade, and its share in the other three industries remained stable. The EU's share rose or was steady in construction and utilities but fell substantially in mining and agriculture. Japan's share fell sharply in all of these industries. China had gains across all industries, particularly agriculture and utilities. The Asia-9's shares were stable or slightly higher.

Table 6-B
Share of global value added for selected industries, by region/country/economy: Selected years, 1995–2007
(Percent distribution)

Industry and region/country/economy	1995	1997	1999	2001	2003	2005	2007
Agriculture							
Global value added (current $billions)	1,113.3	1,150.1	1,033.4	1,003.9	1,167.6	1,390.0	1,835.8
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	8.4	9.6	9.1	9.8	9.8	9.6	9.1
EU	21.9	19.4	19.5	18.1	18.7	16.8	15.8
Japan	9.2	6.6	7.9	6.9	6.1	5.0	3.6
China	13.1	15.2	17.3	19.0	18.0	20.3	21.3
Asia-9	19.4	19.3	19.3	18.8	18.9	18.9	19.5
All other countries	28.0	30.0	26.9	27.4	28.5	29.5	30.7
Construction							
Global value added (current $billions)	1,626.4	1,587.7	1,591.6	1,607.5	1,846.3	2,311.3	2,775.2
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	17.6	21.3	25.5	29.2	26.9	26.2	22.0
EU	30.0	27.5	28.3	26.8	31.7	31.9	34.3
Japan	26.8	21.6	21.1	18.2	15.1	12.5	9.4
China	3.2	4.1	4.5	4.9	5.2	5.6	6.7
Asia-9	7.9	8.6	6.2	6.0	6.7	7.5	8.4
All other countries	14.6	16.9	14.4	14.9	14.3	16.3	19.3
Mining							
Global value added (current $billions)	469.7	552.0	462.6	600.4	748.3	1,305.1	1,695.3
United States	15.8	16.8	18.5	19.8	19.2	17.1	16.2
EU	15.4	12.2	13.0	11.5	10.5	8.5	7.6
Japan	1.9	1.2	1.2	0.9	0.6	0.3	0.3
China	7.2	9.4	11.6	10.3	10.8	9.6	10.2
Asia-9	7.9	7.6	7.9	7.6	7.4	6.8	7.0
All other countries	51.9	52.8	47.8	49.9	51.5	57.6	58.6
Utilities							
Global value added (current $billions)	718.9	693.8	700.1	687.3	795.7	961.7	1,149.7
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	25.2	25.9	26.5	29.4	27.6	24.9	24.5
EU	26.6	25.6	24.5	21.2	25.2	25.7	26.0
Japan	25.4	21.8	23.4	22.4	19.3	16.3	12.6
China	2.7	3.9	5.0	5.5	6.0	9.2	10.3
Asia-9	5.1	5.7	5.5	5.9	6.1	5.8	6.1
All other countries	15.0	17.1	15.1	15.6	15.8	18.1	20.5

EU = European Union

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Percents may not add to 100% because of rounding.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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Table 6-1
Global value added for selected service industries, by region/country/economy: Selected years, 1995–2007
(Percent distribution)

Service industry and region/country/economy	1995	1997	1999	2001	2003	2005	2007
Wholesale and retail							
Global value added (current $billions)	3,575.8	3,601.9	3,683.1	3,717.3	4,242.7	5,020.3	5,899.8
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	27.2	30.4	32.9	34.9	32.7	30.8	28.8
EU	27.0	25.7	25.9	24.4	27.8	27.7	28.4
Japan	23.5	18.9	18.7	16.5	14.5	13.4	10.8
China	2.2	2.9	3.1	3.6	3.9	4.1	4.6
Asia-9	5.8	6.2	5.6	5.9	6.1	6.8	7.6
All other countries	14.3	15.9	13.8	14.6	15.1	17.2	19.9
Real estate							
Global value added (current $billions)	2,570.2	2,606.8	2,755.7	2,889.0	3,371.9	3,929.9	4,623.7
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	31.7	34.8	36.9	40.5	37.8	36.3	34.3
EU	31.6	30.0	29.3	26.9	31.4	32.6	35.0
Japan	21.9	17.7	18.1	16.8	15.3	13.9	11.3
China	1.4	1.7	1.9	2.2	2.4	2.7	3.3
Asia-9	3.2	3.5	3.1	3.1	3.1	3.3	3.5
All other countries	10.2	12.2	10.7	10.6	10.0	11.2	12.5
Transport and storage							
Global value added (current $billions)	1,207.6	1,206.2	1,237.8	1,255.9	1,452.9	1,775.4	2,147.4
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	18.7	21.0	23.2	23.6	21.8	20.5	19.0
EU	29.9	29.1	29.7	28.0	32.1	31.7	32.3
Japan	23.2	17.4	17.1	15.4	13.8	11.8	9.4
China	3.8	4.7	5.5	7.0	6.6	7.4	8.1
Asia-9	6.6	7.0	6.4	6.5	6.9	7.6	8.3
All other countries	17.8	20.8	18.0	19.5	18.9	21.0	22.9
Restaurants and hotels							
Global value added (current $billions)	706.8	734.1	787.1	806.2	934.3	1,116.1	1,336.3
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	26.3	29.4	31.0	33.0	31.2	29.9	28.4
EU	29.4	28.7	29.4	27.8	32.1	32.6	33.7
Japan	21.6	17.4	17.0	15.2	14.0	12.5	10.4
China	2.7	3.5	3.7	4.3	4.2	4.8	5.6
Asia-9	6.1	6.3	5.2	5.5	5.6	5.9	6.6
All other countries	13.8	14.7	13.7	14.2	12.9	14.2	15.3

EU = European Union

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Percents may not add to 100% because of rounding.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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good that is assembled in China from components that, in turn, are imported from other Asian economies, China's value added may be small because its contribution is limited to final assembly of the good (Koopman, Wang, and Wei 2008). Much of the value added may originate from Asian, EU, or U.S. firms that manufactured the components or conducted design, marketing, software development, and other activities. The factory price and shipping cost of the good, however, would be fully credited to China's exports and U.S. imports. Accurately apportioning value added is fraught with difficulties (see sidebar, "Tracing the Geography of the Value Chain of Products").

Trade of High-Technology Goods

A country's success in exporting its goods to other countries is one measure of its comparative economic advantage—the goods it produces are provided not just to its local market but are also competitive in a world market.

The gross value of global exports of high-technology products—communications and semiconductors, computers and office machinery, pharmaceuticals, scientific instruments, and aerospace—reached $2.9 trillion in 2008, up from $915 billion in 1995 (appendix table 6-19).[12] (See sidebar, "Product Classification and Determination of Country of Origin of Trade Goods" for discussion on how trade goods

Table 6-2
Global value added for manufacturing industries, by selected technology level and region/country/economy: Selected years, 1995–2007
(Percent distribution)

Manufacturing technology level and region/ country/economy	1995	1997	1999	2001	2003	2005	2007
Medium high							
Global value added (current $billions)	1,394.7	1,343.5	1,313.1	1,251.6	1,462.2	1,747.8	2,127.1
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	22.5	24.9	26.7	26.6	23.3	19.3	17.4
EU	31.5	31.0	31.2	29.7	32.7	31.9	32.3
Japan	23.9	20.4	20.6	19.0	17.5	16.9	13.3
China	2.7	3.6	3.5	5.0	7.1	10.2	13.4
Asia-9	6.5	6.7	5.9	6.7	7.2	8.1	8.6
All other countries	12.9	13.4	12.1	13.1	12.3	13.7	15.0
Medium low							
Global value added (current $billions)	1,352.5	1,325.3	1,277.5	1,257.9	1,464.9	1,981.5	2,518.8
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	19.1	22.0	23.8	24.0	20.7	19.3	16.1
EU	31.2	29.5	30.2	28.3	30.3	28.0	28.1
Japan	23.8	19.9	18.9	17.5	15.6	13.5	9.8
China	3.5	3.9	4.1	5.6	7.4	10.0	14.2
Asia-9	7.6	8.2	7.4	7.6	8.1	9.0	9.5
All other countries	14.8	16.5	15.5	17.0	17.8	20.1	22.3
Low							
Global value added (current $billions)	1,809.3	1,766.6	1,792.2	1,743.3	1,942.2	2,229.1	2,549.7
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	24.7	26.9	30.2	31.3	28.7	26.1	23.0
EU	31.5	30.2	29.5	27.3	30.4	29.7	29.8
Japan	18.8	14.8	15.0	13.9	12.1	10.7	8.3
China	2.9	4.1	4.0	5.1	6.3	8.7	11.9
Asia-9	6.0	6.3	5.7	5.7	5.8	6.0	6.5
All other countries	16.1	17.7	15.7	16.7	16.8	18.7	20.4

EU = European Union

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Technology level of manufacturing classified by Organisation for Economic Co-operation and Development on basis of R&D intensity of output. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Percents may not add to 100% because of rounding.

SOURCE: IHS Global Insight, World Industry Service database, special tabulations (2009).

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are classified.) Removing intrabloc (within the EU) and intracountry (China to Hong Kong) exports reduces these totals to $732 billion in 1995 and an estimated $2.3 trillion in 2008—base figures for the analyses that follow (figure 6-16). Among the five high-technology products, the world export value was greatest in communications and semiconductors (45% of the total) followed by computers (20%), giving the ICT products about two-thirds of the total (figure 6-17; appendix tables 6-20 through 6-24).

The threefold increase in exports was greater than the rise in global production of these industries over the period, from $2.0 trillion to $4.0 trillion (figure 6-16). This probably reflects the broadened geographic base of high-technology manufacturing overall, the expansion of multinational firms' production to overseas venues, and the shift of production from vertically integrated firms to greater reliance on international external suppliers.

Global Trade Balance Trends in High-Technology Manufactures

The expansion of high-technology trade has led to changes in the relative positions of the developed and developing countries (figure 6-18; appendix table 6-19). Measured in relative volume of exports, the U.S. position has declined from 21% in 1995 to 14% in 2008, reflecting broad drops in exports of U.S. ICT goods (communications and semiconductors and computers and office machinery), which account for nearly 45% of the nation's high-technology exports (figure 6-19; appendix tables 6-19 through 6-21). (See sidebar, "Product Classification and Determination of Country of Origin of Trade Goods," for discussion of how exports are credited to countries.) Japan's share declined steadily over the period, from 18% to 8%, again largely because of declining exports of ICT goods. The EU's high-technology export share remained approximately stable at 16%–18%.

Amidst a great increase in world exports, China's share surged from 6% to 20% over little more than a decade,

Product Classification and Determination of Country of Origin of Trade Goods

The characteristics of goods in international trade are determined from a product perspective. Data on product trade are first recorded at the country'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, a customs agent for the receiving country 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.

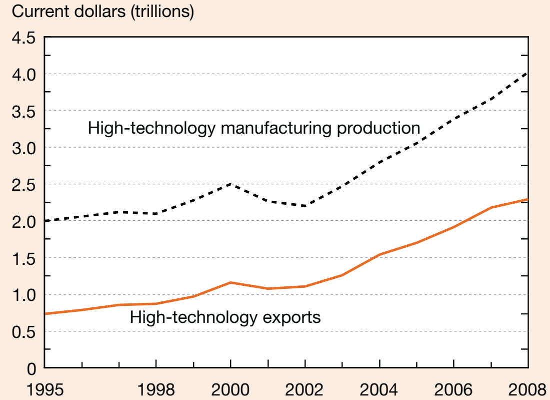
Data on international product trade assign products to a single country of origin. For goods manufactured with international components, the country of origin is determined by where the product was "substantially transformed" into its final form. For example, a General Motors car that was assembled in the United States with components imported from Germany and Japan and that is destined for export to Canada will be labeled "Made in the USA." The country where the product was "substantially transformed" may not be the location where the most value was added.

*The Harmonized Commodity Description and Coding System, or Harmonized System (HS), is a system for classifying goods traded internationally that was 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.

making it the largest single exporting country for high-technology manufactured goods (figure 6-18; appendix table 6-19). The Asia-9 region has maintained its position at more than a quarter of the total. However, this largely reflects the rise of a manufacturing supplier zone around China that is focused on ICT goods (see "Trends in the Geographic Distribution of Bilateral High-Technology Trade," later in this chapter).

Notable differences are apparent in the export performance of these countries and regions for the five products (figure 6-19; appendix tables 6-20 through 6-25). The United States and Japan have been losing export shares in most industries, with the exception of the U.S. aerospace share, which has fluctuated at about 50%. EU shares have held approximately steady, with strong market shares for pharmaceuticals, aerospace, and scientific instruments. China's market shares have grown substantially since 2000,

Figure 6-16
Global production of high-technology manufacturing industries and exports of high-technology products: 1995–2008



NOTES: Production is gross revenue, which includes purchases of domestic and imported materials and inputs. High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. High-technology manufacturing production on industry basis. High-technology exports on product basis.

SOURCE: IHS Global Insight, World Industry Service and World Trade Service databases, special tabulations (2009).

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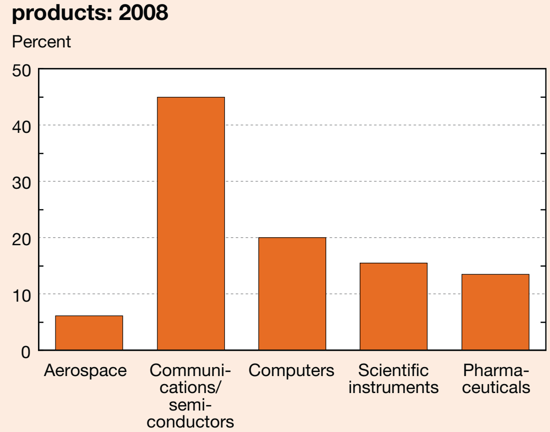
Figure 6-17
Distribution of global exports of high-technology products: 2008



NOTES: High-technology exports on product basis and include aerospace, communications and semiconductors, computers and office machinery, scientific instruments and measuring equipment, and pharmaceuticals.

SOURCE: IHS Global Insight, World Industry Service and World Trade Service databases, special tabulations (2009).

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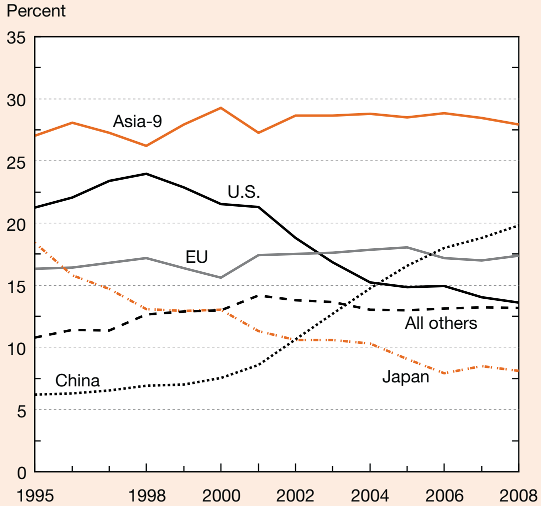
Figure 6-18
Global exports of high-technology products, by selected region/country/economy: 1995–2008



NOTES: High-technology products include aerospace, communications and semiconductors, computers and office machinery, scientific instruments and measuring equipment, and pharmaceuticals. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. China's exports exclude exports between China and Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. EU exports exclude exports among EU member countries.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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capturing almost 40% of the world export market in computers and office machinery and showing strong growth in semiconductors export shares (but negligible shares in aerospace and pharmaceuticals). The Asia-9 region accounts for large shares of semiconductor and computer exports and, together with China, captured more than 60% of the world export market share in these industries.

Throughout the 1980s and into the mid-1990s, the United States consistently exported more high-technology products than it imported, in contrast to deficits recorded for other U.S. manufacturing products.[13] A growing U.S. import volume in the late 1990s shifted the U.S. high-technology trade balance from surplus to deficit (figure 6-20 and appendix table 6-19). In 2000, the deficit was $32 billion in current dollars; by 2008, the deficit had widened to $80 billion.

ICT goods are driving the U.S. high-technology trade deficit: In 2008, the ICT industries ran a deficit of almost $120 billion in current dollars (figure 6-20; appendix table 6-26). The emergence of large deficits in these products reflected rising domestic demand, which coincided with a broad shift in location of the production of ICT goods to developing countries, largely in Asia. This, in turn, stimulated imports of ICT goods from these countries. Pharmaceuticals contributed a further $21 billion to the overall 2008 deficit (appendix table 6-23).

U.S. trade in aerospace products registered a trade surplus of $50 billion in 2008, continuing its trend of surpluses for the past two decades; trade in scientific instruments added a smaller surplus of $9 billion (appendix tables 6-22 and 6-24).

The EU high-technology trade balance remained roughly stable, with a deficit of about $20 to $50 billion over this period (figure 6-20; appendix table 6-19). However, the EU ICT deficit grew from $38 billion in 1995 to $117 billion in 2008, reflecting the same underlying structural shift (appendix table 6-26). Rising surpluses in aerospace, pharmaceuticals, and scientific instruments offset the increasing ICT deficit (appendix tables 6-22 through 6-24).

The trade positions of China and the Asia-9 also changed substantially. China's trade position, which had been in balance for much of the 1980s and 1990s, moved to a surplus after 2001 (figure 6-20; appendix table 6-19) and rapidly increased from less than $13 billion in 2003 to almost $130 billion in 2008, driven by the ICT goods trade (appendix table 6-26). The Asia-9's trade surplus grew from about $50 billion to more than $220 billion over the past decade, entirely due to an expansion of its surplus in ICT goods (however, see the next section). Japan's surplus showed little change, despite its loss of market share in production of high-technology industries.

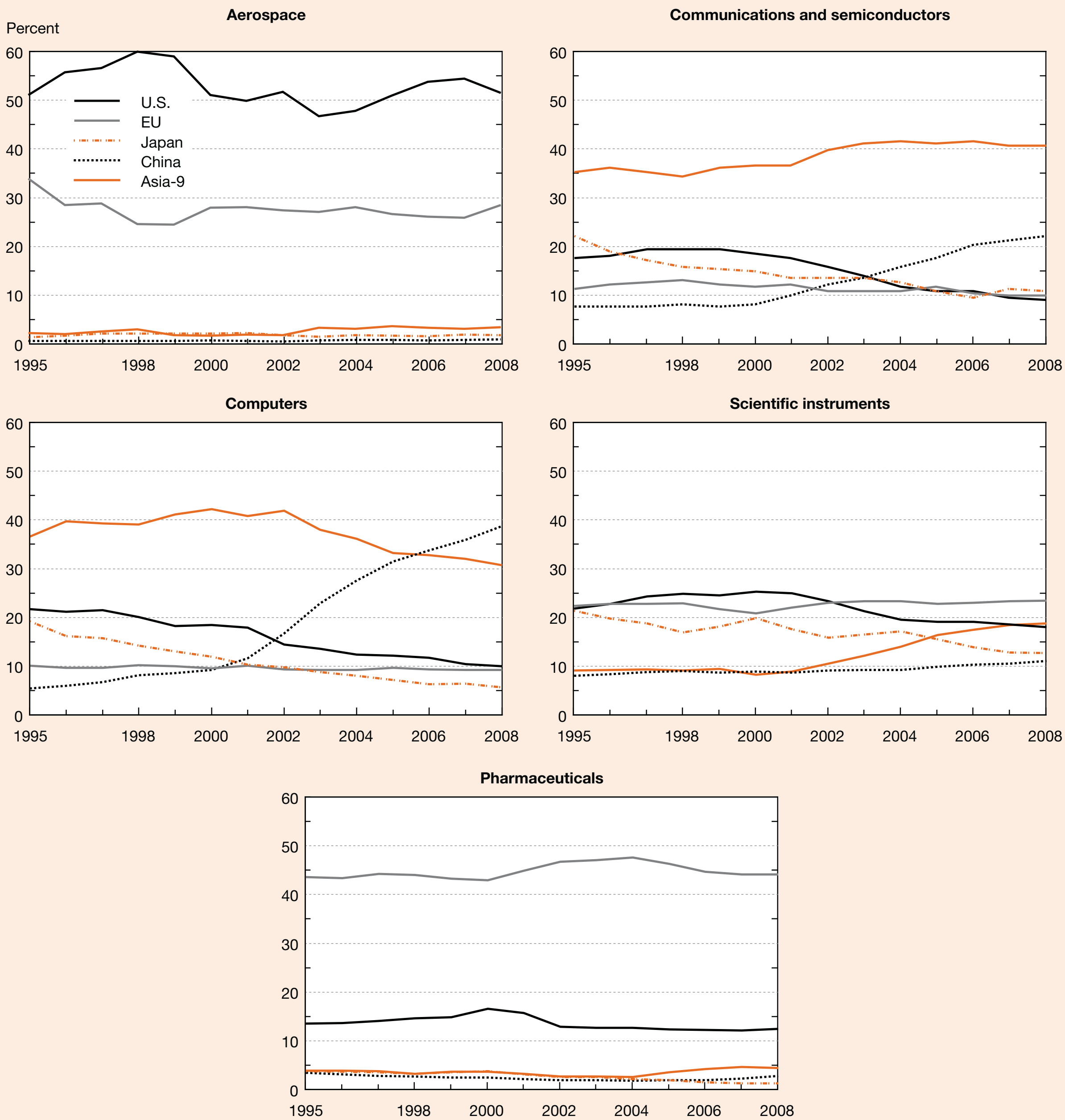
Geographic Distribution of Bilateral High-Technology Trade

The shift in trade in global high-technology manufactures over the past decades (i.e., the shift away from the developed regional/national economies to China and the Asia-9) was accompanied by a pronounced shift in the distribution of bilateral trade among these and the three other economies—the United States, the EU, and Japan. Trade in ICT goods, the largest single category of high-technology industry goods, illustrates these shifting patterns.

Final assembly of ICT goods and components shifted—from the United States, the EU, Japan, and developed economies among the Asia-9—toward China early in this decade, and some assembly work has subsequently shifted from China to the less-developed Asia-9 economies (Athukorala and Yamashita 2006, Ng and Yeats 2003, Rosen and Wing 2005). This discussion examines trends in bilateral trade distribution of ICT goods.

The rise of China as the world's major assembler and exporter of many electronic goods is reflected by a sharp increase in China's share of ICT imports in the United States, the European Union, and Japan (figure 6-21; appendix tables 6-27 through 6-29). China's share of these economies' ICT imports was 40%–50% in 2008, compared with 10% or less in 1995. Data on China's bilateral exports show that about 65% of its ICT exports were shipped to the United States, Japan, and the EU, suggesting that most of China's exports are finished products destined primarily for developed countries (figure 6-22; appendix table 6-30). The trends for China's

Figure 6-19
Region/country/economy share of global exports of selected high-technology products: 1995–2008



EU = European Union

NOTES: High-technology products include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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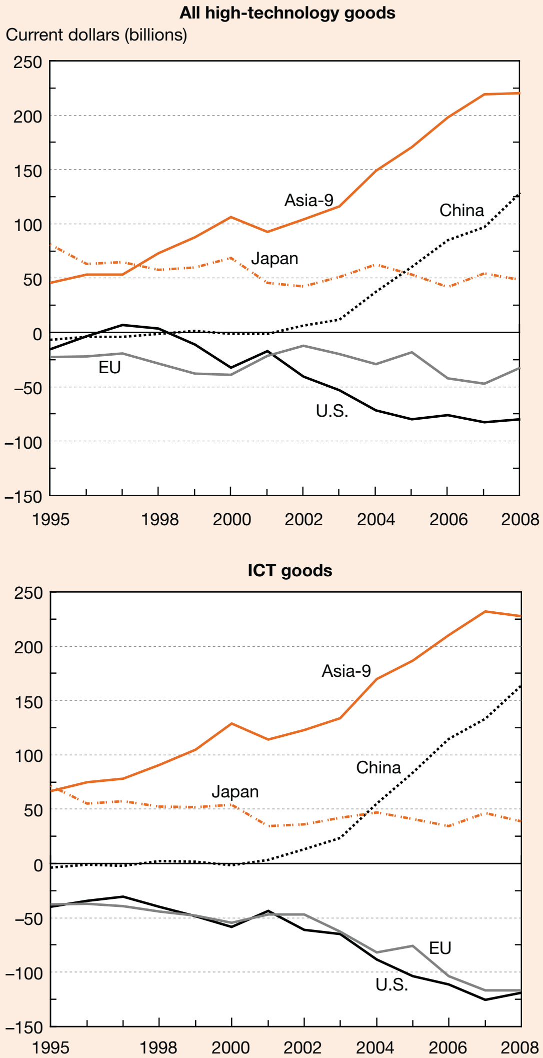
ICT exports by share of developed economy showed little change over time.

Trends in data regarding China's imports and the Asia-9's exports of ICT goods suggest that much of final assembly has shifted to China, with the Asia-9 acting as key suppliers of components and inputs. The Asia-9's share of China's ICT imports rose from 40% in 1995 to 71% in 2008 (figure 6-22; appendix table 6-30). Imports from Taiwan increased

Figure 6-20
Trade balance of high-technology and ICT products, by selected region/country/economy: 1995–2008



EU = European Union; ICT = information and communications technology

NOTES: High-technology products include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, scientific instruments and measuring equipment. ICT products include communications services, computer and related services, communications and semiconductors, and computers and office machinery. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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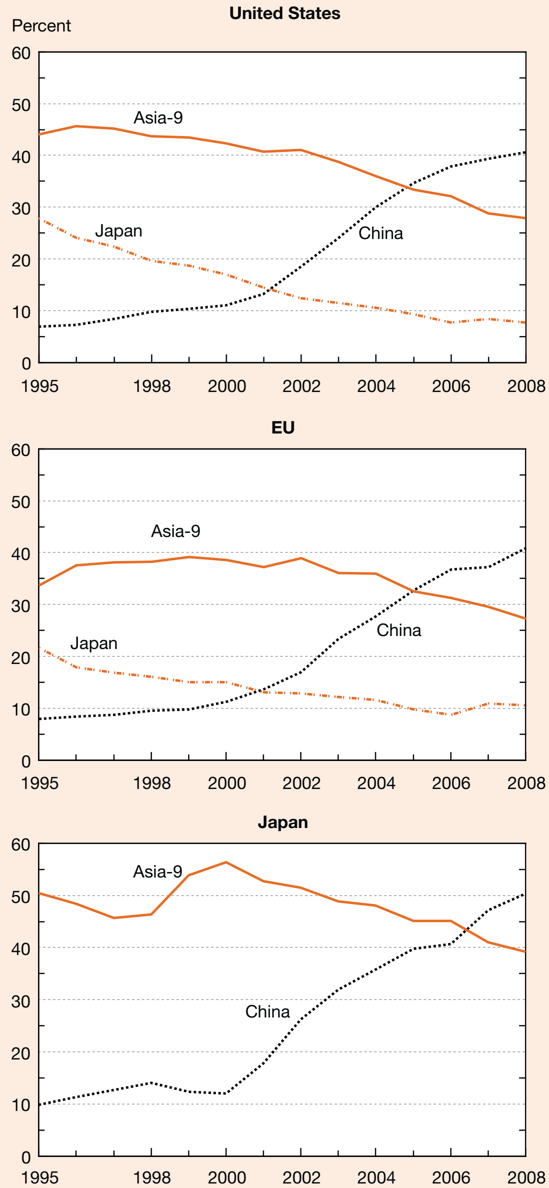
Figure 6-21
United States', EU's, and Japan's imports of ICT products, by share of selected region/country/economy of origin: 1995–2008



EU = European Union; ICT = information and communications technology

NOTES: ICT products include communications and semiconductors and computers and office machinery. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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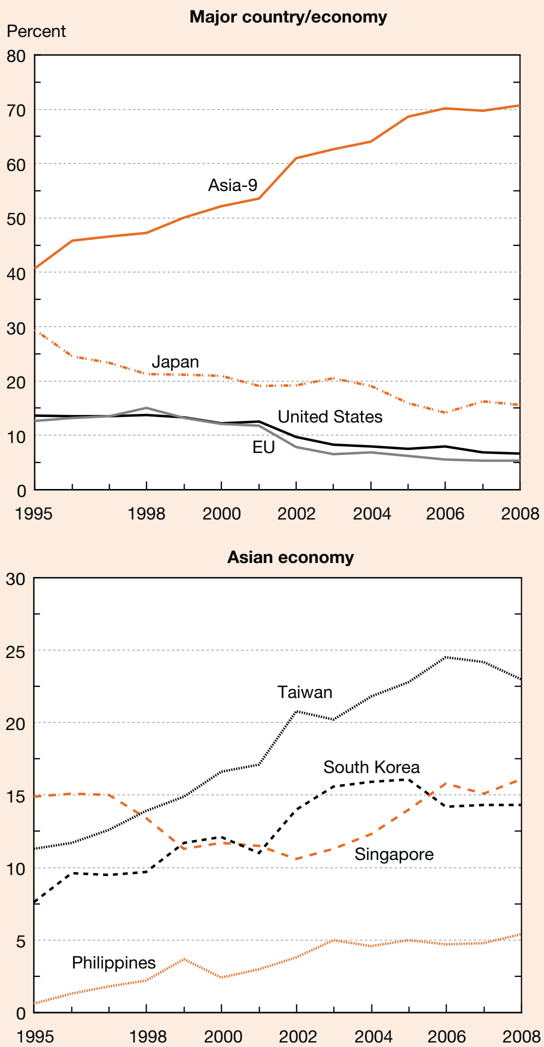
the most, from 11% to 23% of China's total ICT imports. South Korea's and the Philippines' shares also increased by about 5 percentage points each, reaching 14% and 5%, respectively; Singapore's share was stable. However, Japan's share of China's imports fell from 30% to 16%.

Japan's ICT export data show a pronounced shift toward China, rising from a 10% share of its ICT export goods to 28% since 1995 (figure 6-23; appendix table 6-29). The share of Japanese exports to the United States fell sharply over the period, from 36% to 15%; its share to the Asia-9

Figure 6-22
China's imports of ICT products, by share of selected region/country/economy of origin: 1995–2008



EU = European Union; ICT = information and communications technology

NOTES: ICT products include communications and semiconductors and computers and office machinery. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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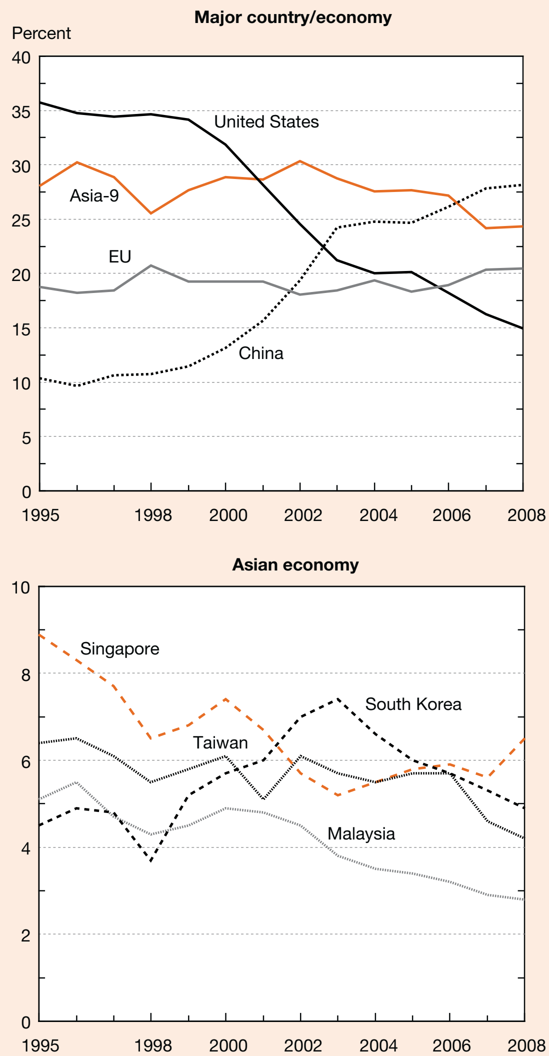
Figure 6-23
Japan's exports of ICT products, by share of selected region/country/economy of destination: 1995–2008



EU = European Union; ICT = information and communications technology

NOTES: ICT products include communications and semiconductors and computers and office machinery. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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was steady at about 25% (figure 6-21; appendix tables 6-27 and 6-31). These patterns are consistent with reports that Japanese (and Taiwanese) manufacturers began exporting components for assembly in plants they established in China. U.S. purchases of ICT goods from Japan may have been supplanted by goods assembled in and shipped from China for Japanese and Taiwanese firms.

The Asia-9's bilateral export data are consistent with China's import data showing the rise of the Asia-9 as a major supplier to China's ICT manufacturing industries. China's share of the Asia-9's exports nearly quadrupled from 8% to 31% over the decade (figure 6-24; appendix table 6-31). China's share growth was strongest in the exports of South Korea (from 8% to 30%), Taiwan (from 12% to 43%), Singapore (from 10% to 29%), and the Philippines (from 5% to 38%) (figures 6-24 and 6-25; appendix tables 6-32 through 6-35). The share of Asia-9's ICT exports going directly to the United States or the EU fell sharply during this period (appendix tables 6-27 and 6-28).

The data indicate that the Asia-9 countries/economies have come to be assemblers and exporters of both intermediate and finished ICT goods, the former going to China and other Asia-9 destinations, the latter largely to the United States, the EU, and other developed nations. The intra-Asia-9 share of Asia-9 ICT imports rose from 36% to 46% over the past decade (figure 6-26; appendix table 6-31), coinciding with a sharp increase (from 7% to 26%) in imports from China. This is consistent with the Asia-9 countries/economies importing components from China for final or intermediate assembly and re-exporting them back to China for final assembly and export.

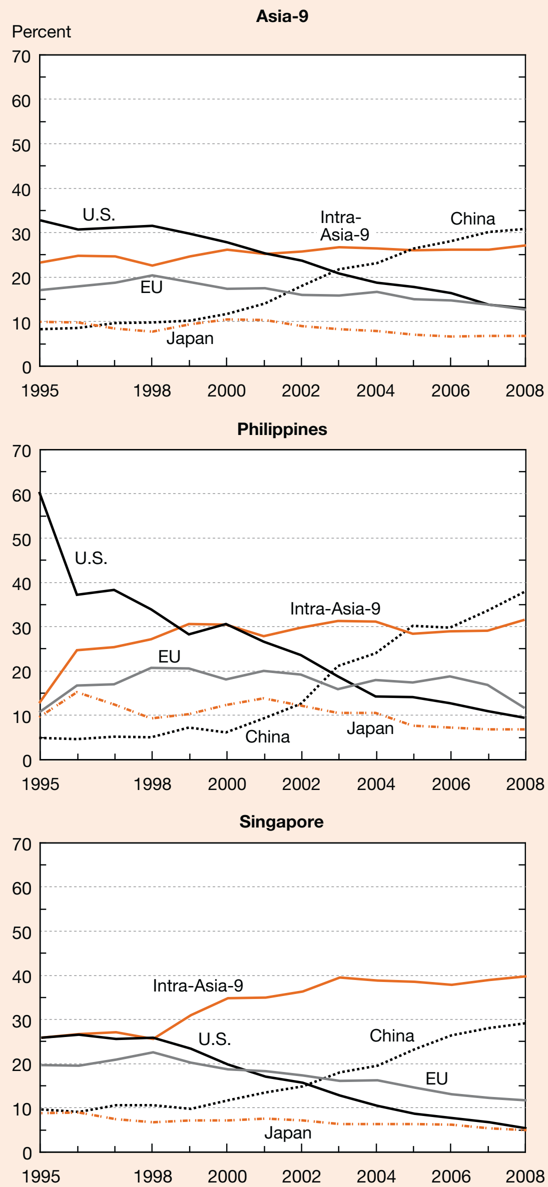
The Asia-9 countries/economies—particularly Malaysia, South Korea, Taiwan, and Singapore—remain substantial suppliers of ICT goods to the EU and the United States (about 30% each) and to Japan (39%) (figure 6-24; appendix tables 6-31 and 6-33 through 6-36).

Exports of Medium- and Low-Technology Manufactured Products

The U.S. export performance in products associated with less knowledge intensity and less use of R&D provides a context for its high-technology status. In these industries, the United States has historically had lower world export shares, although some convergence, which largely reflects declines in the U.S. high-technology share, has been evident since the late 1990s.

The U.S. share of world exports in medium-high-technology products (i.e., motor vehicles, chemicals, railroad equipment) was 14% in 2008, which was equal to its share in high-technology industries (table 6-3) and which placed it fourth behind the EU (24%, excluding intra-EU trade) and Japan and the Asia-9 (15% each). The U.S. and EU shares have remained stable over the past decade, whereas Japan's share has fallen from 22% to 15%. China, ranked fifth, has rapidly expanded its share of global exports from 4% to 13% (excluding trade between China and Hong Kong).

Figure 6-24
Asia-9, Philippines, and Singapore's exports of ICT products, by share of selected region/country/economy of destination: 1995–2008



EU = European Union; ICT = information and communications technology

NOTES: ICT products include communications and semiconductors and computers and office machinery. Intra-Asia-9 is trade among Asia-9 countries/economies. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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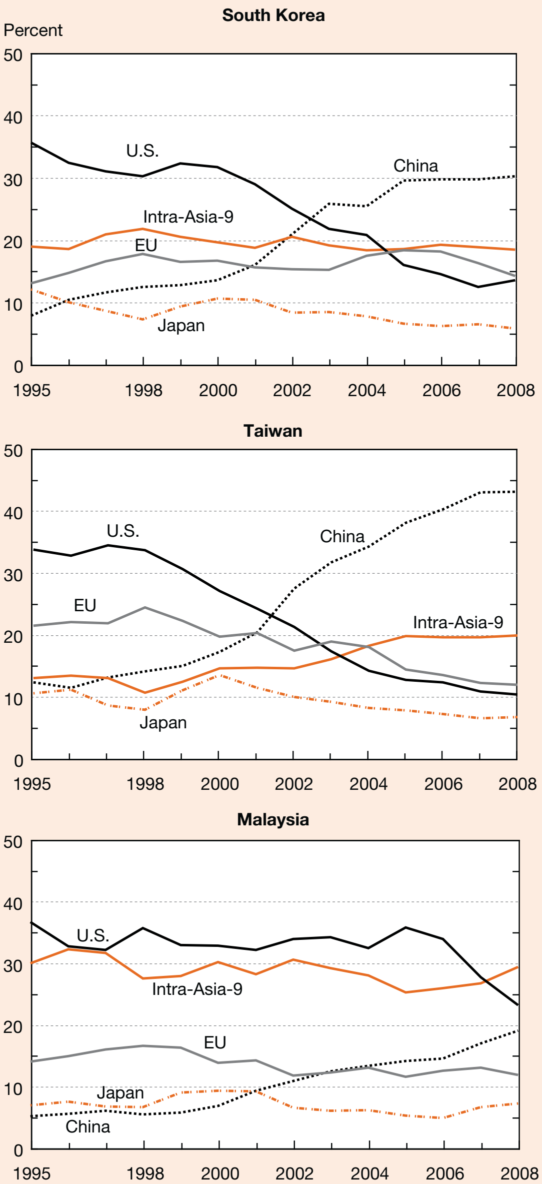
Figure 6-25
South Korea's, Malaysia's, and Taiwan's exports of ICT products, by share of selected region/country/economy of destination: 1995–2008



EU = European Union; ICT = information and communications technology

NOTES: ICT products include communications and semiconductors and computers and office machinery. Intra-Asia-9 is trade among Asia-9 countries/economies. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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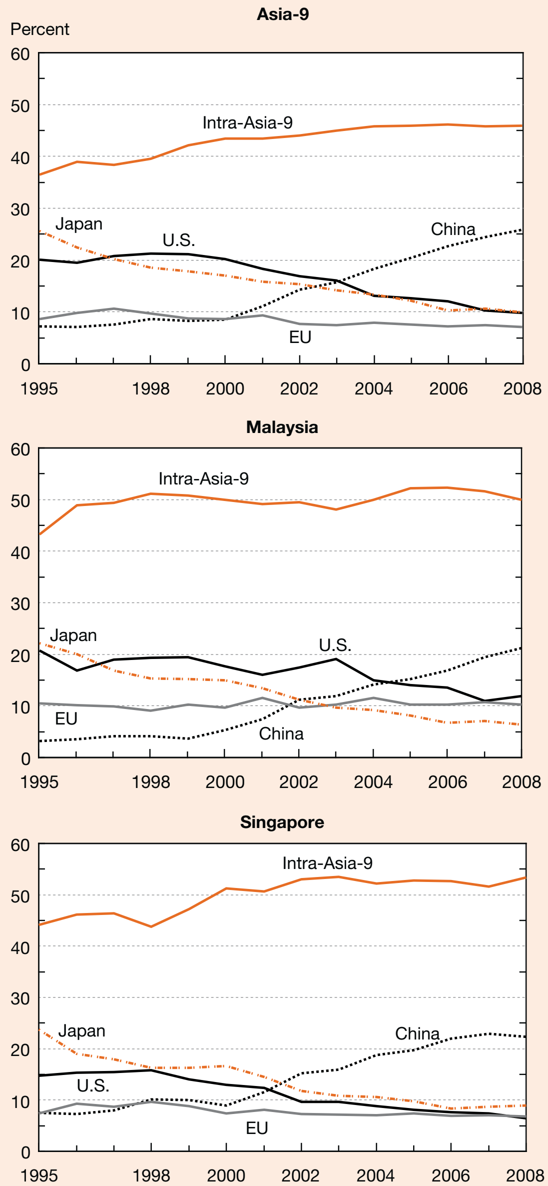
Figure 6-26
Asia-9's, Malaysia's, and Singapore's imports of ICT products, by share of selected region/country/economy of origin: 1995–2008



EU = European Union; ICT = information and communications technology

NOTES: ICT products include communications and semiconductors and computers and office machinery. Intra-Asia-9 is trade among Asia-9 countries/economies. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (15 January 2009).

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Table 6-3
Exports of manufactured products, by selected technology level and region/country/economy: Selected years: 1995–2008
(Percent distribution)

Manufacturing technology level and region/country/economy	1995	1998	2001	2004	2006	2008
Medium high						
Global exports (current $billions)	630.4	697.0	805.7	1,171.6	1,477.8	1,812.0
All countries	100.0	100.0	100.0	100.0	100.0	100.0
United States	17.3	18.0	16.8	14.0	14.2	14.1
EU	25.5	25.2	24.4	24.6	23.4	23.7
Japan	21.7	19.2	17.4	17.2	16.0	15.2
China	3.9	4.9	6.5	8.8	10.8	12.8
Asia-9	11.3	10.6	12.2	14.9	15.1	15.2
All other countries	20.2	22.2	22.6	20.6	20.5	19.0
Medium low						
Global exports (current $billions)	396.2	413.4	480.5	816.2	1,258.6	1,769.3
All countries	100.0	100.0	100.0	100.0	100.0	100.0
United States	10.8	12.3	11.8	8.3	8.2	8.4
EU	20.7	20.1	17.7	16.9	16.1	15.8
Japan	13.2	11.2	9.1	8.2	6.9	6.6
China	5.2	6.0	7.1	9.4	10.5	12.7
Asia-9	15.8	17.2	16.9	18.5	18.6	18.0
All other countries	34.3	33.2	37.6	38.7	39.6	38.5
Low						
Global exports (current $billions)	559.7	561.0	626.4	818.9	993.3	1,235.7
All countries	100.0	100.0	100.0	100.0	100.0	100.0
United States	14.5	14.7	14.0	11.8	11.9	12.0
EU	20.7	20.5	19.1	19.7	18.4	18.3
Japan	3.8	3.8	3.6	3.0	2.7	2.5
China	12.1	13.6	15.3	17.9	20.3	21.8
Asia-9	20.1	18.3	18.5	16.8	16.5	16.2
All other countries	28.8	29.1	29.5	30.9	30.1	29.3

EU = European Union

NOTES: Global exports exclude intra-EU exports and exports between China and Hong Kong. EU exports exclude intra-EU exports, and China exports exclude exports between China and Hong Kong. Manufacturing technology level classified by Organisation for Economic Co-operation and Development. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Luxembourg, Malta, and Slovenia. Percents may not add to 100% because of rounding.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations (2009).

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The United States also ranks fourth (8%) in share of world exports in medium-low-technology products (table 6-3), behind the EU and the Asia-9 (16% and 18%, respectively) and China (13%). U.S. export share in low-technology products in 2008 (at 12%) also placed it fourth behind China (22%), the EU (18%), and the Asia-9 (16%). In both of these industry groups, China's world export share expanded greatly since the mid-1990s but not to the same degree as for high-technology exports.

U.S. Trade in Advanced Technology Products

The Census Bureau has developed a classification system for internationally traded products that embody new or leading-edge technologies. This classification system has significant advantages for determining whether an industry and its products are high technology and may be a more precise and comprehensive measure than the industry-based OECD classification.

This system allows a highly disaggregated, focused examination of technologies embodied in U.S. imports and exports. It categorizes trade into 10 major technology areas:

- **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 (excluding communications satellites), turbojet aircraft engines, flight simulators, and automatic pilots.
- **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.
- **Electronics**—the development of electronic components (other than optoelectronic components), including

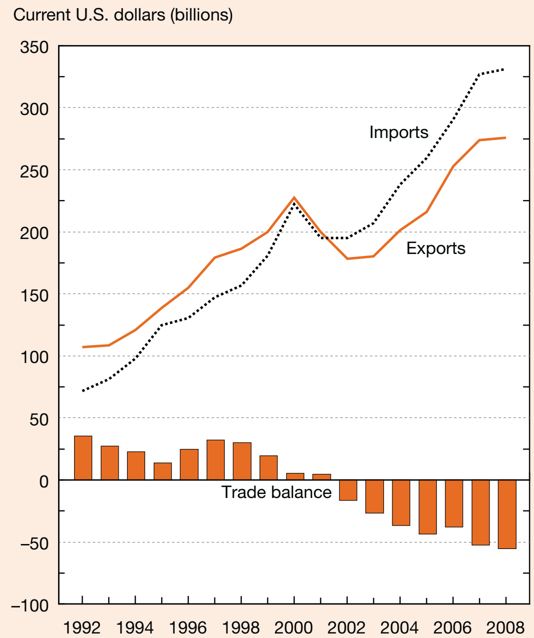
integrated circuits, multilayer printed circuit boards, and surface-mounted components (such as capacitors and resistors) that improve performance and capacity and, in many cases, reduce product size.

- **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.
- **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.
- **Life sciences**—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.
- **Nuclear**—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 the life sciences rather than this category.)
- **Weapons**—the development of technologies with military applications, including guided missiles, bombs, torpedoes, mines, missile and rocket launchers, and some firearms.

U.S. trade in advanced technology products is an important component of overall U.S. trade, accounting for about one-fifth of total trade volume for the past two decades. In 2008, U.S. exports of advanced technology products were $276 billion (nearly 21% of goods exports) and imports were $331 billion (16% of total goods imports) (figures 6-27 and 6-28 and appendix table 6-37). As with high-technology industries trade accounts, imports of advanced technology products grew faster than exports since the early 1990s, sending the U.S. trade balance in these products into deficit in 2002 (figure 6-28). By 2008, the deficit reached $56 billion, comprising 7% of the total U.S. goods trade deficit ($816 billion).

Changes in exchange rates may have been a contributing factor to these trends because the U.S. dollar's value against a basket of its major trading partners' currencies appreciated more than 60% between the early 1990s and 2002, coinciding with the shift from surplus to deficit (figure 6-28). However, the dollar depreciated about 20% through 2008, and the deficit continued to widen.

Figure 6-27
U.S. advanced technology product trade: 1992–2008



NOTE: U.S. advanced technology product trade classified by Census Bureau and consists of advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications, life sciences, optoelectronics, nuclear, and weapons.

SOURCE: Census Bureau, Foreign Trade Statistics, Country and Product Trade Data, Advanced Technology Products, http://www.census.gov/foreign-trade/statistics/product/index.html, accessed 15 September 2009.

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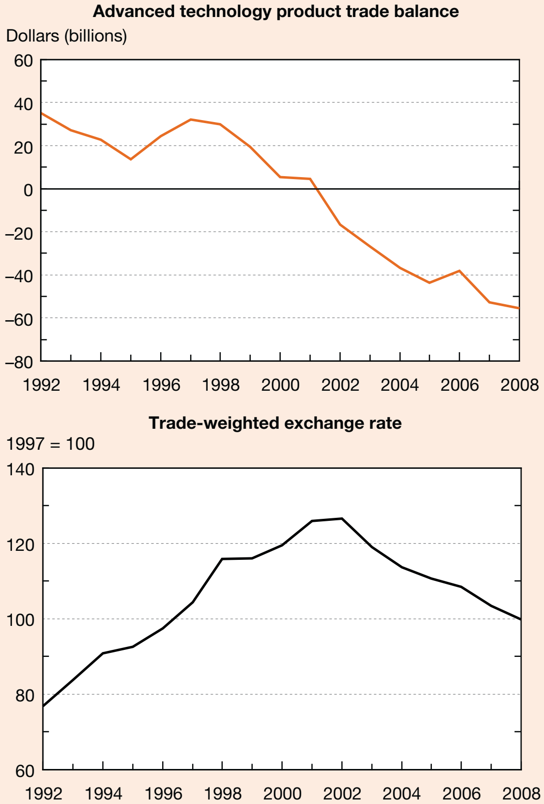
It is likely that the growing deficit was affected by changing world production and trade patterns, adoption of new business and production processes, establishment of productive capacity abroad, and the emergence of export-oriented high-technology industries in Asia and other regions and countries.

U.S. Advanced Technology Product Trade, by Technology

Five technology areas—information and communications, aerospace, electronics, the life sciences, and optoelectronics—accounted for a combined share of about 90% of U.S. advanced technology product trade in 2008 (figure 6-29; appendix tables 6-38 through 6-47). Information and communications had the largest single share (43%), followed by aerospace (21%), electronics (13%), the life sciences (11%), and optoelectronics (5%). Three of these technologies have generated substantial trade deficits: information and communications ($104 billion), optoelectronics ($21 billion), and the life sciences ($15 billion) (figure 6-30). The rapid rise in the overall deficit between 2002 and 2008 was driven by the deficit in ICT, widening from $48 billion to more than

Figure 6-28
U.S. advanced technology product trade balance and trade-weighted exchange rate: 1992–2008



NOTES: Trade-weighted exchange rate is index of U.S. dollar's value against a basket of its major trading partners' currencies. U.S. advanced technology product trade classified by Census Bureau and consists of advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications, life sciences, optoelectronics, nuclear, and weapons.

SOURCES: Census Bureau, Foreign Trade Statistics, Country and Product Trade Data, Advanced Technology Products, http://www.census.gov/foreign-trade/statistics/product/index.html, accessed 15 September 2009; and Federal Reserve Bank of St. Louis, Economic Research, TWEXBMTH, Trade Weighted Exchange Index: Broad, http://research.stlouisfed.org/ fred2/series/TWEXBMTH?cid=105, accessed 7 November 2009.

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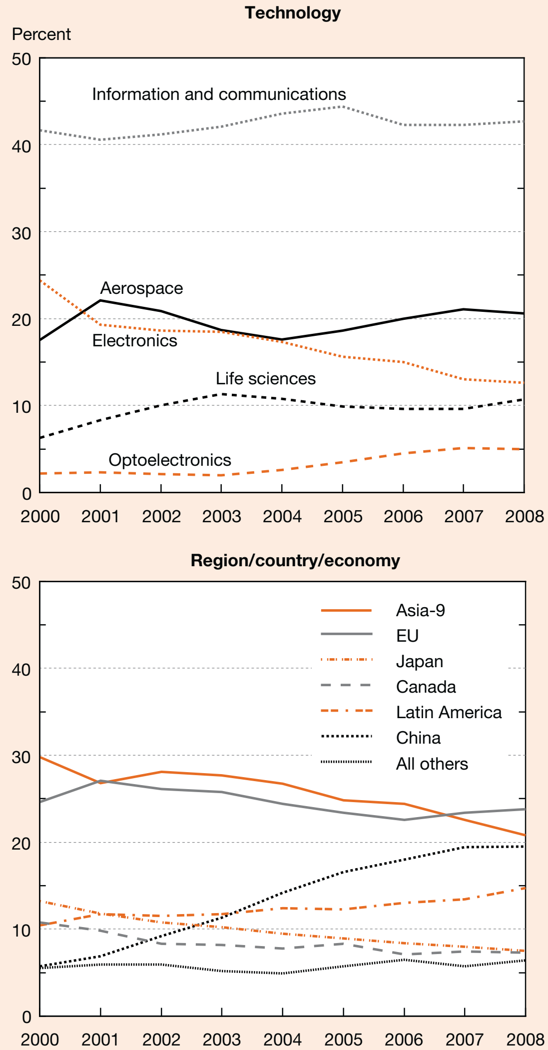
$100 billion. The trend from surplus to deficit is similar to the trend in trade of ICT high-technology products.

Two technologies, aerospace and electronics, have generated significant trade surpluses (figure 6-30; appendix tables 6-38 and 6-39). The United States is the leading producer of aerospace products; it had a trade surplus of $55 billion in 2008 ($28 billion more than in 2000), as exports jumped from $53 billion to $90 billion and imports increased more moderately from $26 billion to $35 billion. The surplus in electronics was $25 billion in 2008 ($13 billion higher than at the beginning of the decade). In this technology, both

Figure 6-29
U.S. advanced technology product trade, by selected technology and region/country/economy: 2000–08



EU = European Union

NOTE: U.S. advanced technology product trade classified by Census Bureau and consists of advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications, life sciences, optoelectronics, nuclear, and weapons. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. Latin America includes Angilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea, French Guiana, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Venezuela, and Uruguay.

SOURCE: Census Bureau, Foreign Trade Statistics, Country and Product Trade Data, Advanced Technology Products, http://www.census.gov/foreign-trade/statistics/product/index.html, accessed 15 September 2009.

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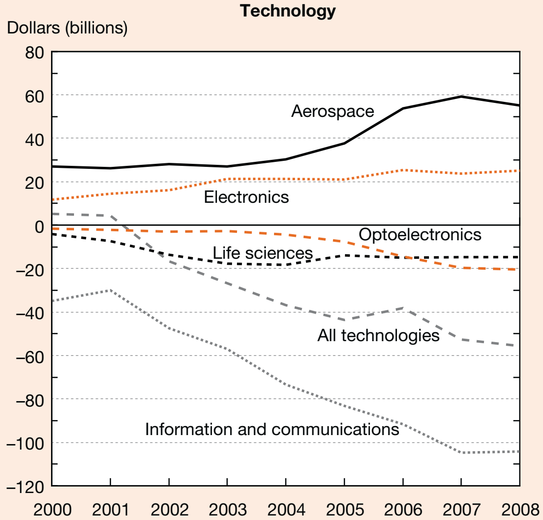
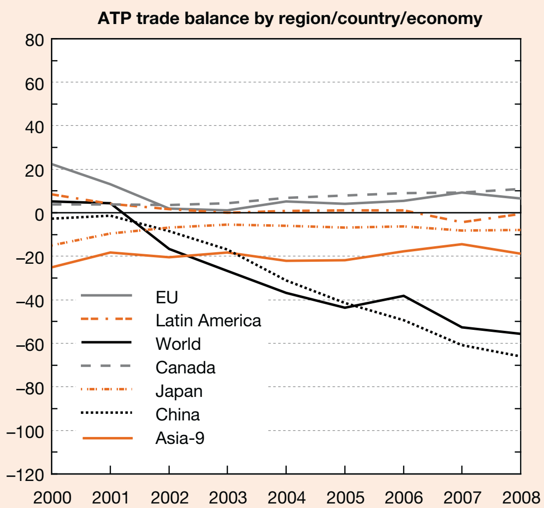
Figure 6-30
U.S. advanced technology product trade balance, by selected technology and region/country/economy: 2000–08





ATP = advanced technology products; EU = European Union

NOTES: U.S. advanced technology product trade classified by Census Bureau and consists of advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications, life sciences, optoelectronics, nuclear, and weapons. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Latin America includes Angilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea, French Guiana, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Venezuela, and Uruguay.

SOURCE: Census Bureau, Foreign Trade Statistics, Country and Product Trade Data, Advanced Technology Products, http://www.census.gov/foreign-trade/statistics/product/index.html, accessed 15 September 2009.

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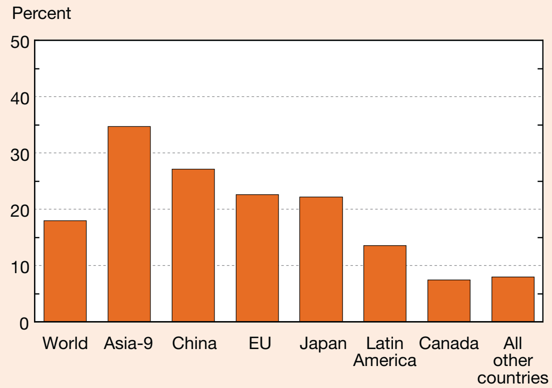
imports and exports fell during the period, but imports declined more steeply.

U.S. Advanced Technology Trade, by Region and Country

The majority of U.S. advanced technology trade occurs with six regions/countries: the EU (24%), the Asia-9 (21%), China (19%), Latin America (15%), Japan (7%), and Canada (7%) (figure 6-29 and appendix table 6-37). U.S. trade with Asia (Asia-9, China, and Japan) accounts for nearly half of total U.S. advanced technology trade. U.S. merchandise trade with Asia also contains a higher-than-average share of advanced technology goods. This share in 2008 was twice the U.S. average for exports to the Asia-9 (35%) and 27% for China. Japan's 22% share equaled that of the EU (figure 6-31).

China and Japan. China exported $92 billion of advanced technology products to the United States (about one-fourth of U.S. imports) and imported $26 billion in 2008. The United States has the largest deficit with China, which is its third largest trading partner among the six regions/countries

Figure 6-31
Advanced technology product share of U.S. merchandise trade, by region/country/economy: 2008



EU = European Union

NOTES: U.S. advanced technology product trade classified by Census Bureau and consists of advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications, life sciences, optoelectronics, nuclear, and weapons. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. Latin America includes Angilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea, French Guiana, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Venezuela, and Uruguay.

SOURCES: Census Bureau, Foreign Trade Statistics, Country and Product Trade Data, Advanced Technology Products, http://www.census.gov/foreign-trade/statistics/product/index.html; and U.S. International Trade in Goods, http://www. census.gov/foreign-trade/statistics/historical/index.html, accessed 15 September 2009.

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and the largest single country (figure 6-30; appendix table 6-37). ICT goods account for nearly 90% of U.S. imports of advanced technology products from China (appendix table 6-40). U.S. exports of advanced technology goods include aerospace, electronics, and information and communications (appendix tables 6-38 through 6-40).

The volume of U.S.-China advanced technology trade more than quadrupled over this decade, and in 2003 China surpassed Japan as the United States' single largest country partner in these goods (appendix table 6-37). U.S. imports from China have increased much faster than its exports to China, pushed by a rising trade volume in ICT technologies. The steep rise in imports and flat export growth widened the U.S. deficit with China in information and communications from $6 billion to $75 billion (figure 6-30; appendix table 6-40).

Japan was the largest trading country partner with the United States until it was overtaken by China in 2003 (appendix table 6-37). Information and communications technology constituted nearly half of all U.S. imports from Japan in 2008, similar to its prevalence in imports from China (appendix table 6-40). Among advanced technology exports to Japan, aerospace accounted for the largest share (42%); information and communications products ranked second (18%) (appendix table 6-38).

The Asia-9. The Asia-9's trade was one-fifth of total advanced technology trade volume in 2008 (figure 6-29), with exports of $73 billion to the United States and imports of $54 billion (figure 6-30; appendix table 6-37). Malaysia, Singapore, South Korea, and Taiwan are the Asia-9's major U.S. trading partners. The $19-billion U.S. deficit with the Asia-9 consists of a $12-billion deficit with Malaysia and smaller deficits with South Korea, Taiwan, and Thailand (and a small surplus with Singapore).

As with China, ICT products constituted the largest share of total U.S. advanced technology trade with the Asia-9. Important suppliers are Malaysia ($17 billion), South Korea ($13 billion), and Taiwan ($8 billion) (appendix table 6-40). U.S. imports of $52 billion and exports of $9 billion produced a deficit of more than $40 billion in ICT products in 2008.

The Asia-9 ICT deficit in information and communications was partly offset by a $24-billion combined surplus in aerospace, electronics, and flexible manufacturing products (appendix tables 6-38, 6-39, and 6-45). Combined U.S. exports of these technologies were $41 billion in 2008, 76% of total U.S. exports to the Asia-9. Important customers of these three technologies were South Korea, Singapore, and Taiwan (in all three categories), India (aerospace), and Malaysia and the Philippines (electronics).

The U.S. trade position in advanced technology goods with the Asia-9 has been relatively stable over this decade. This may reflect the migration of final assembly of many ICT goods from the Asia-9 to China, coinciding with a widening deficit of ICT trade with China.

The European Union. Trade with the EU accounts for nearly one-fourth of U.S. advanced technology product trade (figure 6-29; appendix table 6-37). The EU exported $69 billion and imported $76 billion, resulting in a $7-billion surplus in 2008 (figure 6-30). Five EU members—France, Germany, Ireland, the Netherlands, and the United Kingdom—accounted for nearly 80% of total U.S.-EU trade in these goods. Aerospace, the life sciences, and ICT had a combined 77% share of the volume of U.S.-EU advanced technology product trade in 2008 (appendix tables 6-38, 6-40, and 6-41).

The United States had substantial surpluses with the EU in aerospace ($13 billion) and ICT goods ($9 billion) (appendix tables 6-38 and 6-40). Important EU customers of aerospace and ICT are France, Germany, and the UK; the Netherlands purchases the most U.S. ICT goods of the EU countries.

The life sciences produced a $15-billion deficit (appendix table 6-41). Ireland was by far the largest EU supplier of life sciences products, accounting for more than half of the EU's $27 billion in exports to the United States in 2008. Other substantial suppliers were Belgium, France, Germany, and the UK.

The U.S. trade surplus with the EU narrowed from $22 billion in 2000 to $7 billion in 2008 (figure 6-30), reflecting the deficit in life sciences rising from $6 billion to $16 billion due to much more rapid growth of imports (appendix tables 6-37 and 6-41).

Latin America and Canada. U.S. advanced technology trade with Latin America amounted to 15% of total U.S. advanced trade in 2008 (figure 6-29; appendix table 6-37). Mexico is by far the largest trading partner in Latin America (10% share of U.S. advanced technology trade), followed by distant-second Brazil (2%). ICT products accounted for half of Latin America's total U.S. trade in these products (appendix table 6-40).

Strong growth in U.S. aerospace and ICT exports was more than offset by large import increases in optoelectronics and ICT (appendix tables 6-38, 6-40, and 6-42). Mexico was the main supplier of optoelectronic imports, which rose from $0.5 billion to $15 billion. The United States also had a substantial deficit with Mexico in ICT goods ($10 billion). The U.S.-Mexico trade deficit in these goods reflects, in part, Mexico's duty-free imports of U.S. components and their assembly and re-export to the United States.

U.S. advanced technology trade with Canada amounted to 7% of total trade in 2008 (figure 6-29; appendix table 6-37). Canada exported $17 billion and imported $28 billion, resulting in a surplus of $11 billion (figure 6-30; appendix table 6-37). ICT and aerospace constituted three-quarters of this bilateral trade (appendix tables 6-38 and 6-40). The United States had a $9-billion surplus with Canada in ICT goods and a $2-billion deficit in aerospace products.

Globalization of Knowledge-Intensive Service Industries

Services have historically been more local and insulated from global competition than manufactured goods because they were less easily traded and often had to be located near the consumer. However, rapid growth of new international markets, increased competition, and advances in communications and other enabling technologies have ushered in the globalization of services. Tradable knowledge-intensive services include three commercial services: business, financial, and communications. Education and health have also become globalized but to a much lesser extent than the commercial knowledge-intensive services. Overall, the current extent of globalization of knowledge-intensive services is less than that of high-technology manufacturing industries.

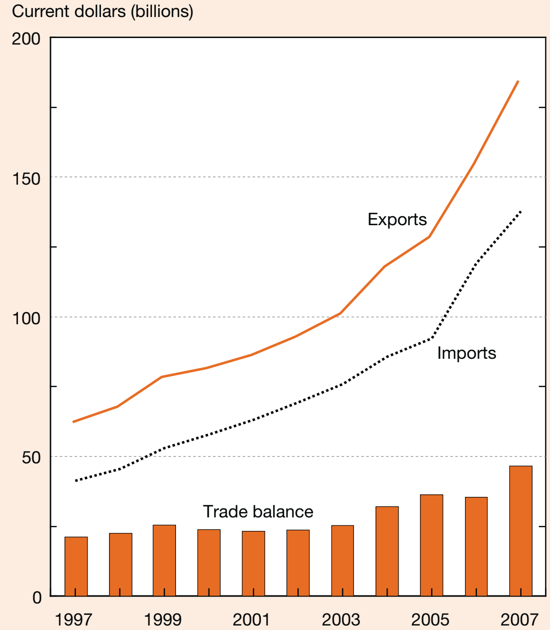
The volume of U.S. trade in commercial knowledge-intensive services is lower than trade in high-technology manufactured goods but is producing increased surpluses. Commercial knowledge-intensive service industries are a key component of the overall U.S. trade in private services, accounting for 40% of the total (appendix table 6-49). U.S. exports of (receipts for) commercial knowledge-intensive service industries were $185 billion in 2007 (nearly 40% of total private services exports), and imports (payments) were $138 billion (again, 40% of the total) (figure 6-32). The resulting surplus, $47 billion, accounted for one-third of the overall surplus in private services trade ($139 billion) in 2007.

Business, professional, and technical services, the category that includes R&D and computer services, is the largest component of trade in commercial knowledge-intensive service industries (55%) (table 6-4; appendix table 6-49) (See "Business to Business Linkages, Exports, and Imports of R&D Services" in chapter 4 for discussion of trends in U.S. trade in R&D services, a component of business services). Finance is the second-largest component (40%), with communications being much smaller (5%).

U.S. trade in commercial knowledge-intensive services has been in surplus for the past 10 years (figure 6-33), in contrast to deficits in U.S. trade of high-technology goods. Business services produced a $39-billion surplus in 2007, out of a total of $47 billion (table 6-4; appendix table 6-49). Financial services gained a small surplus, and telecommunications services trade is balanced.

The bulk of U.S. trade in commercial knowledge-intensive service industries was with the EU (42%), with business services as the largest component (table 6-4). The next-largest trade partner was Latin America (21%), with a relatively large share in financial services that may, in part, reflect offshore banking in the Caribbean. The Asia-9's share of trade in commercial knowledge-intensive services was much smaller than in high-technology products.

Figure 6-32
U.S. trade in commercial knowledge-intensive services: 1997–2007



NOTES: Knowledge-intensive services classified by Organisation for Economic Co-operation and Development and include business, financial, communications, education, and health. Commercial knowledge-intensive services exclude education and health.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. International Services: Cross-Border Trade 1986– 2007, and Services Supplied Through Affiliates, 1986–2006, http://www.bea.gov/international/intlserv.htm, accessed 15 September 2009.

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U.S. Multinationals in Knowledge- and Technology-Intensive Industries

The Bureau of Economic Analysis (BEA) conducts an annual survey of U.S. multinationals that includes firms in KTI industries. The BEA data are not strictly comparable with the world industry data. However, the BEA data do provide useful information on the globalization of activity and the employment of U.S. multinationals in these industries.

Commercial Knowledge-Intensive Service Industries

U.S. multinationals in commercial knowledge-intensive service industries generated $720 billion in value added in 2006, of which more than 80% ($602 billion) occurred in the United States, according to BEA data (figure 6-34; appendix table 6-50). Financial services ranked first by value added ($270 billion), followed by business services ($239 billion) and communication services ($212 billion).[14] The proportion of value added from their U.S. operations was highest in communications (94%), followed by financial services (86%) and business services (71%). The distribution of

Table 6-4
U.S. exports and imports of commercial knowledge-intensive services, by region/country/economy: 2007
(Billions of dollars)

Service and region/country/economy	Exports	Imports	Balance
All commercial knowledge-intensive services			
All countries	184.5	137.8	46.7
Asia-9	12.7	12.2	0.5
Canada	14.6	10.8	3.8
China	7.8	4.1	3.7
EU	75.7	60.2	15.5
Japan	12.2	5.6	6.6
Latin America	34.1	34.1	0.0
All others	27.4	10.9	16.6
Financial services			
All countries	68.6	61.7	6.9
Asia-9	2.9	1.2	1.7
Canada	5.7	1.9	3.9
China	2.6	1.1	1.5
EU	27.6	26.8	0.8
Japan	4.1	1.6	2.5
Latin America	18.1	19.5	-1.4
All others	7.5	9.7	-2.1
Telecommunications			
All countries	8.3	7.3	0.9
Asia-9	0.6	0.8	-0.2
Canada	0.7	0.5	0.2
China	0.2	0.3	-0.1
EU	2.7	2.5	0.2
Japan	0.3	0.2	0.1
Latin America	2.8	2.1	0.7
All others	1.0	0.9	0.1
Business, professional, and technical services			
All countries	107.7	68.8	38.9
Asia-9	9.2	10.2	-1.0
Canada	8.1	8.4	-0.2
China	5.0	2.7	2.3
EU	45.4	30.9	14.5
Japan	7.9	3.9	4.0
Latin America	13.2	4.8	8.4
All others	18.9	8.0	10.9

EU = European Union

NOTES: Knowledge-intensive services classified by Organisation for Economic Co-operation and Development and include business, financial, communications, education, and health. Commercial knowledge-intensive services exclude education and health. Business, professional and technical services classified as part of business services. China includes Hong Kong. Latin America includes Argentina, Bermuda, Brazil, Chile, Mexico, and Venezuela. Detail may not add to total because of rounding.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. International Services: Cross-Border Trade 1986–2007, and Services Supplied Through Affiliates, 1986–2006, http://www.bea.gov/international/intlserv.htm, accessed 15 September 2009.

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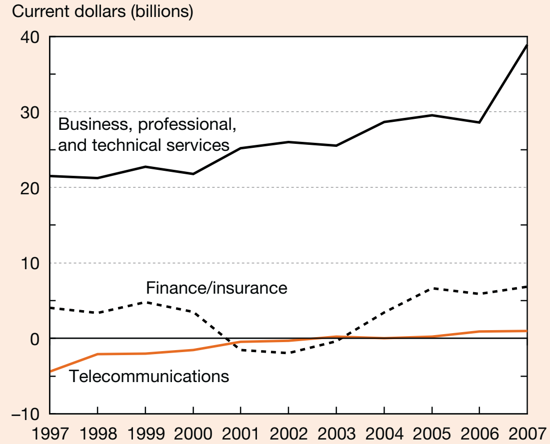
Figure 6-33
U.S. trade balance of selected commercial knowledge-intensive services, by selected industry: 1992–2007



NOTES: Knowledge-intensive services classified by Organisation for Economic Co-operation and Development and include business, financial, communications, education, and health. Commercial knowledge-intensive services exclude education and health. Business, professional, and technical services classified as part of business services.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. International Services: Cross-Border Trade 1986–2007, and Services Supplied Through Affiliates, 1986–2006, http://www.bea.gov/international/intlserv.htm, accessed 15 September 2009.

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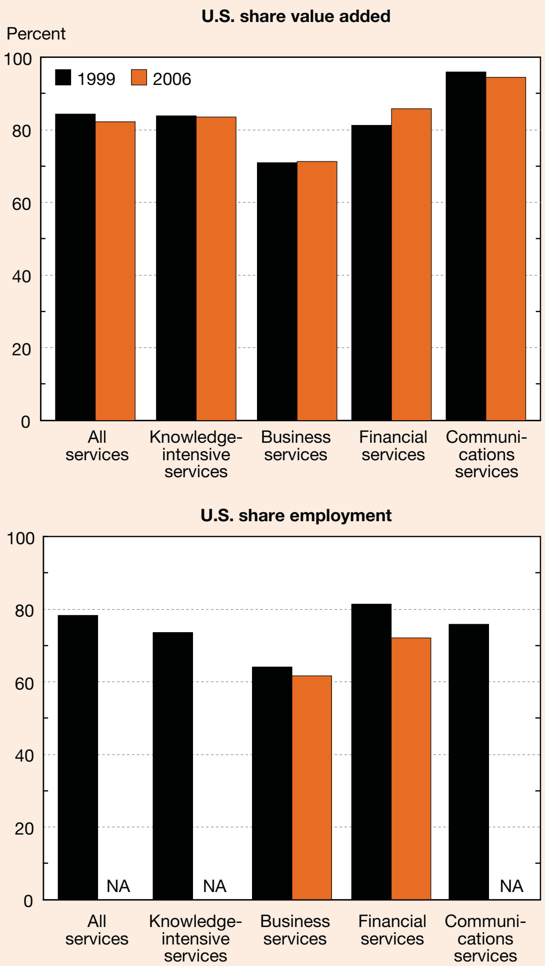
value added between U.S. and foreign affiliates showed little change between 1999 and 2006.

The U.S. multinationals in commercial knowledge-intensive service industries employed 3.7 million workers in the United States in 2006, of whom about 40% were employed in business services and about 30% each in communications and financial services (appendix table 6-50). Business and financial services firms employed 0.9 million and 0.5 million, respectively, at their foreign affiliates (data are not available for communications services). From 1999 to 2006, the foreign employment shares rose from 19% to 28% in financial services and from 36% to 38% in business services (figure 6-33).

High-Technology Manufacturing Industries

BEA data show that U.S. multinationals in four of these five industries generated more than $300 billion worldwide in value added in 2006, of which about two-thirds originated in the United States (appendix table 6-50). Production in the computer industry was the most globalized, as measured by the distribution between U.S. and foreign value added, with 48% of value added originating from the United States in 2006, down from 64% in the late 1990s (figure 6-35). The U.S. value added in the communications and semiconductors industry also showed a substantial shift to foreign

Figure 6-34
Globalization indicators of U.S. multinational corporations in commercial knowledge-intensive services: 1999 and 2006



NA = not available

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge-intensive services classified by Organisation for Economic Co-operation and Development and include business, financial, communications, education, and health. Commercial knowledge-intensive services exclude education and health.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies 1999–2006, http:// www.bea.gov/international/di1usdop.htm, accessed 15 September 2009.

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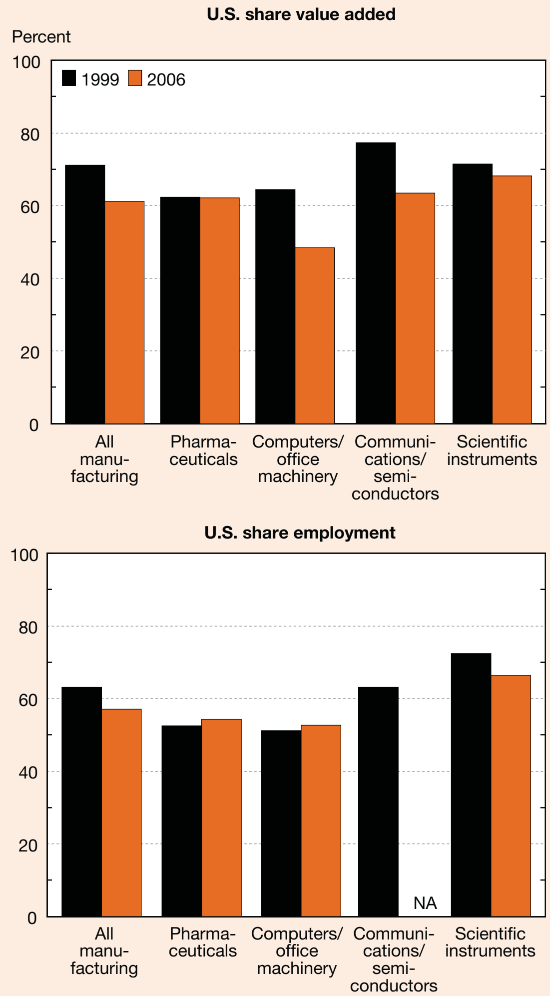
Figure 6-35
Globalization indicators of U.S. multinational corporations in selected high-technology manufacturing industries: 1999 and 2006



NA = not available

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. High-technology manufacturing industries classified by Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies 1999–2006, http://www.bea.gov/international/di1usdop.htm, accessed 15 September 2009.

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production, from 77% to 63%. The U.S. share was relatively stable in pharmaceuticals and scientific instruments.

U.S. multinationals in high-technology manufacturing employed 1.3 million workers in the United States in 2006 (appendix table 6-50). Employee data for foreign affiliates, available for three of the four industries, show that nearly half of the total workforce for pharmaceuticals and computers is employed abroad, along with one-third of the scientific instruments workforce. The distribution between U.S. and foreign employment showed little change in pharmaceuticals and computers from 1999 to 2006. However, the U.S.

employment share in scientific instruments fell from 72% to 66% over this period (figure 6-35).

Information and Communications Technology Services and Manufacturing

U.S. multinationals in the ICT industries generated more than $400 billion worldwide in value added in 2006, of which 70% was attributable to ICT services and 30% to ICT manufacturing (appendix table 6-50). U.S. ICT multinationals generated most (75%) of their production from their headquarters and other U.S. locations, and the remainder from their foreign affiliates (figure 6-36).

However, the distribution of value added between U.S. and foreign affiliates varies widely by industry. The U.S. share of value added in ICT services was highest in telecommunications (97%), about average in information and data processing services (77%), and considerably lower in computer systems design (58%) (figure 6-36; appendix table 6-50). In the two ICT manufacturing industries, the domestic value-added portion is below the overall ICT average: 64% in communications and semiconductors and 48% in computers and office machinery.

Globalization of ICT, as measured by the U.S. and foreign shares of value added, has increased in this decade. The U.S. share dropped from 81% of value added to 75% because of substantial declines in the two ICT manufacturing industries, whereas the U.S. share of value added remained stable in the ICT service industries (figure 6-36; appendix table 6-50). (Employment data for foreign affiliates for 2006 are not available for four of the five ICT industries.)

U.S. and Foreign Direct Investment in Knowledge- and Technology-Intensive Industries

Foreign direct investment (FDI) has the potential to generate employment, raise productivity, transfer skills and technology, enhance exports, and contribute to long-term economic development (Kumar 2009). Receipt of FDI may indicate a developing country's emerging capability and integration with countries that have more established industries. FDI in specific industries may suggest the potential for their evolution and the creation of new technologies.

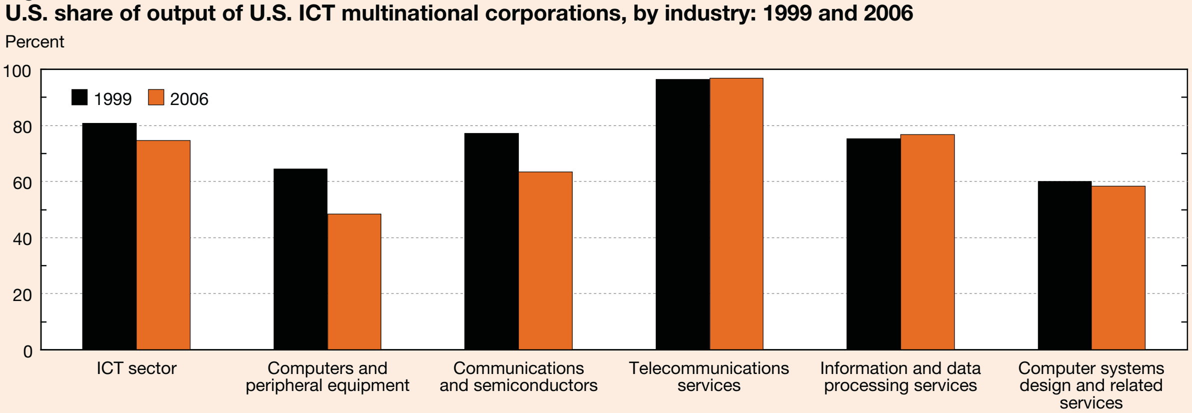
This section uses data from the BEA on U.S. direct investment abroad and foreign investment in the United States in KTI industries. The rising volume of trade by U.S.-based KTI firms has been accompanied by increases in U.S. direct investment abroad and FDI in the United States.

U.S. Direct Investment Abroad in Knowledge- and Technology-Intensive Industries

According to data from the BEA, the stock of U.S. direct investment abroad had reached $121 billion in high-technology manufactures and $834 billion in commercial knowledge-intensive service industries by 2008 (table 6-5; appendix table 6-51).[15] This represented one-quarter of the stock of all U.S. direct overseas investment in all manufacturing industries ($0.5 trillion) and about one-third of U.S. direct overseas investment in all services ($2.5 trillion).

The stock of U.S. foreign direct investment abroad in high-technology manufacturing industries increased from $87 billion in 2000 to $121 billion in 2008 (table 6-5; appendix table 6-51). Communications and semiconductors increased from $42 billion to $54 billion, pharmaceuticals

Figure 6-36
U.S. share of output of U.S. ICT multinational corporations, by industry: 1999 and 2006



ICT = information and communications technology

NOTES: ICT output on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies, 1999–2006, http://www.bea.gov/international/di1usdop.htm, accessed 15 September 2009.

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from $25 billion to $37 billion, aerospace from $3 billion to $11 billion, and scientific instruments from $3 billion to $10 billion. However, the investment stock of the computer industry dropped by 36%, from $14 billion to $9 billion, and its share of all high-technology manufacturing industries fell by half, from 16% to 7%.

The stock of U.S. direct investment abroad in commercial knowledge-intensive service industries was $834 billion in 2008, one-third of the stock of total U.S. direct investment abroad in all services (table 6-5; appendix table 6-51). Financial services dominated commercial knowledge-intensive services investments at $634 billion (76%), up from $217 billion in 2000. Business services grew from $61 billion in 2000 to $185 billion in 2008. However, the stock of U.S. FDI in communications fell from $27 billion to $15 billion.

Geographic data on U.S. FDI investments in high-technology industries is limited to computer and electronic products, which includes computers, communications and semiconductors, and scientific instruments. For these products, the EU was the largest recipient with $27 billion (35% share in 2008), followed by $23 billion in the Asia-9 (30%) (table 6-6). Investments in Canada, China, and Japan were 4%–13% of the total. There was little change in these shares from 2000 to 2008.

The largest foreign destinations for U.S. direct investment in financial services are the EU ($314 billion in 2008) and Latin America ($195 billion), for a combined 80% of the total (table 6-6). The Asia-9, Canada, China, and Japan have 5% or less of the total. The EU was the largest recipient at $78 billion (64% share) of investment in information services, which includes communications. Investments in Asia were smaller, with 2% in China and 5% each in the Asia-9 and Japan.

Data on professional, scientific, and technical services, a component of business services, show that the EU had $53 billion of the $81 billion in stock of worldwide U.S. FDI in this industry in 2008 (table 6-6). The Asia-9, Canada, and China were the next-largest recipients with shares of 5%–10%. The shares of these regions/countries shifted between 2000 and 2008. Canada's share increased from 6% to 10% and China's share increased from 2% to 5%. Japan's share fell sharply from 16% to 3%.

Foreign Direct Investment in U.S. Knowledge- and Technology-Intensive Industries

According to BEA data, the stock of FDI in U.S. high-technology manufacturing industries stood at $187 billion in 2008, up from $133 billion in 2000 and above the stock of $128 billion in U.S. investment abroad (table 6-5; appendix table 6-51). The FDI stock in the U.S. pharmaceuticals industry was about $125 billion in 2008, and the stock in communications and semiconductors was $25 billion, for a combined share of 80% of FDI stock in U.S. high-technology industries. The share of pharmaceuticals doubled, from 34% to 67%, and the share of communications and semiconductors fell from 47% to 13%.

FDI stock in U.S. commercial knowledge-intensive service industries was $390 billion in 2008, compared with

Table 6-5
Stock of U.S. direct investment abroad and foreign direct investment in United States, by selected industry/service: 2000 and 2008
(Billions of dollars)

Industry/service	U.S. direct investment abroad 2000	U.S. direct investment abroad 2008	Foreign direct investment in U.S. 2000	Foreign direct investment in U.S. 2008
All industries	1,316.2	3,162.0	1,256.9	2,278.9
Manufacturing	343.9	512.3	480.6	795.3
High-technology manufacturing	87.3	120.8	132.5	186.8
Aerospace	2.9	11.3	4.5	10.5
Communications and semiconductors	41.9	53.7	61.7	24.9
Computers and peripheral equipment	14.1	8.6	2.5	6.5
Pharmaceuticals	25.3	37.1	44.7	124.8
Scientific and measuring equipment	3.1	10.1	19.0	20.1
All services	874.6	2,486.1	735.9	1,285.0
Commercial KI services	305.0	834.1	NA	389.5
Business services	61.0	185.2	47.0	91.0
Communications	26.9	14.9	NA	49.7
Finance	217.1	634.0	167.0	248.9

NA = not available

NOTES: High-technology manufacturing industries and commercial knowledge-intensive services classified by Organisation for Economic Co-operation and Development. Detail may not add to total because of rounding.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad, Balance of Payments and Direct Investment Position Data, http://www.bea.gov/international/di1usdbal.htm, and Foreign Direct Investment in the U.S.: Balance of Payments and Direct Investment Position Data, http://www.bea.gov/international/di1fdibal.htm, accessed 15 September 2009.

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Table 6-6
Stock of U.S. direct investment abroad and of foreign direct investment in United States, by selected industry and region/country/economy: 2000 and 2008
(Billions of dollars)

Industry/service and region/country/economy	U.S. direct investment abroad 2000	U.S. direct investment abroad 2008	Foreign direct investment in U.S. 2000	Foreign direct investment in U.S. 2008
Computers and electronic products				
All regions/countries/economies	59.9	76.5	92.8	63.3
Asia-9	20.0	22.9	NA	NA
Canada	4.9	4.6	27.1	-0.3
China	5.1	9.9	0.2	NA
EU	23.3	26.7	40.4	40.1
Japan	3.6	3.3	17.3	19.0
Latin America	0.7	1.4	2.8	1.5
All others	2.3	7.7	NA	NA
Financial services				
All regions/countries/economies	217.1	634.0	167.0	248.9
Asia-9	6.2	21.6	NA	NA
Canada	26.3	32.7	19.9	62.1
China	6.7	13.4	NA	0.0
EU	NA	314.1	94.8	146.0
Japan	22.9	28.0	14.1	21.7
Latin America	73.7	195.1	12.7	-19.8
All others	NA	29.1	NA	NA
Information services				
All regions/countries/economies	52.3	121.9	146.9	158.0
Asia-9	1.1	6.5	NA	NA
Canada	2.3	4.1	12.9	11.8
China	0.7	1.1	0.3	NA
EU	33.7	77.5	98.6	126.1
Japan	2.5	5.6	NA	1.8
Latin America	6.9	8.6	13.3	0.7
All others	5.2	18.5	NA	NA
Professional, scientific, and technical services				
All regions/countries/economies	32.9	81.2	30.5	62.1
Asia-9	1.5	5.2	NA	NA
Canada	1.9	8.2	1.2	2.2
China	0.8	3.7	NA	NA
EU	16.0	52.8	27.7	45.1
Japan	5.4	2.8	0.8	5.0
Latin America	3.5	2.1	0.5	1.8
All others	3.8	6.4	NA	NA

NA = not available

EU = European Union

NOTES: Regions/countries/economies are destination of U.S. direct investment abroad and source/origin of foreign direct investment in U.S. industries. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU data for 2000 exclude Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia. Latin America includes Argentina, Bermuda, Brazil, Chile, Mexico, and Venezuela. EU data for 2008 include all 27 member countries.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad, Balance of Payments and Direct Investment Position Data, http://www.bea.gov/international/di1usdbal.htm, and Foreign Direct Investment in the U.S.: Balance of Payments and Direct Investment Position Data, http://www.bea.gov/international/di1fdibal.htm, accessed 15 September 2009.

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$729 billion in the stock of U.S. investment abroad in these industries (table 6-5; appendix table 6-51). The largest industry was financial services ($249 billion), followed by $91 billion in business services and $50 billion in communications. FDI stock in U.S. financial services increased by nearly 50% (from $167 to $249 billion) and nearly doubled in business services (from $47 billion to $91 billion). (Data for communications services are not available for 2000.)

Limited data on geographic origin show that the EU and Japan are the largest sources of foreign direct investment in U.S. computer and electronic products industries, which comprised more than 90% of the stock of worldwide investment in these U.S. industries ($63 billion) in 2008 (table 6-6). The EU's investment stayed constant at about $40 billion between 2000 and 2008. However, its share increased from 44% to 63% because of a $30-billion decline in the stock of total inward investment in this industry during this period. Japan's investment rose from $17 billion in 2000 to $19 billion in 2008. Canada's investment fell sharply from $27 billion (29% share) to a slight negative position ($0.3 billion).[16]

In commercial knowledge-intensive service industries, the two largest sources of FDI in U.S. financial services are the EU and Canada, which provided more than 80% of the $264 billion in stock of worldwide investment in this industry in 2008 (table 6-6). The EU had the largest share (80%) of the $146 billion in investment stock in the U.S. information services industry in 2008. Its share increased 13 percentage points between 2000 and 2008. Latin America's share fell from 9% to less than 1%. The EU was also the largest investor in professional, scientific, and technical services, with a share of 73% ($45 billion of inward investment in 2008). The EU's share, however, fell almost 20 percentage points between 2000 and 2008. Japan's share of investment in this industry more than doubled, from 3% to 8%.

Innovation-Related Indicators of U.S. and Other Major Economies

Innovation—the creation of new or significantly improved products or processes, along with novel marketing activities and organizational methods—is widely recognized as instrumental to the realization of commercial value in the marketplace and as a driver of economic growth.[17] ICT technologies, for example, have stimulated innovation of new products, services, and industries that have transformed the world economy over the past several decades. However, direct measures of innovation for the United States and many other regional/national economies remain limited. (See the section on intangible assets in this chapter and sidebar, "Developments in Innovation-Related Metrics," in chapter 4.)

U.S. Trade in Intangible Assets

Intangible assets are those that embody knowledge content, for example, patents, trademarks, and licensing of computer software (Idris 2003). These can be traded (licensed for use). The United States has a longstanding surplus in trade of intangible assets with the rest of the world (figure 6-37).

U.S. receipts for exports of intangible assets were $83 billion in 2007, 14% higher than in 2006 (figure 6-37; appendix table 6-52).[18] U.S. imports (payments) were $25 billion (up by 5%), producing a $58-billion surplus. U.S. exports and imports of intangible assets have grown every year but one between 1992 and 2007, and the surplus has widened over the period.

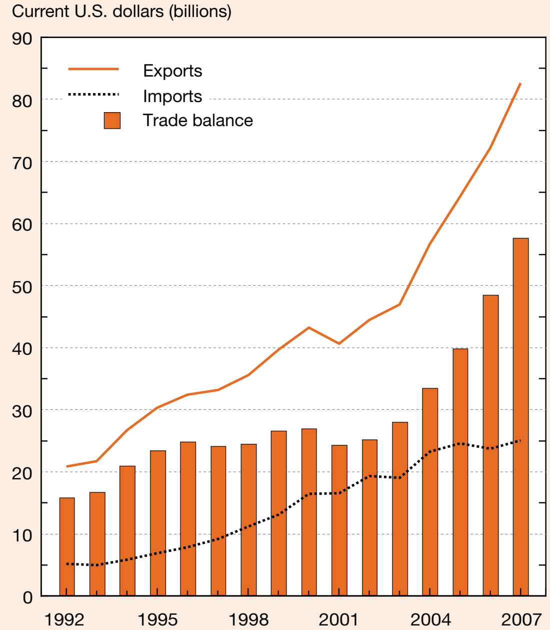
About three-quarters of the intangible assets trade involved exchanges between multinationals and their affiliates, either with U.S. parents and their foreign affiliates or with foreign parents and their U.S. affiliates (appendix table 6-52).[19] Firms with marketable industrial processes may prefer affiliated over unaffiliated transactions to exercise greater control over the distribution and use of this property, especially when the intellectual property is instrumental to the firm's competitive position in the marketplace (Branstetter, Fishman, and Foley 2006). Differential tax policies may also affect a firm's choice of transaction mechanisms.

Despite the greater value of transactions among affiliated companies, both affiliated and unaffiliated transactions have grown at the same pace over the past two decades. These trends suggest a greater internationalization of U.S. business activity and a growing reliance on intellectual property and other intangible assets developed overseas.[20]

U.S. Trade in Industrial Processes

A major component of U.S. intangible assets trade is industrial processes—the use of patents, trade secrets, and other proprietary rights. These data are used as approximate

Figure 6-37
U.S. trade in intangible assets: 1992–2007



NOTE: Intangible assets include industrial processes, books, records, tapes, broadcasting and recording, franchise fees, trademarks, and use of computer software. Industrial processes include royalties, license fees, and other fees associated with use of patents, trade secrets, and other proprietary rights used in connection with production of goods.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. International Services: Cross-Border Trade 1986–2007, and Services Supplied Through Affiliates, 1986–2006, http://www.bea.gov/international/intlserv.htm, accessed 15 September 2009.

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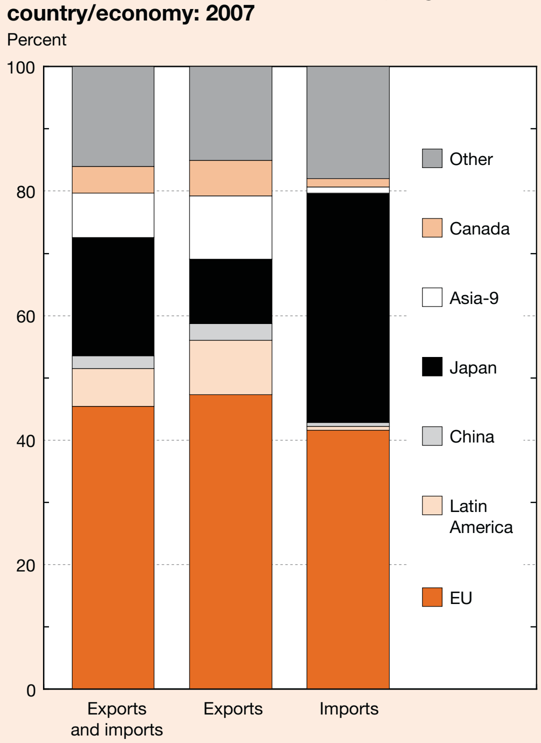
indicators of relative comparative advantage in the creation of industrial technology and its subsequent diffusion.

Comparable data on trade in industrial processes are available only for 2006 and 2007. These data include the combined transactions among affiliated firms (i.e., among firms that are tied to one another by ownership rights) and unaffiliated ones.

U.S. exports of industrial processes were $37 billion in 2007, 45% of total intellectual property exports; U.S. imports were $18 billion, 72% of total intangible assets imports (figure 6-38). The resulting surplus, $19 billion, accounted for one-third of the overall surplus in U.S. trade in intangible assets.

The EU had the largest share of any economy (45%) in U.S. trade in industrial processes, followed by Japan (19%). Latin America, the Asia-9, and China had shares below 10% (figure 6-38). More than half of the U.S. surplus in 2007 was with the EU ($10.2 billion). The United States ran a surplus of $3–$4 billion with the Asia-9 and Latin America, and nearly a $1-billion surplus with China. These surpluses were partially offset by a $2.8-billion deficit with Japan.

Figure 6-38
U.S. trade in industrial processes, by region/country/economy: 2007



NOTES: Industrial processes include royalties, license fees, and other fees associated with use of patents, trade secrets, and other proprietary rights used in connection with production of goods. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU includes all 27 member states. "Other" includes Australia, Israel, New Zealand, Norway, South Africa, Saudi Arabia, and others (data source lists unspecified countries as "other").

SOURCE: U.S. Bureau of Economic Analysis, International Economic Accounts, U.S. International Services: Cross-Border Trade 1986– 2007, and Services Supplied Through Affiliates, 1986–2006, http://www.bea.gov/international/intlserv.htm, accessed 15 September 2009.

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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 in exchange for publicly disclosing details and licensing the use of the invention.[21] Inventors obtain patents from government-authorized agencies for inventions judged to be "new…useful…and…nonobvious."[22]

Patenting is an intermediate step toward innovation, and patent data provide indirect and partial indicators of innovation. Not all inventions are patented, and the propensity to patent differs by industry and technology area. Not all patents are of equal value; patents may be obtained to block rivals, negotiate with competitors, or help in infringement lawsuits (Cohen, Nelson, and Walsh 2000).

Indeed, the vast majority of patents are never commercialized. However, the smaller number of patents that are commercialized result in new or improved products or processes or even entirely new industries. In addition, their licensing may provide an important source of revenue, and patents may provide important information for subsequent inventions and technological advances.

This discussion focuses largely on patent activity at the U.S. Patent and Trademark Office (USPTO). It is one of the largest patent offices in the world and has a significant share of applications and grants from foreign inventors because of the size and openness of the U.S. market.[23] These market attributes make U.S. patenting data useful for identifying trends in global inventiveness.

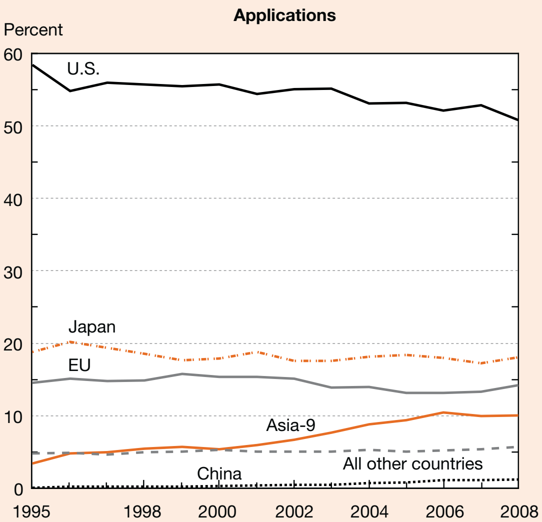
This section also deals with a subset of patents that their owners presume to be of sufficient economic value to warrant the high costs associated with patent filing and maintenance in three of the world's largest markets: the United States, the EU, and Japan.[24]

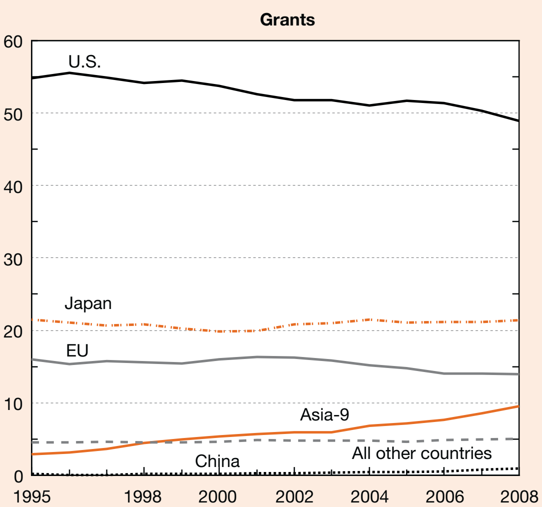
Trends in Applications for USPTO Patents

Data on patent filings provide a more current look at inventiveness trends than do data on patents granted because of the long lead times.[25] As it turns out, trends in patent applications are a reasonable proxy for later trends in patents granted.

Inventors filed 456,000 patent applications with USPTO in 2008, unchanged from 2007, but nearly double the number a decade ago (figure 6-39; appendix tables 6-53 and 6-54). The strong growth of U.S. patent applications between the mid-1990s and 2007 coincided with a strengthening of the patent system and the extension of patent protection into new technology areas through policy changes and judicial decisions during the 1980s and 1990s (NRC 2004). The

Figure 6-39
Region/country/economy share of USPTO patent applications and grants: 1995–2008





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

NOTES: Patent applications allocated among regions/countries/economies on basis of residence of first-named inventor. Patent grants fractionally allocated among regions/countries/economies on basis of proportion of residences of all named inventors. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU includes all 27 member states.

SOURCE: USPTO, Number of Utility Patent Applications Filed in the United States, by Country of Origin, Calendar Years 1965 to Present, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.htm, accessed 2 October 2009; and Historic Data, All Technologies (Utility Patents) Report, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/h_at.htm#PartA1_1a, accessed 15 September 2009.

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flattening of growth in 2008 may reflect the onset of the global financial crisis and economic downturn in 2008.

Inventors residing in the United States filed 232,000 of these applications in 2008, about 9,000 less than in 2007 and the first yearly decline since 1996 (figure 6-39; appendix tables 6-53 and 6-54).[26] The U.S. resident share continued to fall, dropping from 53% in 2007 to 51% in 2008, and down from 55% in 1996, which may be indicative 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 (see sidebar, "U.S. Patents Granted, by Type of Ownership").[27]

Japan, the EU, and the Asia-9 are the main sources of inventors outside of the United States who file U.S. patent applications (figure 6-39; appendix table 6-54). Japan-based inventors filed 82,000 applications (18%) in 2008, followed by 65,000 by EU inventors (14%) and 46,000 (10%) by Asia-9 inventors, mostly from South Korea and Taiwan. China is ranked a distant fifth with a 1% share. The majority of applications from other regions originate from advanced countries, including Australia, Canada, and Switzerland.

The number of patent applications from Japan and the EU grew more slowly from 1995 to 2008 than those originating elsewhere (appendix tables 6-53 and 6-54). The Asia-9's number of applications rose at more than twice the average rate, driven by increases in South Korea and Taiwan, and increased the Asia-9 share from 5% to 10% (figure 6-39). Growth in the number of applications from India and China accelerated during this period but from very low levels. The location of China-based inventors shifted from Hong Kong (64% of China's patent applications in 1997) to mainland China (81% of China's patent applications in 2008).

USPTO patents granted among these five major world regions/countries reveal trends very similar to those observed for patent applications through 2008 (figure 6-39; appendix tables 6-56 and 6-57). However, the U.S. share edged down from 50% in 2007 to 49% in 2008, the first time the U.S. share has been less than half for the past four decades (USPTO 2008). The Asia-9's share rose from 9% to 10% and the shares of the EU, Japan, and China remained steady.

USPTO Patents Granted, by Technology Area

This section discusses trends in several technology areas. The biggest—information and communications technologies—accounts for nearly 40% of all USPTO patents (figure 6-40 and appendix table 6-60). Two smaller technology areas, aerospace and pharmaceuticals, are closely associated with their respective high-technology industries. Measurement and control equipment is linked with scientific instruments industries. Biotechnology, medical equipment, and medical electronics are important technologies for health care.

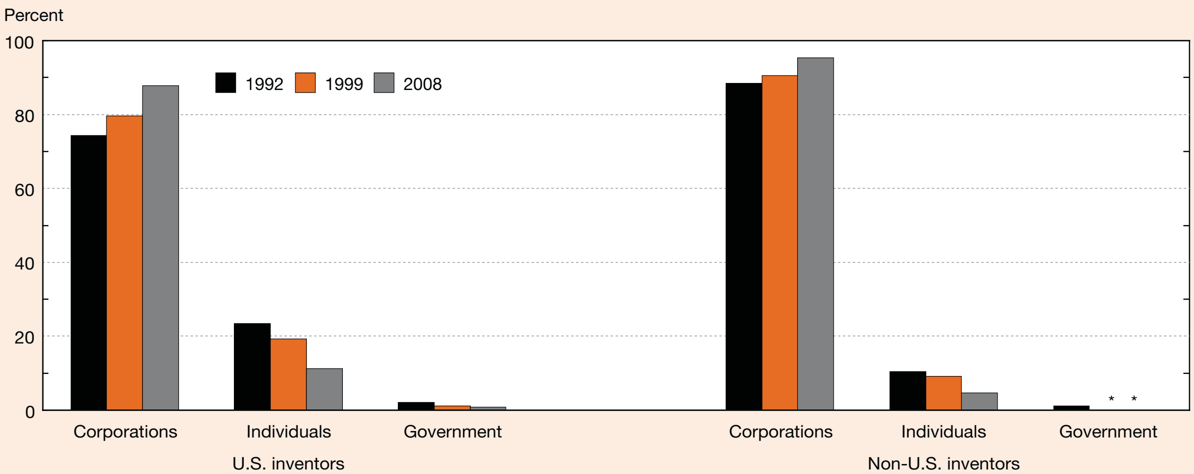
ICT Patenting. Patents in the largest single patent group, ICT—computers, semiconductors, and telecommunications—have risen rapidly and accounted for 65,000

U.S. Patents Granted, by Type of Ownership

Corporations own the majority of patents granted to U.S. entities, and their share has been steadily increasing since the early 1990s (figure 6-C). In 2008, U.S. corporations owned 88% of patents issued to U.S. inventors, with individuals owning 11%; in 1992, the respective shares were 74% and 24%. The U.S. Patent and Trademark Office defines the corporate sector as including 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 2005. (For a further discussion of academic patenting, see "Academic Patents, Licenses, Royalties, and Startups" in chapter 5.)

Corporations also own the majority of U.S. patents issued to the rest of the world; that share has also been increasing over the past decade. The individual ownership share of patents issued to the rest of the world (which is about half the level in the United States) has fallen since the early 1990s.

Figure 6-C
USPTO patents granted, by ownership type: 1992, 1999, and 2008



* = <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 2 October 2009.

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(41% share) of the 158,000 patents granted in 2008, up from 22,000 (21%) in 1995 (figure 6-40 and appendix tables 6-58 and 6-60). The U.S. share of ICT patents (48%) was identical to its total share of patents; it was higher in computers (55%) and substantially lower in semiconductors (37%) (figures 6-39 and 6-41).

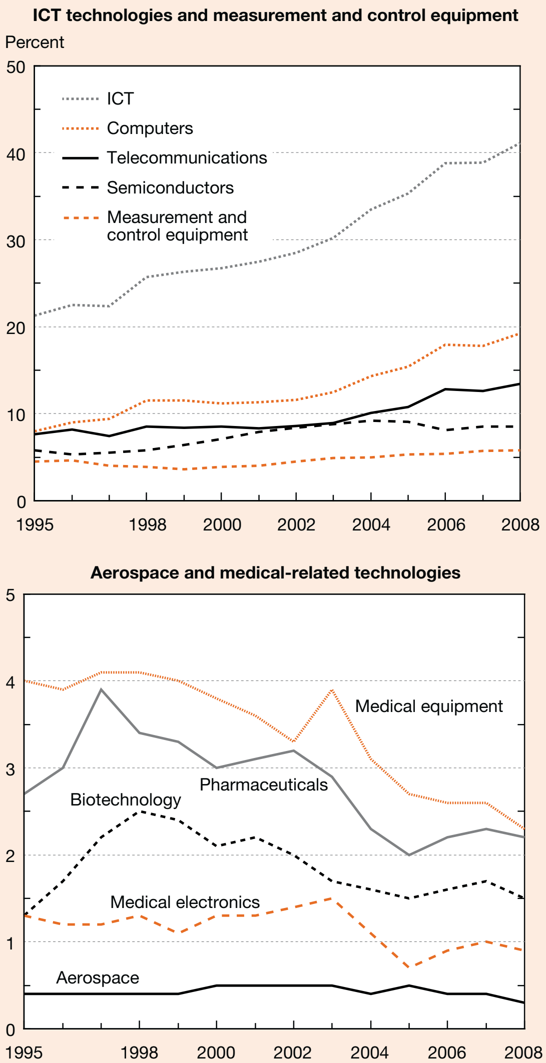
Japan ranked second in ICT patents (23% in 2008) (figure 6-41; appendix table 6-59). This area of strength, relative to its average share of 21%, reflects a higher-than-average share in semiconductors (29%) (figure 6-39; appendix table 6-62). Nevertheless, Japan's overall ICT share declined steeply during the decade, from 36% in 1995 to 23% in 2008, reflecting declining shares in all three ICT technologies (appendix tables 6-61 through 6-63).

The EU, fourth-ranked in ICT, was relatively weaker in these technologies compared with its overall share (figures 6-39 and 6-41; appendix tables 6-59 and 6-61 through 6-63). Its share has been roughly flat in all three ICT technology areas.

The Asia-9's share of ICT patents more than doubled, from 5% in 1995 to 13% in 2008, because of strong growth in all three technology areas (figure 6-41; appendix tables 6-59, 6-61, 6-62, 6-63). The Asia-9 surpassed the EU in 2007 and ranked third in ICT patents. The majority of patents fueling this growth originated from South Korea and Taiwan. China's share of USPTO ICT patents was small (1%), but strong growth from a low base in computer and semiconductor patents was evident over the decade.

Patents in Other Technology Areas. The United States has a comparatively higher-than-average share of patents in aerospace and four technology areas connected with health: pharmaceuticals, biotechnology, medical equipment, and medical electronics (figures 6-39 and 6-42; appendix tables 6-64 through 6-68). Its share of aerospace patents fluctuated

Figure 6-40
USPTO patent grants, by selected technology area: 1995–2008



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

NOTE: Technologies classified by The Patent Board™.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2009).

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broadly above 60%. In the health-related areas, the U.S. share stayed above 60% in medical equipment and medical electronics, and was just below 60% in pharmaceutical and biotechnology patents.

The EU's patents position is relatively strong in aerospace, pharmaceuticals, biotechnology, measurement and control equipment, and medical electronics (figure 6-42; appendix tables 6-64, 6-66, 6-68, and 6-69). Its share of patents in these technologies is about 20% compared with its 14% overall share (figure 6-39). Its share in medical equipment patents is close to its overall share.

As a group, the Asia-9 is relatively weaker in these technologies, as indicated by its patent shares in each technology area, which are half or less of the overall Asia-9 share; the exception is measurement and control equipment, which is near the average (7%) (figures 6-39 and 6-42; appendix tables 6-64 through 6-69). The Asia-9 share has risen over the past decade in measurement and control equipment, pharmaceuticals, and biotechnology. Its share has remained roughly stable in the other technologies.

China's share in pharmaceuticals, biotechnology, and measurement and control equipment is the same as its overall share (figures 6-39 and 6-42; appendix tables 6-65, 6-66, and 6-69). Its shares in aerospace, medical equipment, and medical electronics are 0.5%, significantly below its overall share (1%) (appendix tables 6-64, 6-67, and 6-68).

Patenting of Valuable Inventions: Triadic Patents

Using patent counts as an indicator of national inventive activity does not differentiate between inventions of minor and substantial economic potential. Inventions for which patent protection is sought in three of the world's largest markets—the United States, the EU, and Japan—are likely to be viewed by their owners as justifying the high costs of filing and maintaining these patents in three markets. That is, they are deemed to be substantially economically valuable.

The number of such "triadic" patents was estimated at about 51,600 in 2006 (the last year for which these data are available), up from 41,500 in 1997, and showing little growth after 2004. The United States, the EU, and Japan held basically equal shares (figure 6-43; appendix table 6-70),[28] and their nearly identical positions in triadic patents contrast with a far greater gap between them in USPTO patent applications and grants.

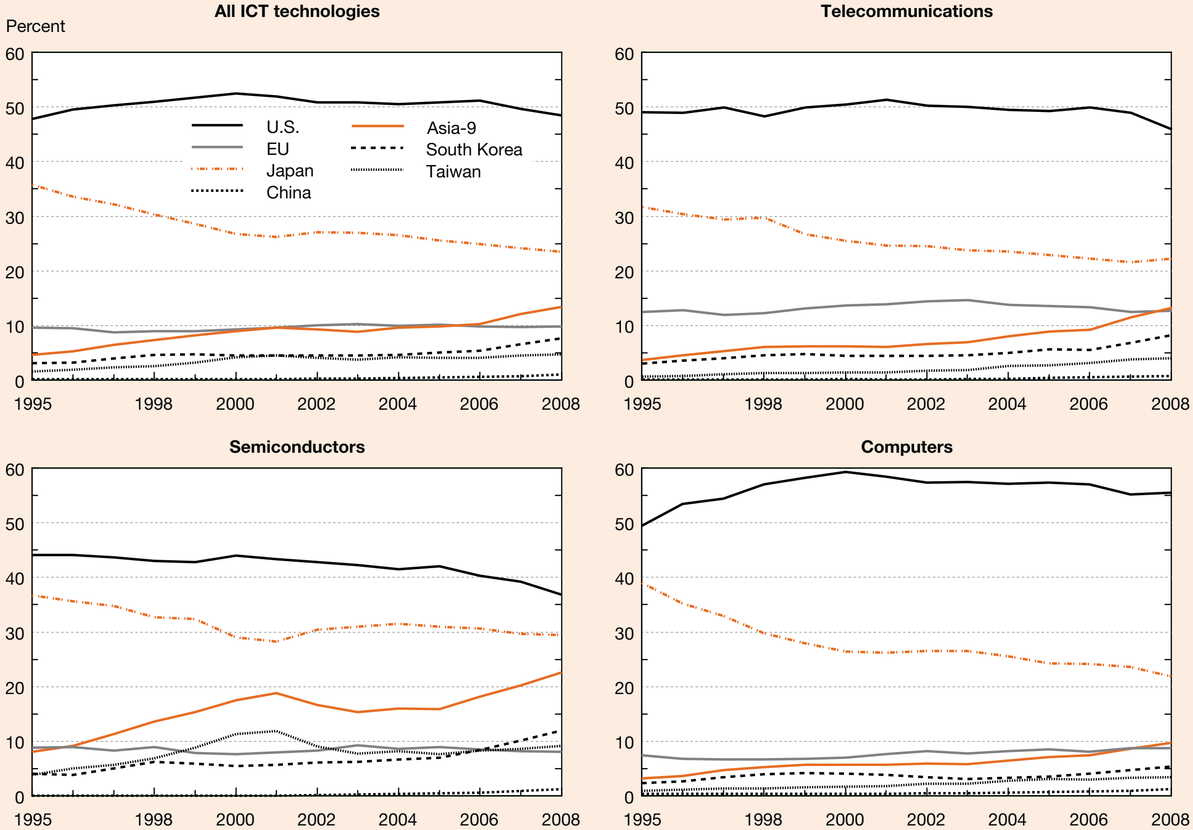
The United States, the EU, and Japan together accounted for more than 93% of triadic patents in 1997, but that share dropped to 87% by 2006 (figure 6-43; appendix table 6-70). The Asia-9's corresponding share increase from 1% in 1997 to 6% in 2006 was almost entirely driven by increasing South Korean high-value filings. Taiwan had much lower activity in triadic patent filings than in total USPTO applications and grants, and high-value patent filings by China and India, though increasing, remain minuscule.

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, that is, those employing fewer than 500 people. Biotechnology, the Internet, and computer software are examples of industries built around new technologies in whose initial commercialization small businesses played an essential role.

This section covers patterns and trends that characterize small businesses operating in high-technology industries. It is based on data from the Census Bureau. Two sources of financing for high-technology small businesses are examined, using

Figure 6-41
USPTO patents granted in information and communications technology, by selected region/country/economy: 1995–2008



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

NOTES: Technologies classified by The Patent Board™. Patent grants fractionally allocated among regions/countries/economies on the basis of proportion of residences of all named inventors from different regions/countries/economies. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU includes all 27 member states.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2009).

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data from the National Venture Capital Association and the University of New Hampshire's Center for Venture Research.

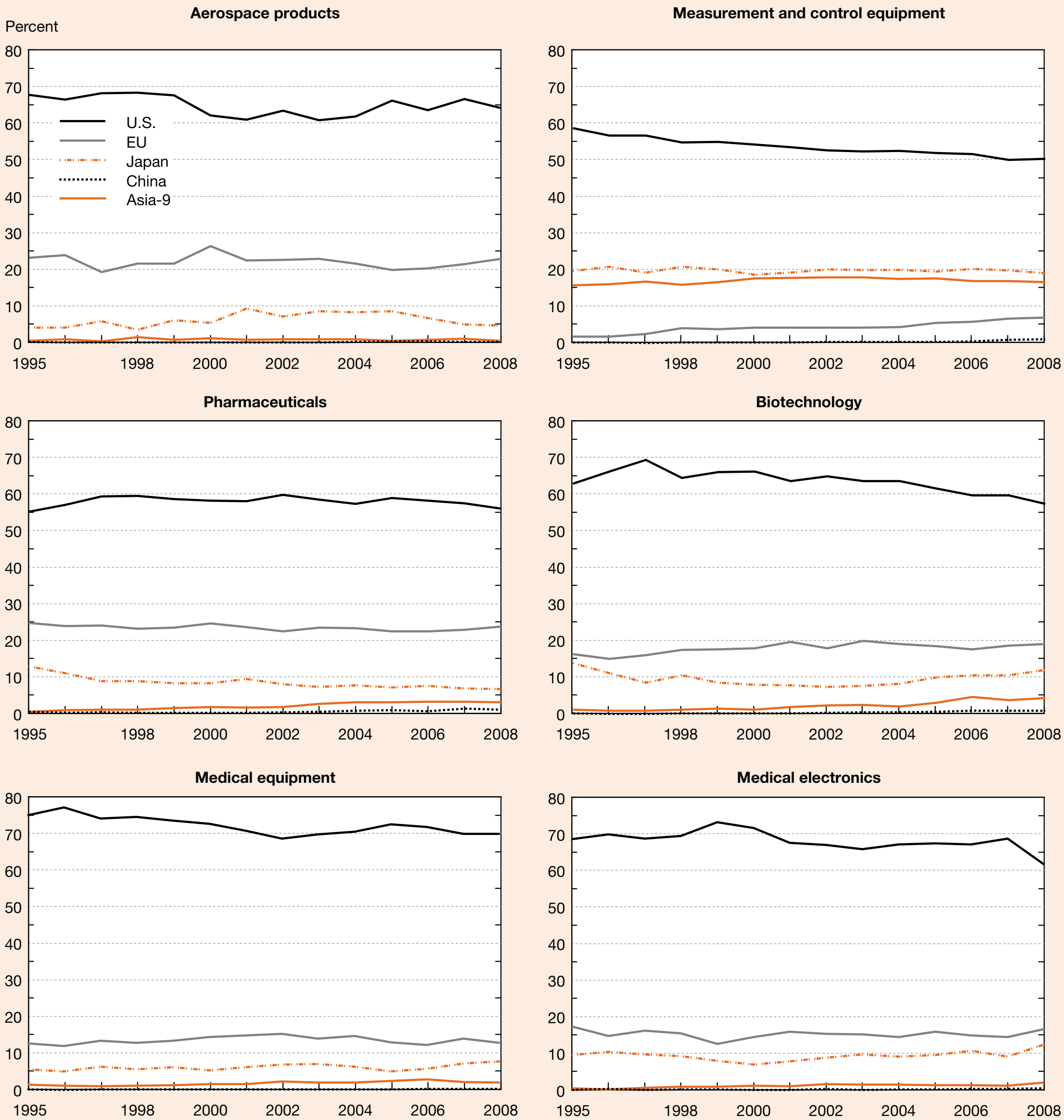
Employment in High-Technology Small Businesses

Small firms (those with fewer than 500 employees) employed about one-third of all workers in industries classified by the Bureau of Labor Statistics (BLS) as high technology. In contrast, small firms accounted for slightly more than half of total employment in all industries[29] in 2006 (table 6-7). About one-half million small businesses operating in high-technology industries employed 5 million workers in 2006 (appendix table 6-71).[30]

In 2006, most workers in these high-technology small businesses (68%) were in the service sector (table 6-8; appendix table 6-71), concentrated in six BLS high-technology categories: architecture, computer systems design, consulting, management, commercial equipment and services, and R&D. These service industries collectively employed more than 85% of workers employed by all small businesses in high-technology service industries in 2006. The manufacturing sector employs most of the remaining workers in high-technology small businesses (30% in 2006).

Small business employment in high-technology 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 (table 6-8; appendix table 6-71). These six industries collectively employed more than half of all workers in all manufacturing high-technology small businesses and 15% of the entire high-technology small business labor force in 2006.

Figure 6-42
USPTO patents granted in selected technologies, by selected region/country/economy: 1995–2008



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

NOTES: Technologies classified by The Patent Board™. Patent grants fractionally allocated among regions/countries/economies on basis of proportion of residences of all named inventors. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU includes all 27 member states.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2009).

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Financing of High-Technology Small Businesses

Entrepreneurs seeking to start 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, called *angel investment* and *venture capital investment,* 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.)

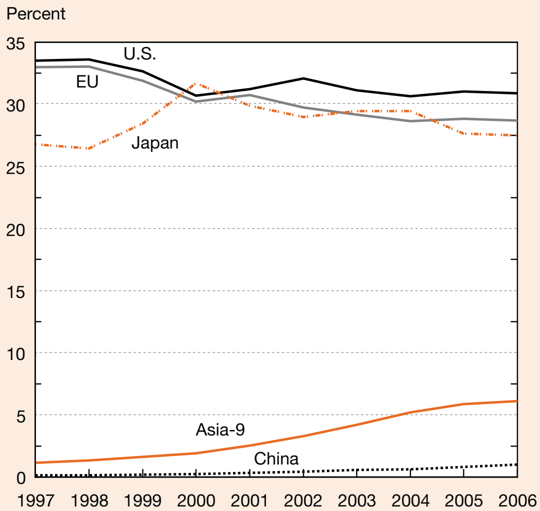
Angel investors tend to be wealthy individuals who invest their own funds in entrepreneurial businesses, either individually or through informal networks, usually in exchange for ownership equity. Venture capitalists manage the pooled investments of others (typically wealthy investors, investment banks, and other financial institutions) in a professionally managed fund. In return, venture capitalists receive ownership equity and almost always get to participate 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** supports proof-of-concept development (seed) and initial product development and marketing (startup).
- **Early funds** support the initiation of commercial manufacturing and sales.
- **Expansion financing** provides working capital for company expansion, funds for major growth (including plant expansion, marketing, or development of an improved product), and financing to prepare for an initial public offering (IPO).
- **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 a private company.

Angel investor funds are concentrated in the seed-startup and early stages. During the 2007–08 period, they provided 80% of investment for these stages, compared with 20% in

Figure 6-43
Global triadic patent families, by selected region/country/economy: 1997–2006



EU = European Union

NOTES: Triadic patent families include patents applied for in U.S. Patent and Trademark Office, European Patent Office, and Japan Patent Office. Patent families fractionally allocated among regions/countries/economies based on proportion of residences of all named inventors. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. China includes Hong Kong. EU includes all 27 member states.

SOURCE: Organisation for Economic Co-operation and Development, Patents Statistics http://stats.oecd.org/WBOS/index.aspx, Patents by Region database, accessed 2 October 2009.

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Table 6-7
Firms and employment in U.S. small businesses versus all businesses: 2006

	All technologies		High technology	
Business	Firms (thousands)	Employment (millions)	Firms (thousands)	Employment (millions)
All businesses	6,022	120.0	519	15.4
Small businesses (number)	6,004	60.2	504	5.3
Small businesses (%)	99.7	50.2	97.1	34.4

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. High-technology small business employment is lower bound estimate because employment not available for a few industries due to data suppression.

SOURCES: Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/csd/susb/susb06.htm, accessed 1 June 2009; 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 1 June 2009.

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Table 6-8
Leading types of employers among high-technology small businesses, by industry: 2006

Industry	Employment (thousands)	Percent distribution
All industries	5,275	100.0
Service industries	3,599	68.2
Top six combined	3,085	58.5
Architectural, engineering, and related services	923	17.5
Computer systems design and related services	667	12.6
Management, scientific, and technical consulting services	637	12.1
Management of companies and enterprises	352	6.7
Professional and commercial equipment and supplies merchant wholesalers	311	5.9
Scientific research and development services	194	3.7
All others	514	9.7
Manufacturing	1,554	29.5
Top six combined	800	15.2
Motor vehicle parts manufacturing	163	3.1
Metalworking machinery manufacturing	139	2.6
Semiconductor and other electronic component manufacturing	136	2.6
Other general purpose machinery manufacturing	135	2.6
Other fabricated metal product manufacturing	127	2.4
Navigational, measuring, electromedical, and control instruments manufacturing	100	1.9
All others	754	14.3
Other	122	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 a single location with no subsidiary 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. High-technology small business employment is lower bound estimate because employment not available for a few industries due to data supression. Other includes agriculture, mining, and utilities.

SOURCES: Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/csd/susb/susb06.htm, accessed 1 June 2009; 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 1 June 2009.

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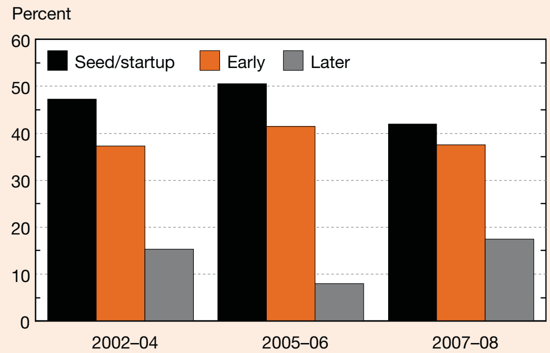
later stages (figure 6-44). Venture capital, however, is provided primarily for expansion and later-stage funding (figure 6-45; appendix table 6-72).

This section examines angel and venture capital investment patterns in the United States, focusing on the period from 2001 to 2008. The section examines (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 Investment. According to data from the Center for Venture Research, angel investors provided $19 billion in financing in 2008, a sharp drop from $26 billion in 2007 following 5 consecutive years of increases (figure 6-46; appendix table 6-73).[31] An estimated 55,000 businesses received financing from angel investors in 2008, 1,600 fewer than in 2007 but 4,500 more than in 2006 (table 6-9). The average investment per business fell from about $455,000 in 2007 to $346,000 in 2008.

Although angel investors continue to concentrate on the riskiest stage of business development, they have become more conservative in their investment patterns. The share of angel funding going to seed-startup was 42% in the 2007–08 period compared with 47% in the 2002–04 period (figure 6-44).

Figure 6-44
Distribution of U.S. angel capital investment, by financing stage: 2002–08



NOTES: Seed/startup includes proof of concept, research, and product development. Early includes financing for activities, such as initial expansion, commercial manufacturing, and marketing. Later includes major expansion of activities, preparation for an initial public offering, acquisition financing, and management and leveraged buyout.

SOURCE: Jeffrey Sohl, Analysis Reports, Center for Venture Research, University of New Hampshire, http://wsbe.unh.edu/analysis-reports-0, accessed 7 November 2009.

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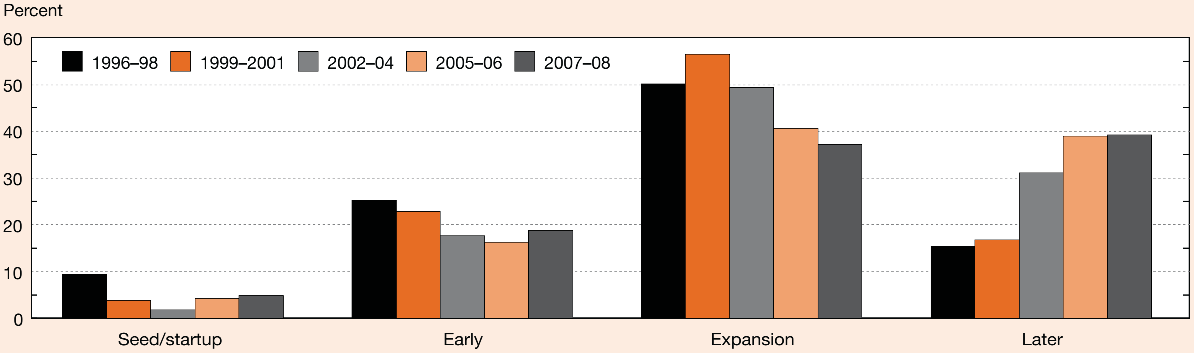
Figure 6-45
U.S. venture capital investment, by share of investment stage: 1996–2008



NOTES: Seed/startup includes proof of concept, research, and product development. Early includes financing for activities, such as initial expansion, commercial manufacturing, and marketing. Expansion includes major expansion of activities or preparation for initial public offering. Later includes acquisition financing and management and leveraged buyout.

SOURCE: PriceWaterhouseCoopers/National Venture Capital Association MoneyTree™ Report based on data from Thomson Reuters, https://www.pwcmoneytree.com/MTPublic/ns/index.jsp, accessed 7 November 2009.

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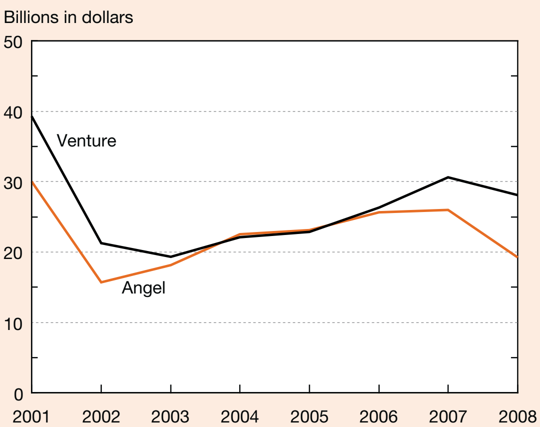
Figure 6-46
U.S. angel and venture capital investment: 2001–08



SOURCES: PriceWaterhouseCoopers/National Venture Capital Association MoneyTree™ Report based on data from Thomson Reuters, https://www.pwcmoneytree.com/ MTPublic/ns/index.jsp, accessed 7 November 2009; and Jeffrey Sohl, Analysis Reports, Center for Venture Research, University of New Hampshire, http://wsbe.unh.edu/analysis-reports-0, accessed 7 November 2009.

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Changes in the technology areas that attract angel investment may indicate changes in the parts of the economy that offer future growth opportunities. Healthcare services received the largest share of angel investment in 2008 (16%), 5 percentage points lower than its 2006 share (figure 6-47). Software received 13% of total angel investment in 2008, 5 percentage points lower than its 2006 share. Biotechnology received 11% of total investment in 2008, 7 percentage points lower than its 2006 share. The share of industrial/energy increased from 6% in 2006 to 8% in 2008, possibly reflecting opportunities that angel investors see in green and clean energy technologies.

Businesses receiving angel investment in 2007 employed about 200,000 workers (table 6-10). This figure is about the same as employment in the 2005–06 period. Each business employed an average of 3.5 workers in 2007, slightly lower than the average in 2005–06.

U.S. Venture Capital Investment. U.S. venture capitalists invested $28.1 billion in 2008, an 8% decline compared with the level in 2007 and the first decline since 2003 (figure 6-46; appendix table 6-72). The amounts of angel and venture capital investment have been very similar for the past 5 years. Since declining sharply in 2001 following the end of the dot.com boom, angel and venture capital investments have generally been strengthening, but in 2008 they remained well below their previous peaks.

Venture capitalists financed 3,300 firms in 2007, far fewer than the number of businesses financed by angel investors in the same year (57,000) (table 6-9; appendix table 6-72). Average venture capital investment has been about $8.5 million per firm for the past several years, much larger than the corresponding figure for angel investment.

The number of businesses funded by venture capital and the average amount of investment have been increasing during the past several years. The number of businesses was about 3,300 in 2007–08, one-quarter higher than the average for the 2002–05 period (table 6-9; appendix table 6-72). The average investment per business in 2008 ($8.6 million) was about $675,000 lower (not inflation adjusted) than that in 2007 but approximately $650,000 higher than the average for the 2002–03 period.

Table 6-9
Average investment of angel and venture capital per business: 2002–08

Year	Angel capital: Businesses (*n*)	Angel capital: Total investment ($billions)	Angel capital: Average investment/ business ($thousands)	Venture capital: Businesses (*n*)	Venture capital: Total investment ($billions)	Venture capital: Average investment/ business ($thousands)
2002	36,000	15.7	436	2,634	21.3	8,087
2003	42,000	18.1	431	2,461	19.3	7,842
2004	48,000	22.5	469	2,625	22.1	8,419
2005	49,500	23.1	467	2,708	22.9	8,456
2006	51,000	25.6	502	3,089	26.3	8,514
2007	57,120	26.0	455	3,301	30.6	9,270
2008	55,480	19.2	346	3,262	28.1	8,614

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

SOURCES: Jeffrey Sohl, Analysis Reports, Center for Venture Research, University of New Hampshire, http://wsbe.unh.edu/analysis-reports-0; and National Venture Capital Association and Price Waterhouse Coopers, Money Tree Report, https://www.pwcmoneytree.com/MTPublic/ns/index.jsp, accessed 15 March 2009.

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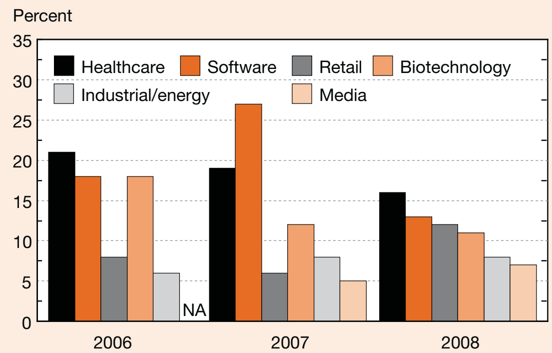
Venture capital investment has become generally more conservative than angel investment, and venture capital investments have more often been made in the later stages of business development. Capital provided for expansion and later-stage financing accounted for a combined share of 75% or more from 2002 to 2008 (figure 6-44; appendix table 6-72). Expansion financing accounted for half or more of all venture capital investment from 1996 through 2004, after which its share declined to 37% in 2007–08 as later-stage investments rose to 39%.

Venture capitalists have largely abandoned the seed-startup stage, which was 9% in the 1996–98 period, declined to 2% in the 2002–04 period, and recently recovered to a modest 5% (figure 6-44; appendix table 6-72). The factors behind the downturn are thought to be the desire for lowered investment risk, a shorter time horizon for realizing gains, and an increase in venture capital companies' base level for investment, which has come to exceed the amounts typically required for the earliest stages. The recent increase is thought to reflect the emergence of promising new investment opportunities after the closeout of holdings in mature companies (NVCA 2007a).

Figure 6-47
U.S. angel capital investment, by selected technology area: 2006–08



NOTES: Technology areas classified by Center for Venture Research, University of New Hampshire.

SOURCE: Jeffrey Sohl, Analysis Reports, Center for Venture Research, University of New Hampshire, http://wsbe.unh.edu/analysis-reports-0, accessed 7 November 2009.

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Venture Capital Financing, by Industry. Computer software had the largest share of venture capital funding of any industry in 2007–08 (18%) but registered a 5-percentage-point decline from 1999–2001 levels (figure 6-48; appendix table 6-72). Likewise, the share of telecommunications declined to 7% in 2007–08, about half of its 1999–2001 level.

Biotechnology received the second highest share of venture capital funding in 2007–08 (16%), slightly below the 2002–06 level but more than triple its share during the 1999–2001 period (figure 6-48; appendix table 6-72). The trend in medical devices and equipment was similar. Its share quadrupled from 3% during the 1999–2001 period to 13% in 2007–08.

Industrial/energy's share more than doubled from 6% in 2005–06 to 13% in 2007–08, similar to the trend in angel investment and thought to reflect investor interest in renewable and clean energy (figure 6-48; appendix table 6-72). Likewise, investments in clean technologies—a cross-cutting category of green and renewable energy—increased from a 9% share of venture investment in 2007 to a 15% share in 2008.

Table 6-10
Investors and employees of firms receiving angel capital investment: 2001–07

Year	Businesses receiving investment	Angel investors	Total employees	Average employees per business receiving investment
2001	NA	NA	NA	NA
2002	36,000	200,000	NA	NA
2003	42,000	220,000	NA	NA
2004	48,000	225,000	141,200	2.9
2005	49,500	227,000	198,000	4.0
2006	51,000	234,000	201,400	3.9
2007	57,120	258,200	200,000	3.5

NA = not available

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

SOURCE: Jeffrey Sohl, Analysis Reports, Center for Venture Research, University of New Hampshire, http://wsbe.unh.edu/analysis-reports-0.

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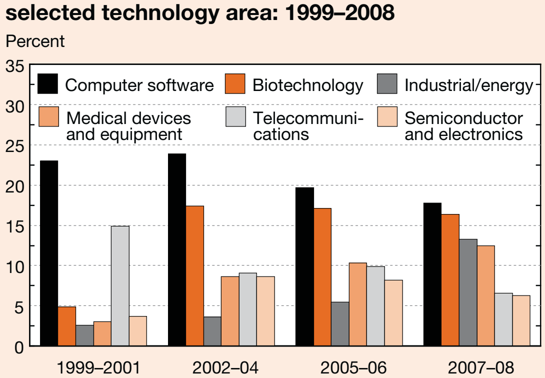
Figure 6-48
U.S. venture capital investment, by share of selected technology area: 1999–2008



SOURCE: PriceWaterhouseCoopers/National Venture Capital Association MoneyTree™ Report based on data from Thomson Reuters, https://www.pwcmoneytree.com/MTPublic/ns/index.jsp, accessed 7 November 2009.

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Innovation and Knowledge-Based Economic Growth

The World Bank developed its Knowledge Economy Index (KEI) to show the potential of countries to adopt, generate, diffuse, and harness knowledge in economic development. Knowledge is regarded as an important factor of innovation, given the shift of economic activity toward KTI industries and the growing importance of intangible assets.

The KEI is a simple average of four indicator scores that measure countries' relative standing in ICT, innovation, education, and economic incentive and institutional regime. In turn, the four component indicators are composed of several variables each. Countries are ranked in order of their scores on each variable, and scores are normalized on a scale of 0 to 10 compared with all countries: The top 10% of performers get a normalized score between 9 and 10, the next decile receives normalized scores between 8 and 9, and so on.

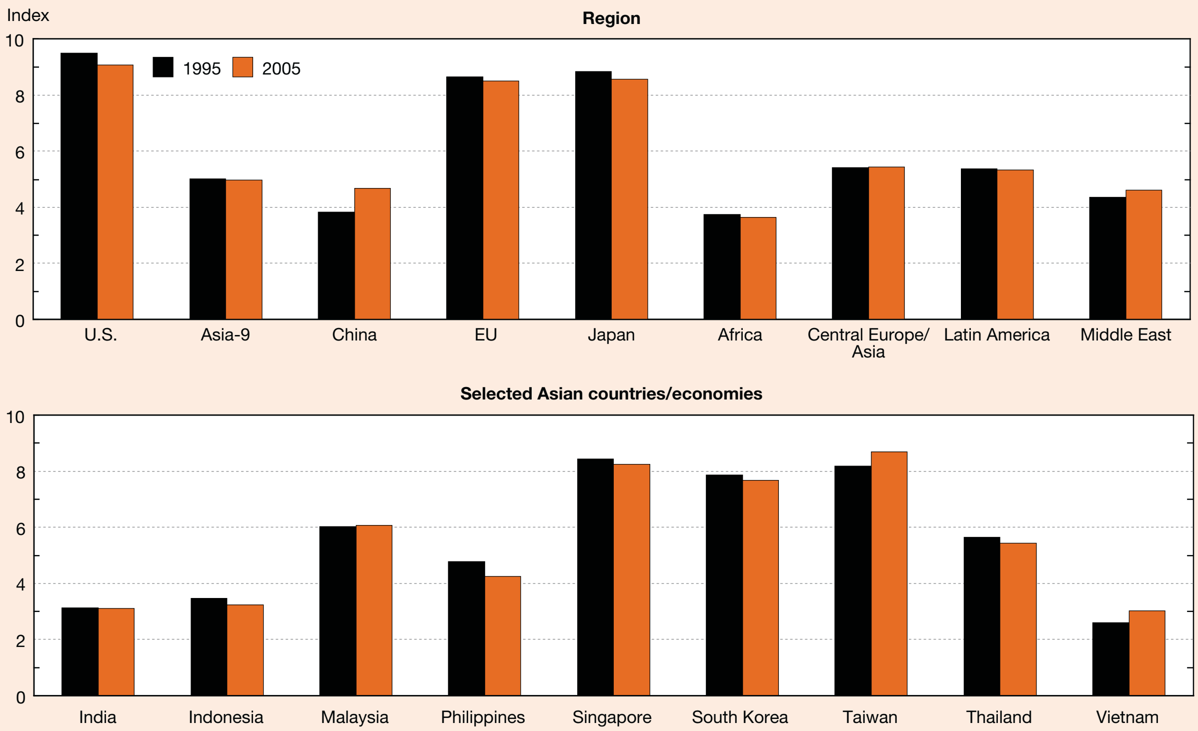
The 2005 KEI scores of the United States, Japan, and the EU were the highest among the major regions/countries/economies, followed by those of Taiwan, Singapore, and South Korea (figure 6-49; appendix table 6-74). Over a decade (1995–2005), the KEI scores of the United States, the EU, and Japan declined somewhat (figure 6-49; appendix table 6-74). The U.S. score fell largely because of a decline in the ICT sector, whose index value dropped from 9.8 to 8.9, and also because of weakness in the education sector. Japan's lowered KEI score reflected a decline in Japan's economic incentive regime; the EU's score was reduced because of a lowered education sector score.

Among the developing countries/economies, China, Taiwan, and Vietnam showed considerable improvement over the decade, albeit from very different levels (figure 6-49; appendix table 6-74). China improved its scores in all four component indicators, with the largest gains in the ICT and innovation scores. Although China's gap with the developed economies narrowed, its KEI score remains well below those of the developed economies.

Among the Asia-9, Taiwan and Vietnam showed solid increases (figure 6-49; appendix table 6-74). India's KEI index remained unchanged, thus widening the gap with China. India's modest score gains in innovation and economic incentive regime values were offset by weaknesses in ICT and education indicators, which remained in the 20% percentile range.

Among other developing countries, Brazil, Croatia, and Sri Lanka showed solid gains (appendix table 6-74). The improvement in Brazil's score reflected a large increase in its education score and a rise in its ICT score.

Figure 6-49
World Bank Knowledge Economic Index, by selected region/country/economy: 1995 and 2005



NOTES: Knowledge Economy Index is simple average of four indicator scores, each composed of several variables, measuring regions/countries/economies' relative standing in information and communications technology, innovation, education, economic incentive, and institutional regime. Regions/countries/economies ranked in order of scores on each variable, and scores normalized on 0–10 scale against all regions/countries/economies. Top 10% of performers receive normalized score between 9 and 10, decile receives normalized scores between 8 and 9, and so on. Scores for regions weighted by country's/economy's share of region's economic activity according to World Bank's gross domestic product on 2005 purchasing power parity basis. Africa includes Angola, Burkina Faso, Cameroon, Egypt, Ghana, Kenya, Madagascar, Malawi, Mali, Morocco, Mozambique, Nigeria, Senegal, South Africa, Tanzania, Tunisia, Uganda, and Zimbabwe. Asia-9 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam. Central Europe/Asia includes Albania, Armenia, Azerbaijan, Belarus, Croatia, Georgia, Kazakhstan, Kyrgyz Republic, Macedonia, Moldova, Russia, Tajikistan, Turkey, and Ukraine. China includes Hong Kong. EU excludes Malta. Latin America includes Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay, and Venezuela. Middle East includes Bahrain, Iran, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria, and Yemen.

SOURCE: World Bank, Knowledge Assessment Methodology, http://web.worldbank.org/WBSITE/EXTERNAL/WBI/WBIPROGRAMS/KFDLP/EXTUNIKAM/0,,menuPK:1414738~pagePK:64168427~piPK:64168435~theSitePK:1414721,00.html, accessed 2 October 2009.

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Conclusion

The U.S. economy continues to be a leading global economy and competitor in technology-based industries as measured by its overall performance, market position in KTI industries, and position in patenting and other measures of technological capability. The U.S. economy has grown relatively rapidly and become more productive while sustaining a high and rising per capita income.

The strong competitive position of the U.S. economy is tied to continued U.S. global leadership in many KTI industries. The United States continues to hold the dominant market position in commercial knowledge-intensive service industries, which account for nearly one-fifth of global economic activity. The U.S. trading position in technology-oriented services remains strong, as evidenced by the continued U.S. surplus in commercial knowledge-intensive services and licensing of patents and trade secrets.

Although the United States remains a leader in many KTI industries, its market position in most of these industries has either flattened or slipped. The historically strong U.S. trade position in advanced technology products has shifted to deficit because of the faster growth of imports. This shift is due in part to U.S. companies moving assembly and other routine activities to China and other East Asian countries. However, the U.S. deficit also reflects the development of indigenous capability of East Asian countries in high-technology manufacturing industries.

China and other emerging Asian economies are showing rapid progress in their overall economic progress and technological capabilities. Their market positions in KTI industries—particularly high-technology manufacturing industries—have strengthened, and their shares of U.S. and economically valuable patents have risen, led by South Korea and Taiwan. World Bank indicators of innovative capacity also show that these emerging Asian economies are converging with the United States or are making rapid progress.

China has become a leading global producer and exporter of high-technology manufacturing goods by becoming the world's major assembly center, supplied by components and inputs from East Asian economies. However, China's rapid progress in other indicators of technological capability and the nascent rise of globally competitive Chinese companies suggest that China is moving to more technologically challenging and higher end manufacturing activities.

The EU's position is similar to that of the United States—relatively strong economic performance with flat or slight declines in its market position of KTI industries. Japan's economy has shown less dynamism compared with the United States and the EU, and its market position has declined steeply in many KTI industries. Japan's loss of market position in high-technology manufacturing industries is due, in part, to Japanese companies shifting production to China and other Asian economies.

The severe downturn of the global economy, starting in 2008, has interrupted these trends observed over the past decade. The United States, the EU, and other developed economies have experienced sharp declines in their commercial knowledge-intensive service industries. The steep drop in exports of high-technology manufacturing goods has adversely affected many Asian economies and slowed China's growth. Whether the global downturn will lead to fundamental changes in the market positions of the United States and other major economies in the production and trade of KTI industries remains uncertain.

Notes

1. The Asia-9 includes India, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam.

2. See OECD (2001) for a discussion of classifying economic activities according to degree of "knowledge intensity." A different, product-based classification of the Census Bureau is used in part of the discussion on trade.

3. 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 United Kingdom, 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 (2004).

4. The combined estimated R&D expenditures of these regions/countries were $969 billion (2007 purchasing power parity) of an estimated $1.1 trillion in global R&D expenditures in 2007.

5. Purchasing power parity is the exchange rate required to purchase an equivalent market basket of goods.

6. This is an imprecise measure for comparing productivity growth, especially between developed and developing economies. One reason is that productivity is more difficult to measure in the service sector, and services typically have a far larger part of GDP in developed compared with developing economies.

7. See Atkinson and McKay (2007:16–17), for a discussion and references to the impact of IT on economic growth and productivity.

8. See Bresnahan and Trajtenberg (1995) and DeLong and Summers (2001) for a discussion of ICT and general-purpose technologies.

9. This index is composed of three measures: telephones per 1,000 people, computers per 1,000 people, and Internet users per 10,000 people. Country scores on measures are normalized on a scale of 1–10, with 10 being equivalent to the highest score received by a country.

10. See Mann (2006:90–92), for a discussion of the economic benefits of importing versus exporting ICT.

11. The U.S. dollar strengthened about 30% in value between 1995 and 2001 against a trade-weighted basket of European currencies (1995–98) and the euro (1999–2001) and subsequently lost more than 50% in value against the euro between 2001 and 2007. This exchange-rate movement lowered European industry output measured in U.S. current dollars between 1995 and 2001 and raised it between 2001 and 2007.

12. IHS Global Insight data as of July 2009.

13. 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.

14. U.S. multinational financial services data for 1999 and 2006 do not include banks and depository institutions, which are included in the global industry data on financial services.

15. U.S. direct investment abroad by industry and country is a lower-bound estimate because an increasing share of U.S. direct investment (36% in 2008) is through holding companies that invest in other industries that may be in

a different country. For more information, see Ibarra and Koncz (2008).

16. In these data, BEA values foreign direct investment (FDI) at historical cost. According to BEA, a negative FDI position in the United States occurs when total claims of U.S. subsidiaries on their foreign multinational parent companies (MNCs) exceed the foreign MNCs' investment in the United States, which typically results when U.S. affiliates are net lenders to their foreign parents.

17. There are widely different definitions of innovation, but common to these definitions is the commercialization of something that did not previously exist.

18. Earlier data are not comparable because of a change in the data collected.

19. An *affiliate* is 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.

20. 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).

21. 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.

22. 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 19 June 2009.

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

24. 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.

25. 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. EPO reports that the average pendancy was 45.3 months in 2005.

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

27. U.S. patenting data by type of ownership and by state are available only for U.S. patents granted.

28. Triadic patent families with co-inventors residing in different countries are assigned to their respective countries/economies on a fractional count basis (i.e., each country/economy receives fractional credit on the basis of the proportion of its inventors listed on the patent). Patents are listed by priority year, which is the year of the first patent filing. Data for 1998–2003 are estimated by the OECD.

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

30. See Hecker (2005) for a definition and methodology for determining high-technology industries. Several industries identified by BLS as high technology before 2003 are not covered in the Census Bureau's data.

31. Comparable data on angel capital investment before 2001 are not available.

Glossary

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-9: India, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam.

Commercial 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.

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 (EU-27): Current member countries of the European Union are Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the UK.

Foreign direct investment: Financial investment by which a person or an entity acquires a lasting interest in and a degree of influence over the management of a business enterprise in a foreign country.

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

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.

Information and communications technology industries: A subset of knowledge- and technology-intensive industries, consisting of two high-technology manufacturing industries, computers and office machinery and communications equipment and semiconductors and two knowledge intensive service industries, communications and computer services, which is a subset of business services.

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.

Knowledge- and technology-intensive industries: Those that have a particularly strong link to science and technology. These industries are five service industries, financial, business, communications, education, and health and five manufacturing industries, aerospace, pharmaceuticals, computers and office machinery, communications equipment, and scientific (medical, precision, and optical) instruments.

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: A measure of industry production that is the amount contributed by the country, firm, or other entity to the value of the good or service. It excludes the country, industry, firm, or other entity's purchases of domestic and imported supplies and inputs from other countries, industries, firms, and other entities.

Value chain: A chain of activities to produce goods and services that may extend across firms or countries. These activities include design, production, marketing and sales, logistics, and maintenance.

Venture capitalist: 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 participate in managerial decisions.

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