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FACTORS AFFECTING U.S. TRADE AND SHIPMENTS OF INFORMATION TECHNOLOGY PRODUCTS: COMPUTER EQUIPMENT, TELECOMMUNICATIONS EQUIPMENT, AND SEMICONDUCTORS

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ABSTRACT: Despite a recent downturn, the information technology (IT) products sector experienced a tremendous expansion in trade and shipments during the last decade and became an increasingly important component of the U.S. economy. This expansion was driven by a variety of factors such as the globalization of IT production, constant technological innovation, rapid growth in worldwide consumption, and global trade liberalization. This working paper will examine these factors, providing particular attention to the computer equipment, telecommunications equipment, and semiconductor industries.

[1] This paper represents solely the views of the authors and is not meant to represent the views of the U.S. International Trade Commission or any of its commissioners. The invaluable assistance of Scott Baker, Monica Reed, and Wanda Tolson is gratefully acknowledged. Please direct all correspondence to Robert Carr, Office of Industries, U.S. International Trade Commission, 500 E Street, SW, Washington, DC 20436, telephone: 202-205-3402, fax: 202-205-2018, *email: rcarr@usitc.gov.*

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INTRODUCTION

The United States is the world's leading producer and consumer of information technology (IT) products[2] which, during 1991-2000,[3] came to play an increasingly prominent role in U.S. trade and manufacturing. During the period, IT trade rose at a much faster rate than overall U.S. trade and, by 2000, accounted for 17 percent of total imports and 19 percent of total exports (figure 1). The large growth in trade was accompanied by a similarly impressive expansion in IT shipments, which rose to account for 11 percent of total U.S. manufacturing by 2000. Throughout the decade, the IT sector developed not only as an important source of U.S. manufacturing and trade, but also emerged as a critical productivity enabler. In fact, information technology products have often been credited with facilitating much of the recent productivity gain experienced by the U.S. economy.[4] For these reasons, despite a major downturn in the IT sector in 2001 as the U.S. and global economies slowed, many industry experts expect the long-term prospects for the sector to remain positive.

Factors Affecting IT Trade and Shipments

During 1991-2000, there were substantial changes in the value and patterns of U.S. trade and the level of U.S. shipments. Imports of IT products nearly quadrupled to $198 billion while exports of such items more than tripled to $137 billion (figure 2). As a result, a relatively small trade deficit in 1991 grew to almost $61 billion in 2000. As presented in tables 1 and 2, there were also considerable shifts in the composition and relative importance of U.S. trade partners. In general, while the EU, Japan, and Canada dominated U.S. trade in the early 1990s, their relative importance declined as a number of other producers and markets emerged, principally in East Asia. U.S. shipments also showed considerable growth throughout the decade, rising more than 150 percent to nearly $470 billion.

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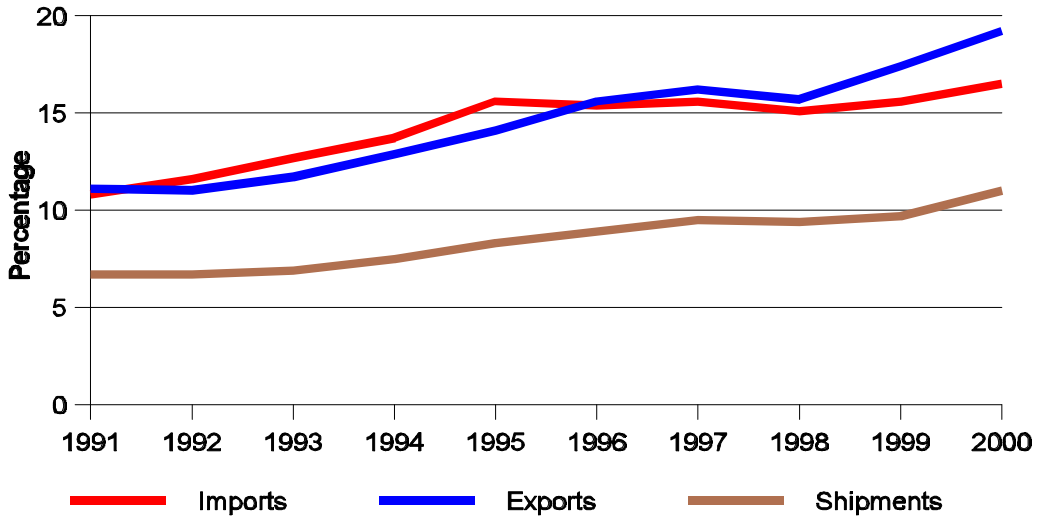
[2] Reed Electronics Research, *Yearbook of World Electronics Data 2000*, vol. 2 (UK: Reed Business Information Ltd., 2000), p. 217. For the purposes of this paper, IT products refer only to merchandise goods; information technology services are not included. Although there is no universally accepted definition for information technology products, there is a core group of items that are included in most definitions. These products are computer equipment, telecommunications equipment, certain office machines, software, electronic components (semiconductors, capacitors, resistors, connectors, etc.), and certain equipment used to manufacture electronic components. For the purposes of this paper, these items will be considered to encompass the IT sector.

[3] At the time of the publishing of this paper, Jan. 2002, full year 2001 data was not yet available for either U.S. trade or shipments.

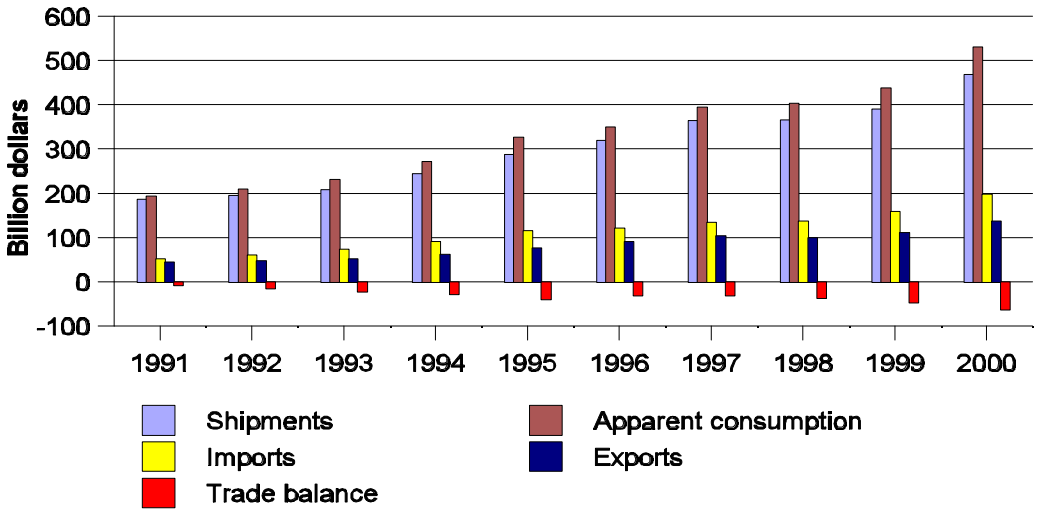
[4] Alessandra Colecchia and Paul Schreyer, *ICT Investment and Economic Growth in the 1990s: Is the United States a Unique Case? A Comparison of Nine OECD Countries* (Paris: OECD, Oct. 25, 2001), pp. 4 and 15; Andrew Szamosszegi, *ITA-2: The Case For IT Liberalization* (Washington, DC: Economic Strategy Institute, Sept. 1999), pp. vi-viii; and Information Technology Industry Council, "Digital Trade Policy: Ensuring Access to Digital Markets," found at Internet address *http://www.itic.org*, retrieved Oct. 10, 2001.

Figure 1
IT products as a percentage of total U.S. merchandise imports, exports, and shipments, 1991-2000



Source: Compiled by USITC staff from official statistics of the U.S. Department of Commerce.

Figure 2
IT products: Selected U.S. economic data, 1991-2000



Source: Compiled by USITC staff from official statistics of the U.S. Department of Commerce.

Table 1
IT products: U.S. imports for consumption, by principal source, 1991 and 2000 *(in thousand dollars)*

Country	1991	Country	2000
Japan	17,816,449	Japan	36,223,931
Singapore	6,058,973	Taiwan	20,275,776
Canada	5,487,191	Korea	19,510,767
Taiwan	4,997,034	Mexico	18,818,552
Korea	3,681,499	Malaysia	17,088,967
Malaysia	2,629,387	China	16,473,879
Mexico	1,549,844	Canada	15,846,402
Germany	1,385,696	Singapore	14,228,157
United Kingdom	1,351,301	Philippines	8,718,291
Hong Kong	1,349,318	Thailand	4,835,956
Thailand	1,211,198	United Kingdom	4,177,322
China	872,281	Germany	3,229,820
Philippines	822,942	Israel	2,601,106
Ireland	553,326	Ireland	2,008,841
France	523,967	Hong Kong	1,945,970
All other	1,971,078	All other	12,489,674
Total	52,261,384	Total	198,473,411
EU15	4,831,730	EU15	15,701,855

Source: Compiled by USITC staff from official statistics of the U.S. Department of Commerce.

Table 2
IT products: U.S. domestic exports, by principal market, 1991 and 2000 *(in thousand dollars)*

Country	1991	Country	2000
Canada	6,470,040	Canada	14,688,408
Japan	5,305,296	Mexico	14,453,836
United Kingdom	3,813,047	Japan	12,830,478
Germany	3,437,011	Korea	10,304,823
Mexico	2,463,952	Taiwan	9,140,566
Singapore	2,440,935	United Kingdom	7,690,010
Netherlands	1,907,763	Singapore	6,964,261
France	1,815,116	Malaysia	6,733,011
Korea	1,803,355	Netherlands	5,901,553
Malaysia	1,796,540	Germany	5,603,164
Taiwan	1,629,418	Philippines	5,245,322
Hong Kong	1,096,957	Hong Kong	4,249,726
Australia	947,451	Brazil	3,500,205
Italy	928,939	France	3,250,682
Thailand	758,143	China	3,055,978
All Other	7,855,408	All Other	22,986,797
Total	44,469,370	Total	136,598,821
EU15	14,489,851	EU15	30,129,839

Source: Compiled by USITC staff from official statistics of the U.S. Department of Commerce.

The primary factors that affected U.S. trade and shipments during the period include the relative strengths and weaknesses of the U.S. industry, extraordinary growth in global demand, the globalization of IT manufacturing, and U.S. participation in a number of international trade agreements. The strengths of the U.S. industry were generally in advanced technologies bolstered by heavy investment in research and development (R&D), and the availability of an educated workforce, advanced infrastructure, and institutions of higher learning. Typically, U.S. firms were among the first to bring newer, more advanced products to market and were leaders in product design and innovation. However, as products matured, manufacturing often moved to lower cost countries. As such, U.S. exports tended to be concentrated in higher end, design- and technology-intensive items, while imports were often more mature, lower end products.

Chief among those factors influencing demand were the tremendous general expansion in global consumption of IT products, certain industry-specific developments, and several regional economic events. Demand for IT products rose throughout the period as the sophistication and utility of these items continually improved, making them increasingly attractive to both businesses and consumers. In addition, a number of important new applications rose to prominence such as data networking, the Internet, and wireless communications, which further drove demand upward. This growth in consumption was largely made possible by a virtuous cycle of cost and performance. Due to constant advances in technology and manufacturing efficiencies, electronic equipment and particularly personal computers (PCs) became more powerful and offered the greater functionality demanded by consumers while consistently declining in price.[5] The development of increasingly powerful and robust software played an important role in the cycle by allowing consumers to benefit from the advances in hardware technology while further driving the development of hardware. The virtuous cycle in turn contributed to an upgrade cycle wherein users regularly upgraded to more powerful products to take advantage of the newest technologies.

Major industry-specific events that affected global demand for IT products include pricing, and deregulation and privatization in major world telecommunication services markets. Pricing, particularly price declines in the semiconductor memory and computer markets, had significant impacts on demand and the levels of trade. With regard to computer equipment, severe price competition throughout the decade made these items increasingly affordable to larger segments of the population contributing to growth in global consumption and trade. In contrast, periods of extreme price erosion for semiconductor memory devices, especially in 1996 and 1998, were severe enough to limit the growth in value of U.S. imports. Deregulation and privatization in the major telecommunication services markets led to increased competition among a growing number of providers to offer expanded communication services, which in turn created additional global demand for telecommunications equipment.

The primary external economic events that impacted IT demand and trade were the 1994-95 Mexican peso devaluation,[6] the 1997-98 Asian financial crisis, and the strong appreciation of the Japanese yen during the first half of the decade. The severe devaluations of the Mexican and certain Asian currencies vis-á-vis the U.S. dollar resulted in reduced competitiveness for U.S. exports in those markets as U.S. products became relatively higher in price. In addition, certain of the countries subject to the devaluations also experienced recessions with real declines in GDP and consumption. With regard to the Asian financial crisis, short term declines in U.S. exports to the affected region contributed to a decrease in

[5] Improved manufacturing efficiencies for semiconductors were the key component in the price declines for computers. Industry representative, email to USITC staff, Jan. 14, 2002.

[6] Unlike most other IT products, semiconductor trade reportedly was not significantly affected by the Mexican peso devaluation. Industry representative, email to USITC staff, Jan. 14, 2002.

overall U.S. IT exports in 1998, the only such year-over-year decline during the period. The exchange rate effects of the Mexican peso devaluation and the Asian financial crisis also influenced trade by making the affected economies more cost competitive as exporters and more attractive as production locations to global IT manufacturers. By comparison, the sharp appreciation of the Japanese yen through the mid-1990s decreased the price competitiveness of Japanese exports and contributed to a process wherein Japanese firms shifted production to lower cost locales. Partly as a result, Japan's position as a global IT producer, exporter, and market diminished during the period.[7]

During 1991-2000, there were considerable shifts in both the composition of U.S. trade partners and their relative importance. At the beginning of the period, the United States, Japan, and the EU accounted for most of the world's IT production, trade, and consumption. However, as the decade progressed, a number of other countries, principally in East Asia, rose in importance as IT producers, exporters, and markets.[8] With regard to U.S. imports, the globalization of IT production was the primary catalyst behind a broadening of U.S. suppliers and a relative decline in the importance of traditional import sources. For example, Japan was the leading source of U.S. IT imports in 1991, accounting for over one-third of the total (table 1). However, by 2000, Japan's share had declined to 18 percent as significant Japanese production capacity moved offshore and competition from other sources increased. In contrast, emerging producers such as Mexico, Korea, the Philippines, and China captured growing portions of the U.S. import market, with their collective share rising from 9 percent to 31 percent during the period. Often drawing upon their experience in consumer electronics manufacturing,[9] these emerging producers moved up the skills ladder into the manufacture of IT products, typically starting with low-end, commodity items and progressing into more advanced products.[10] In general, as products and their technology matured and could be produced in volume in a cost efficient manner, manufacturing tended to migrate to these new locations. As a result, these countries became more important as U.S. suppliers while there was a relative decline in the importance of traditional sources such as Japan, the EU, and Canada.

The globalization of production was due both to the outsourcing of production by traditional manufacturers to affiliates in emerging IT producing countries as well as the establishment in those countries of indigenous industries. During the decade, principally in efforts to lower production costs,

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[7] Michael Borrus, "Left For Dead: Asian Production Networks and the Revival of U.S. Electronics," Berkeley Roundtable on the International Economy (BRIE) Working Paper 100, Apr. 1997, found at Internet address *http://brie.berkeley.edu*, retrieved Oct. 26, 2001. As production of IT equipment shifted offshore, Japan's position as a market for IT subassemblies, parts, and components declined.

[8] Rising East Asian IT producers include Korea, Taiwan, Singapore, Malaysia, the Philippines, Thailand, and China. During 1991-2000, IT producers also emerged outside of East Asia. Examples include Mexico and Israel. Many of these countries, and in particular Singapore, Korea, and Taiwan, had been manufacturing IT products before the 1991-2000 period. However, it was during this decade that their relative importance as producers advanced significantly. In addition, the level of sophistication of their operations also progressed from simple assembly work to component manufacturing and in some cases design.

[9] Items such as television sets, video cassette recorders, and audio equipment. For more on this topic, see Paolo Guerrieri, "International Competitiveness, Regional Integration, and Corporate Strategies, in the East Asia Electronics Market," contained in Stephan Haggard, Dieter Ernst, and Michael Borrus, *International Production Networks in Asia: Rivalry or Riches?* (London and New York: Routledge, 2000), pp. 31-33.

[10] An example is Korea which used its position as a leading television manufacturer to become a leading producer of computer monitors. Korea also entered the semiconductor market as a producer of commodity memory chips.

improve market access, and demonstrate a commitment to important markets,[11] leading global equipment firms increasingly shifted portions of their manufacturing operations to these emerging production locales. This outsourcing of production took the form of direct investment by global (often U.S.-headquartered) manufacturers as well as the use of contract manufacturers. Initially, outsourcing tended to be for low-end component production or assembly work, but increasingly entire systems were manufactured, and in some cases designed, offshore. In addition to outsourcing related to foreign affiliates or contract manufacturers, indigenous IT industries also developed in these areas. Examples include the emergence of world class semiconductor producers in Korea, Taiwan, and Singapore, and the growth of the computer equipment industry in Taiwan.

During the period, U.S. export markets also shifted and broadened considerably, due primarily to the migration of IT production discussed above as well as the general rise in global IT consumption. In 1991, the EU, Canada, and Japan accounted for nearly 60 percent of U.S. exports. However, by 2000, that total had declined to 42 percent. Export markets that rose in importance include Mexico, Korea, Taiwan, the Philippines, China, and Brazil. Collectively, these markets nearly doubled their share of U.S. exports during the period, accounting for one third of the total in 2000. Most of these growing U.S. export markets are also emerging IT producers. In the process of manufacturing IT equipment, these countries often needed to import substantial quantities of integral components and subassemblies. In addition to supplying parts and components to other IT producers, U.S. exports to non-IT producing regions also rose. In general, as income levels increased worldwide and the prices for IT products declined, more consumers were able to afford these items.

International trade agreements also had an effect on U.S. trade, although likely to a more modest extent than the other factors discussed above. Throughout the period, IT products benefitted from a number of tariff reduction agreements including the U.S.-Canada Free Trade Agreement (FTA), the North American Free Trade Agreement (NAFTA), the World Trade Organization's (WTO) Uruguay Round Agreements, and the Information Technology Agreement (ITA). Because U.S. tariffs on information technology products were already very low, these agreements presumably had little impact on the level of U.S. imports. However, the agreements did lower tariff barriers in a number of important foreign markets and likely contributed to increased U.S. exports by improving the U.S. price advantage in those markets. In addition, nontariff measures affecting the IT industry such as intellectual property rights protection and standards, testing, and certification issues were addressed in trade agreements such as NAFTA, the Uruguay Round Agreements, and a 1998 Mutual Recognition Agreement between the United States and the European Union.[12]

[11] Locating production and/or R&D facilities in strategic markets allows the manufacturer to more quickly and efficiently respond to changing customer needs. Industry representative, email to USITC staff, Jan. 14, 2002.

[12] Both NAFTA and the Uruguay Round Agreements address intellectual property rights protections and technical barriers to trade such as standards-related measures.

COMPUTER EQUIPMENT, TELECOMMUNICATIONS EQUIPMENT, AND SEMICONDUCTORS

This section will examine in greater detail the principal factors affecting trends in U.S. trade and shipments during 1991-2000 of computer equipment, telecommunications equipment, and semiconductors. These are the largest product groups within the IT sector and in 2000 combined to account for nearly 85 percent of total IT trade and more than two-thirds of IT shipments. Although the three product groups were influenced by many of the same factors during the period, each has a distinct storyline.

Computer Equipment[13]

Overview

During 1991-2000, the United States was the leading producer and consumer of computer equipment.[14] U.S. firms that manufacture these products were among the world's largest and were in the forefront of many of the industry's technological advances. During the period, there was a tremendous expansion in U.S. trade, shipments, and consumption, with imports in particular exhibiting strong growth and generally increasing their share of U.S. consumption (figure 3). While also strong, export growth was less than that of imports, which resulted in a constant widening of the U.S. trade deficit for these products. U.S. patterns of trade also experienced significant change, as import sources and export markets shifted throughout the decade.

The primary factors affecting U.S. trade and shipments of computer equipment were the extraordinary growth in U.S. and global demand for these products and a continuing trend toward the globalization of production and component sourcing. Certain general economic and industry trends contributed to the growth in demand including the development of increasingly productive computer applications and software for home and business use, intense price competition, technological advances, regional macroeconomic events, and duty reduction agreements. Globalization proceeded throughout the decade as computer equipment industries continued to develop outside of the United States, principally in East Asia, and U.S. firms established or expanded offshore manufacturing operations.

Global demand for computers rose as they became more useful to both home and business users. Growing financial, educational, and entertainment uses contributed to consumer demand for computer equipment. Likewise, from inventory management to customer service functions, businesses worldwide recognized the increased operating efficiencies that computer technology offered.[15] In recent years, the

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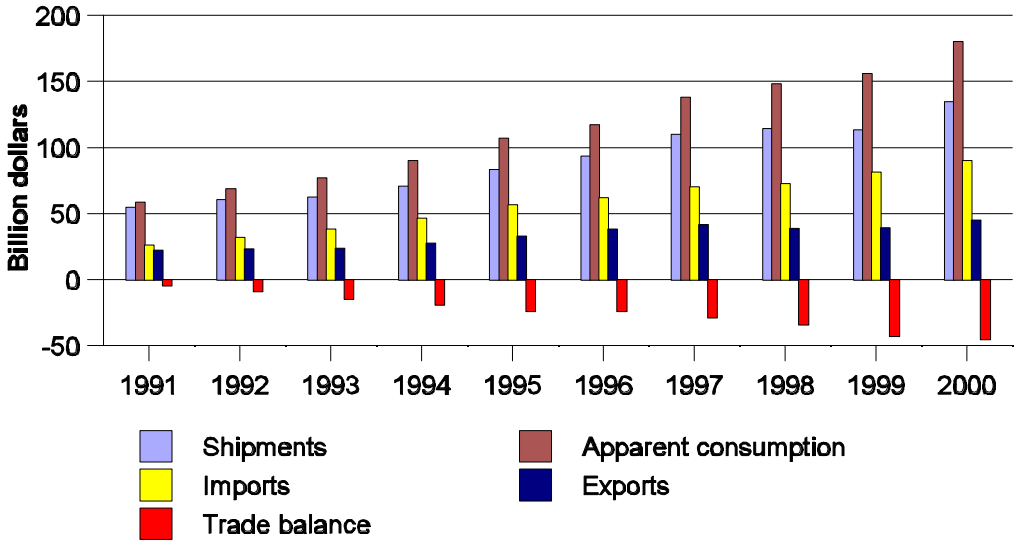
[13] For the purposes of this paper, computer equipment includes the following products: computers, parts, and peripherals, including keyboards, printers, display units, optical scanners and magnetic ink recognition devices, storage units, and power supplies; automatic teller machines; and cash registers. These products are classified under 8470, 8471, 8472, 8473.30, and part of 8504.40 of the Harmonized System (HS), 3341 under the North American Industry Classification System (NAICS), and under 3571, 3572, 3575, and 3577 of the Standard Industrial Classification (SIC). (Semiconductors are not included in this definition, and are discussed separately later in this paper.)

[14] Reed Electronics Research, *Yearbook of World Electronics Data 2000,* vol. 2 (UK: Reed Business Information Ltd., 2000), p. 217.

[15] U.S. Department of Commerce (USDOC), "Computer Equipment," *U.S. Industrial Outlook 1994*, p. 26-1.

Figure 3
Computer equipment: Selected U.S. economic data, 1991-2000



Source: Official statistics of the U.S. Department of Commerce.

development of the Internet and electronic commerce have been leading demand drivers for both business and home users. These technologies along with the evolution of computer networking permit companies to manage and communicate with their employees, customers, and suppliers, while offering consumers convenience and functionality by enabling remote transactions such as banking, shopping, and electronic mail. With regard to home users, Internet access in the United States rose throughout the decade, reaching roughly 60 percent of the population in 2000. Although the United States is still the leading user of the Internet, international use is now growing more quickly.[16]

Fierce price competition among the leading computer equipment manufacturers also contributed to worldwide consumption. As prices declined and computers became more affordable, they were increasingly adopted by both corporate and home users.[17] As discussed earlier, the declines in selling prices for computers were largely made possible by the technological advances that led to falling production costs for computer parts and subassemblies, particularly semiconductors.[18] Advances in

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[16] T.W. Rabbit, "Wired U.S. population grows steadily," *PCWorld.com*, Feb. 19, 2001, found at Internet address *http://www.pcworld.com*, retrieved Oct. 3, 2001; *Computer Industry Almanac, Inc.*, "U.S. Has 33% Share of Internet Users Worldwide Year-end 2000," found at Internet address *http://www.c-i-a.com*, retrieved Oct. 10, 2001. According to the *Computer Industry Almanac*, Internet usage in North America rose by 390 percent during 1995-2000, while worldwide usage grew by 688 percent for the same period.

[17] During the period, an ongoing market trend toward the use of PCs and away from the use of mainframes and minicomputers continued. This trend was made possible as the computing power of PCs advanced markedly, while PC prices remained well below mainframes and minicomputers. By the end of the decade, PCs dominated the global computer market. As PCs became more powerful, they also became less expensive for purchasers. By 2000, the largest segment of the PC market was for machines priced under $1,000.

[18] Gordon E. Moore, former chairman of Intel Corporation, interview, *Scientific American*, Sept. 1997, found at *http://www.sciam.com*, retrieved Sept. 21, 2001. Moore accurately predicted in 1965 that the number of

(continued...)

computer technology also led to an upgrade cycle and replacement market in which consumers often replaced existing computer equipment every few years with newer products in order to take advantage of improvements in software applications. In turn, the availability of newer, more powerful machines drove down the price of older models, further fueling demand and feeding the cycle by expanding the number of consumers that could afford them.

During 1991-2000, the globalization of computer equipment manufacturing influenced the growth of U.S. trade as well as the mix of U.S. trade partners. In a climate of intense price competition, U.S. firms established or expanded manufacturing operations outside the United States and increased their sourcing of parts from foreign suppliers in efforts to increase global competitiveness by lowering production costs and improving proximity to markets.[19] In addition, many U.S.-headquartered computer equipment producers, such as IBM, Compaq Computer, and Hewlett-Packard, established relationships with contract manufacturers that often produced complete computer systems on their behalf, typically in countries such as China, Malaysia, and Mexico, where they are near centers of component manufacturing and labor costs are a fraction of those in the United States.[20] As a result, U.S.-headquartered firms have increasingly supplied the U.S. market with parts or complete systems manufactured abroad.[21] During the period, EU and Japanese manufacturers also shifted portions of their production and component sourcing abroad, principally to East Asia. In addition, indigenous computer equipment industries in this region have

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[18] (...continued)
transistors per integrated circuit would double every year through 1975. Moore, Gordon E., "Cramming more components onto integrated circuits," *Electronics*, vol. 38, No. 8, Apr. 19, 1965, found at Internet address *http://www.intel.com*, retrieved Oct. 10, 2001. As predicted by Moore's law, the number of transistors per integrated circuit has increased geometrically, while the costs of production have declined proportionately. The increasing power of computer processors creates an "upgrade cycle," which refers to the propensity of computer users to seek the fastest processors available. The need for faster processors to handle more powerful operating system and application software contributes to this cycle. Manufacturers were also able to lower production costs during the decade by shifting toward a build-to-order model rather than building to forecasts with the associated costs of carrying inventory. Reduced production costs could then be passed on to customers in the form of lower pricing. In addition, producers such as Dell Computer began to directly market and sell products to their customers, cutting out retail establishments and associated price mark-ups.

[19] U.S. companies began to rely on foreign affiliates and offshore parts sourcing during the 1980s. However, this process accelerated during 1991-2000.

[20] Computer companies such as IBM are referred to as original equipment manufacturers (OEMs), while contract manufacturers such as Flextronics, Solectron, and Celestica are often referred to as electronics manufacturing services (EMS) firms. EMS firms have traditionally been assembly operations, but in recent years have begun assuming additional roles including component sourcing, distribution, and design. Short product life-cycles are critical to competitiveness in the computer industry, and EMS firms reduce OEM costs by decreasing time to market and improving materials procurement and logistics, thus providing increased flexibility to the supply chain. Contract manufacturers also often offer greater economies of scale and reduce the OEM's exposure to capital equipment expenditures. Claire Serant and Laurie Sullivan, "EMS providers taking on demand creation role," *EBN*, Oct. 2, 2001, found at Internet address *http://www.ebnonline.com*, retrieved Oct. 10, 2001; Celestica, "About Celestica," found at Internet address *http://www.celestica.com*, retrieved Oct. 3, 2001. Claire Serant, "Xerox sells four plants to Flextronics in cost cutting move," *EBN*, Oct. 2, 2001, found at Internet address *http://www.ebnonline.com*, retrieved Oct. 10, 2001; and Flextronics International, "Corporate Information," found at Internet address *http://www.flextronics.com*, retrieved Oct. 3, 2001.

[21] Reportedly, more than 60 percent of the hardware value of a typical U.S. PC is made up of floppy and hard drives, motherboards, mouses, monitors, semiconductor memory, and other parts imported from Asia. USDOC, "Computer Equipment," *U.S. Industrial and Trade Outlook, 1999* (New York: McGraw Hill/USDOC, 1999), p. 27-1.

continued to develop.[22] Because of these trends, U.S. imports and the import share of U.S. consumption increased, and the relative importance of import suppliers shifted.

Certain regional macroeconomic events also had significant impacts on U.S. trade and shipments, particularly the Mexican peso crisis and the Asian financial crisis. In general, U.S. exports to these regions declined as a result of the crises. With regard to the peso crisis, some U.S. manufacturers took advantage of NAFTA and the devaluation of the peso by moving portions of their in-house manufacturing to Mexico or shifting production to contract manufacturers located there.

Duty reduction agreements also contributed to the growth in U.S. trade in computer equipment, although the impact of these agreements was likely modest. While the Uruguay Round Agreements significantly reduced tariffs faced by U.S. exporters in certain markets,[23] the tariff barriers between the United States and its major trading partners were already quite low.[24] Similarly, the implementation of NAFTA and the Information Technology Agreement (ITA) also likely had relatively small impacts on U.S. trade. Some ITA signatories such as India continue to have high effective duty rates.[25] In addition, tariffs on computer equipment remain high in many countries that have not yet signed the ITA.[26] Although these countries represented a relatively small share of world consumption, high tariffs limited demand for U.S. computer equipment by imposing additional costs on both businesses and consumers in these countries.[27]

Imports

During the period, U.S. imports of computer equipment more than tripled to $90 billion, representing an average annual growth rate of 15 percent (figure 3). The first half of the decade exhibited the greatest growth; during 1991-96, imports increased at an average annual rate of 19 percent as the PC became increasingly popular among both businesses and consumers. Average import growth slowed considerably to 8 percent from 1996-1998, but rebounded to 12 percent during 1998-2000. The heightened demand for PCs also boosted demand for computer parts and accessories. During the period, imports of computer parts and accessories almost quadrupled to $32 billion, and on a yearly basis generally accounted for one-third of U.S. imports of computer equipment.

During the first part of the decade (1991-93), the U.S. market for computer equipment exhibited strong growth, particularly for PCs.[28] The ever increasing computing power of PCs combined with their

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[22] Examples include the computer equipment industries in Taiwan and Korea.

[23] Some countries reduced tariffs by as much as 100 percent on computer parts. U.S. Trade Representative (USTR), "The Uruguay Round," *Annual Report 1994*, found at Internet address *http://www.ustr.gov*, retrieved Oct. 10, 2001.

[24] USITC, *Industry & Trade Summary: Computers, Peripherals, and Computer Components*, pub. 2821, Oct. 1994, p. 23.

[25] India's current basic tariff on computers is 15 percent, but with additional special duties and surcharges, the effective rate is nearly 39 percent. USDOC, International Trade Administration (ITA), Office of Information Technologies, *ExportIT India*, Feb. 2001, found at Internet address *http://exportit.ita.doc.gov*, retrieved Oct. 9, 2001, p. 3.

[26] As of Feb. 1, 2001, 56 countries participated in the ITA, up from the 37 original participants.

[27] Business Software Alliance, Letter to Robert Zoellick, USTR, May 4, 2001, found at Internet address *http://www.bsa.org*, retrieved Oct. 10, 2001.

[28] USDOC, "Computer Equipment," in *U.S. Industrial Outlook 1994*, p. 26-2.

lower price relative to mainframes and minicomputers attracted business and consumer interest.[29] Intense price competition in PC markets that led to growth in consumption was the primary reason for the increase in U.S. imports during these years. In 1991, peripherals, storage units, and partially assembled computers were important import segments, accounting for almost three-fourths of total U.S. imports of computer equipment.[30] To remain competitive, U.S. firms purchased these components from lower cost Asian suppliers such as Japan, Singapore, and Taiwan, which together accounted for 67 percent of U.S. imports in 1991 (table 3). Though much smaller, Malaysia, China, and Korea were the three fastest growing suppliers during 1991-93. The product mix of imported computer equipment also shifted during these years. By 1993, imports of fully assembled portable computers, peripheral devices (primarily printers and monitors), and computer parts accounted for most of the growth in computer equipment imports.

While the implementation of NAFTA on January 1, 1994 likely did not significantly impact U.S. trade in computer equipment with Canada and Mexico, the Mexican peso crisis in late 1994 probably did. Prior to the implementation of NAFTA, duties on computer equipment among the member states were already negligible, and subsequent increases in U.S. imports from Canada and Mexico were due primarily to heightened U.S. demand for computer equipment. In addition, the devaluation of the peso increased Mexico's attractiveness as an import source, and U.S. firms increased their manufacturing presence in Mexico at this time. Partly as a result, U.S. imports of computer equipment from Mexico doubled between 1994 and 1996, a period when Japan's share of U.S. imports declined as the value of the yen appreciated.

Continued strong demand by U.S. consumers for price-competitive computers, disk drives, and printers fueled the growth of U.S. imports between 1994 and 1996. U.S. imports of disk drives and other data storage devices rose sharply.[31] Particularly significant were the increases in imports from Korea, Malaysia, and Singapore, major sources for the low cost, standardized components used in PCs. U.S. imports from these three countries rose by a combined $7 billion, or 54 percent during this period.

The rate of growth of U.S. imports of computer equipment, in terms of value, slowed in 1997 as demand for these products increased at a more restrained pace.[32] Nevertheless, U.S. consumers continued to demand inexpensive computer equipment supplied primarily by Asian producers. Japan, Singapore, and Taiwan remained the three leading sources for U.S. imports, accounting for 54 percent of total U.S. imports of computer equipment. However, Japan continued to lose market share as Japanese producers shifted manufacturing to lower cost Asian locales, particularly China and Malaysia. U.S., European, and Asian firms operating in higher cost Asian countries (namely Singapore, Taiwan, and Japan) also shifted production to lower cost areas in Asia.

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[29] See USITC, "Automatic data processing machines," *U.S. Trade Shifts in Selected Industries 1993 Annual Report*, inv. No. 332-345, pub. 2805, Sept. 1994, p. 138, for additional information.

[30] See USITC, "Automatic data processing machines," *U.S. Trade Shifts in Selected Commodity Areas Annual Report for 1991*, inv. No. 332-345, pub. 2517, June 1992, p. 67, for additional information.

[31] See USITC, "Automatic data processing machines," *Shifts in U.S. Merchandise Trade in 1995*, inv. No. 332-345, pub. 2992, Sept. 1996, p. 11-5, for additional information.

[32] "Computers: Hardware," *Standard and Poor's Industry Surveys*, July 10, 1997, pp. 1-2, and 7, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved, Sept. 21, 2001.

Table 3
Computer equipment: U.S. imports for consumption, by principal source, 1991 and 2000
(in thousand dollars)

Country	1991	Country	2000
Japan	9,497,727	Japan	14,502,522
Singapore	4,493,528	Taiwan	10,682,035
Taiwan	3,587,818	China	10,618,332
Canada	2,140,485	Singapore	10,092,690
Korea	1,203,008	Mexico	9,042,814
United Kingdom	912,192	Malaysia	8,149,368
Hong Kong	690,904	Korea	7,769,765
Mexico	655,360	Canada	3,741,679
Germany	557,466	Philippines	2,917,725
Thailand	534,229	Thailand	2,738,645
Malaysia	409,375	United Kingdom	2,100,970
Ireland	400,566	Ireland	1,458,084
France	241,975	Hungary	1,262,752
China	193,969	Costa Rica	835,842
Israel	118,299	Germany	747,822
All other	634,827	All other	3,603,374
Total	26,271,428	Total	90,264,419
EU15	2,488,420	EU15	5,986,205

Source: Compiled from official statistics of the U.S. Department of Commerce.

During 1991-2000, the general shift in production locations to lower cost locales significantly altered the relative importance of U.S. import partners. Japan's share of U.S. computer equipment imports dropped from 36 to 16 percent, Taiwan's share declined from 14 to 12 percent, and Singapore's share fell from 17 to 11 percent. In contrast, emerging Asian producers such as China and Malaysia enlarged their shares. During the period, China's share rose from near zero to 12 percent, making it the third largest U.S. supplier. Malaysia's share grew from less than 2 percent to 9 percent. Due in part to U.S. investment, Mexico also rose in importance as a U.S. supplier, with its share of U.S. imports growing from 2 to 10 percent.

Exports

During the 10-year period, U.S. exports of computer equipment more than doubled from $22 billion to $46 billion, representing an average annual growth rate of 8 percent (figure 3). Trends in export growth paralleled those of import growth; exports grew at an average annual rate of 11 percent during 1991-96, moderated between 1996-1999 largely as a result of the Asian financial crisis, and rose strongly by 16 percent in 2000. Global demand for computer equipment rose with the corporate adoption of computers to streamline business processes, the growth of electronic commerce, the increasing diversity of content on the Internet, the growing availability of lower priced Internet connectivity for consumers, and the increasing availability of inexpensive, high performance PCs. Another factor driving worldwide

demand for computer equipment was the large and growing replacement PC market.[33] U.S. leadership in new computer technology and aggressive pricing contributed to global demand for U.S.-manufactured computer equipment. Computer parts and accessories remained the primary U.S. export throughout the period, accounting for approximately two-thirds of exports.[34] A significant portion of these exports were likely to offshore manufacturing operations of U.S. affiliates.

During the first part of the decade (1991-93), the global market for computer equipment grew less rapidly than the U.S. market. Incomplete computers, storage units, and peripherals accounted for three-quarters of U.S. exports of computer equipment.[35] Canada, Japan, and the EU were the dominant U.S. export markets during this period, accounting for more than 70 percent of the total in 1991.

As noted earlier, the conclusion of NAFTA in January 1994 likely did not significantly impact U.S. trade in computer equipment with Canada and Mexico. However, the Mexican peso devaluation reduced the price competitiveness of U.S. exports to that market, which declined 17 percent between 1994-95. Overall, however, U.S. exports expanded in 1995 due to strong demand for U.S.-manufactured printed circuit boards and other computer parts in East Asia and the EU.[36] Demand for U.S. computer parts was particularly strong in Germany and Japan, which caused U.S. exports to those countries to increase by 30 percent and 23 percent, respectively. With regard to completed PCs and network servers, the leading destinations for U.S. exports were Germany, Japan, Canada, and the United Kingdom. While important markets, these countries were also used by U.S. firms as distribution hubs for sales to other parts of Europe and Asia.[37]

In 1996-97, U.S. exports of computer equipment continued to expand with the growing demand for U.S. computer equipment in most markets. During this period, U.S. exports to the United Kingdom grew by 25 percent, due in part to price reductions implemented by leading vendors to encourage sales in the small business market segment and reduce inventory levels of older technology products.[38] In addition, the United Kingdom was a major destination for U.S. exports of components and subassemblies, reflecting U.S. firms' manufacturing operations established there to serve the European market.[39] U.S. exports to Canada, which consisted primarily of finished computers and peripherals, rose due to competitive pricing and corporate adoption of client/server personal networks. Economic recession in Japan and an increase in

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[33] Ibid; and U.S. Foreign Commercial Service (USFCS) and U.S. Department of State (DOS), "Personal computers and peripherals," *Industry Sector Analysis: Japan*, Aug. 15, 2000, found at Internet address *http://www.usatrade.gov*, retrieved Oct. 10, 2001. USFCS and DOS, *Industry Sector Analysis: Taiwan* found at Internet address *http://www.usatrade.gov*, retrieved Oct. 10, 2001.

[34] HS 8473.30.

[35] See USITC, "Automatic data processing machines," *U.S. Trade Shifts in Selected Commodity Areas Annual Report for 1991*, inv. No. 332-345, pub. 2517, June 1992, p. 67, and USITC, "Automatic data processing machines," *U.S. Trade Shifts in Selected Industries 1993 Annual Report*, inv. No. 332-345, pub. 2805, Sept. 1994, p. 138, for additional information.

[36] See USITC, "Automatic data processing machines," *Shifts in U.S. Merchandise Trade in 1995*, inv. No. 332-345, pub. 2992, Sept. 1996, p. 11-5, for additional information.

[37] See USITC, "Automatic data processing machines," *Shifts in U.S. Merchandise Trade in 1995*, inv. No. 332-345, pub. 2992, Sept. 1996, p. 11-6, for additional information.

[38] See USITC, "Automatic data processing machines," *Shifts in U.S. Merchandise Trade in 1997*, inv. No. 332-345, pub. 3120, July 1998, p. 13-6, for additional information.

[39] For example, Compaq's Scottish plant opened in November 1987 and expanded significantly in 1994 due to additional investment. Sun Microsystems opened its Scottish plant in 1990, and by 2000, Scotland reportedly accounted for almost half of Sun's worldwide output. Sun's Scottish production center also controls the supply chain throughout Europe and Asia.

Japan's consumption tax resulted in a slight decline in computer equipment exports to that market, although computer parts exports increased slightly.

U.S. export levels experienced considerable fluctuation during 1998-2000. In 1998, exports declined for the only time during the decade, by roughly 7 percent. The Asian financial crisis and downturns in major markets, such as Japan, contributed to this decline.[40] Exports were relatively flat in 1999, but rebounded strongly by 16 percent in 2000. Computer parts, most of which were destined for foreign affiliates or contract manufacturers accounted for the largest part of the growth.[41] In addition, Asian markets began to recover from the financial crisis.

Although Canada, Japan, and the United Kingdom were the top 3 U.S. export markets throughout the decade, their relative importance declined slightly. Canada's share of U.S. exports dropped from 15 to 13 percent, Japan's from 14 to 10 percent, and the United Kingdom's from 11 to 9 percent (table 4). In contrast, Mexico, Korea, and China increased their share of U.S. exports. During the period, exports to Mexico and Korea roughly quadrupled, while exports to China increased by over 5000 percent. Exports to these countries were both for consumption as well as for incorporation into unfinished computer equipment which, after further assembly, was often exported.

Table 4
Computer equipment: U.S. domestic exports, by principal market, 1991 and 2000
(in thousand dollars)

Country	1991	Country	2000
Canada	3,231,333	Canada	5,878,620
Japan	3,091,344	Japan	4,447,042
Germany	2,433,510	United Kingdom	4,145,946
United Kingdom	2,420,641	Netherlands	4,031,645
Netherlands	1,264,632	Mexico	3,229,616
France	1,115,804	Germany	2,811,886
Mexico	781,829	Korea	1,936,885
Australia	748,111	Singapore	1,850,823
Singapore	689,049	Hong Kong	1,608,366
Korea	527,246	Ireland	1,554,990
Italy	489,071	Brazil	1,465,756
Ireland	487,331	France	1,234,028
Taiwan	393,787	China	1,137,759
Belgium	366,873	Australia	1,019,930
Hong Kong	336,837	Taiwan	935,045
All Other	3,814,480	All Other	7,861,223
Total	22,191,480	Total	45,149,559
EU15	9,462,973	EU15	15,415,538

Source: Compiled from official statistics of the U.S. Department of Commerce.

[40] See USITC, "Automatic data processing machines," *Shifts in U.S. Merchandise Trade in 1998*, inv. No. 332-345, pub. 3220, July 1999, p. 13-9, for additional information.

[41] See USITC, "Computers, Peripherals, and Parts," *Shifts in U.S. Merchandise Trade in 2000*, pub. 3436, July 2001, p. 12-6, for additional information.

Balance of Trade

Throughout the decade, the United States maintained a trade deficit with the world in computer equipment. The deficit grew more than tenfold to $45 billion in 2000, at an average annual growth rate of 31 percent, as U.S. producers continued to shift production abroad and source components and subassemblies from lower cost producers. The deficit grew most rapidly during 1991-96 due to enormous U.S. demand for imports of price-competitive products. Export growth, while strong, rose less rapidly than did imports. The U.S. trade deficit with leading Asian producers such as Japan, Singapore, Taiwan, Korea, and Malaysia grew throughout the period. The exception was 1998, when U.S. deficits with these countries decreased in part as a result of exchange rate effects associated with the Asian financial crisis. The U.S. maintained a significant though fluctuating surplus with Canada throughout the decade. The U.S. trade balance with Mexico shifted from surplus to deficit in 1994 due to the devaluation of the peso and the continued development of the Mexican industry.

U.S. Shipments

During the period, U.S. shipments of computer equipment rose from $55 million to $135 million, an average annual growth rate of 11 percent. Although exports increased, the growth in shipments primarily reflected strong U.S. demand for computer equipment. The same factors which influenced growth in U.S. imports and exports, such as intense price competition, technological advances, the growth of the Internet, and international trade agreements such as the ITA, also fueled the rise in U.S. demand and shipments. In 1999, shipments declined slightly even as domestic consumption continued to rise, indicating displacement of U.S.-produced equipment by imports, primarily from East Asia. However, in 2000 U.S. shipments rebounded by 19 percent as U.S. and global consumption rose strongly. Exports as a share of shipments declined irregularly during the period, from 41 percent in 1991 to 34 percent in 2000. During the decade, the U.S. industry experienced tremendous gains in labor productivity as employment declined by 15 percent while the value of shipments grew by 145 percent.[42]

Telecommunications Equipment[43]

Overview

The United States, along with Japan and the EU, was one of the world's largest producers and consumers of telecommunications equipment during 1991-2000.[44] U.S. manufacturers were generally

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[42] According to the U.S. Bureau of Labor Statistics, U.S. employment in the computer equipment industry was 361,000 in 2000. Employment declined rapidly during 1991-1993, and moved irregularly throughout the remainder of the period.

[43] For the purposes of this paper, telecommunications equipment comprises most wireline network and terminal equipment, including switching and transmission equipment, as well as telephone sets, facsimile machines, and parts for these products. Also included are most types of wireless telecommunications infrastructure and terminal equipment such as transceivers and cellular telephones. Communications satellites, optical fiber, fiber optic cable, and broadcast equipment are not included in the discussion. Telecommunications equipment is covered under HS 8517 and part of HS 8525, NAICS 33421and part of 33422, and SIC 3661and part of SIC 3663.

[44] National Research Board (NRB), "Industry, Technology and the Global Marketplace," *Science and Engineering Indicators 2000* (Arlington, VA: National Academy Press, 2000), pp. 7-1 to 7-29; *Science and Engineering Indicators 1998*, pp. 6-1 to 6-38; Ronald A. Cass and John Hening, "Telecommunications Markets,

(continued...)

considered to be global leaders during this period in the development and manufacture of leading-edge products, particularly digital switching and transmission equipment, data communications and networking equipment, and high-end terminal equipment, such as voice processing systems and multimedia cellular devices. However, as the U.S. telecommunications equipment markets opened further due to increased deregulation and liberalization of telecommunications services, the U.S. industry faced growing competition in its own market from producers in Canada, the EU, and Japan in the higher end network segments of the market.[45] Meanwhile, early in the period, Japan also dominated global production in the relatively less sophisticated terminal equipment segments, such as traditional telephones and facsimile machines, although it progressively shifted such production to lower wage Asian countries, such as Korea, Singapore, Taiwan, Malaysia, Thailand, and China, throughout the decade. Those countries, along with Mexico, increasingly dominated global production of less-expensive commodity products, beginning with traditional telephones, followed by facsimile machines, cordless telephones, and simple cellular handsets.

Some of the factors affecting U.S. trade and production trends during the period include the relative technological capabilities of U.S. and foreign telecommunications and networking equipment firms; increased deregulation and privatization of the telecommunication services industries (the major customers for telecommunications equipment) in the United States and in important overseas markets; the rapid evolution of wireless communications, data communications, and Internet services;[46] increased production sharing and global outsourcing of equipment and components by U.S., EU, Japanese, and Canadian producers; and reduction and elimination of customs duties for telecommunications equipment through various trade agreements concluded between the United States and its major trading partners.

Imports

During 1991-2000, U.S. imports of telecommunications equipment increased at an average annual rate of 22 percent to $34 billion (figure 4). The growth in imports accelerated toward the end of the period, rising by an average annual rate of 37 percent during 1996-2000, and by 65 percent from 1999 to 2000. Much of the increase in imports resulted from rapidly rising domestic demand for telecommunications equipment, as U.S. consumption increased by an average annual rate of 14 percent during the entire period, and by 33 percent from 1999 to 2000. Growing U.S. imports supplemented U.S. production of telecommunications equipment to meet the rising demand.

Japan was by far the largest supplier of U.S. imports in 1991, accounting for $1.8 billion (table 5), or over one-third of U.S. imports of telecommunications equipment in that year. Although

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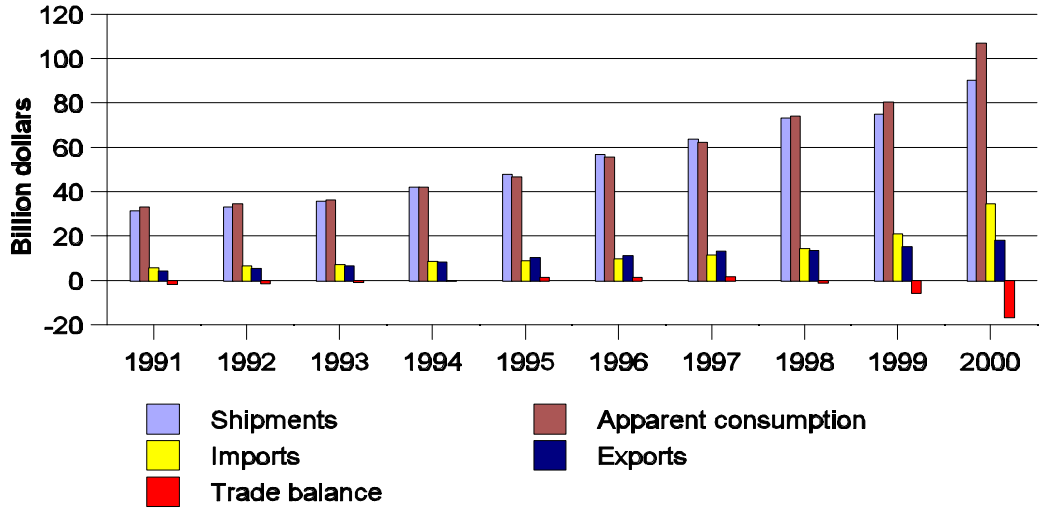
[44] (...continued)
ch. in *International Trade in Telecommunications* (Washington, DC: The AEI Press, 1998), pp. 107-127; Japanese External Trade Organization, "Communications Equipment," *Japanese Market Report 1998*, App.1, figs. 1-3, p. 1, found at Internet address *www.jetro.go.jp;* and official statistics of the U.S. Department of Commerce and European Union.

[45] The higher end segments of the market included fiber optic transmission, network switching, and cellular infrastructure equipment.

[46] Telecommunications Industry Association (TIA), *2001 MultiMedia Telecommunications Market Review and Forecast* (Washington, DC: TIA, 2001), pp. 3-15; National Research Council, *The Internet's Coming of Age* (Washington, DC: 2001), pp. 5, 53-55, and 108-112; Barbara M. Schmitz, "Sustaining the Internet Revolution," *Computer-Aided Engineering*, vol. 12, Dec. 2000, p. 14; and James B. Murray, *Wireless Nation: The Frenzied Launch of the Cellular Revolution in the United States* (Cambridge, MA: Perseus, Aug. 2001), pp. 1-50.

Figure 4
Telecommunications equipment: Selected U.S. economic data, 1991- 2000



Source: Official statistics of the U.S. Department of Commerce.

Canada was the second leading source of U.S. imports in 1991, it accounted for less than one half of the total for Japan.[47] As the period progressed, the need for greater data-carrying capacity (bandwidth) associated with rising Internet usage and new services prompted domestic telecommunications service carriers to increase spending on new advanced technologies[48] leading to increased purchases of equipment from both domestic and foreign manufacturers. Cable television companies and other service providers seeking to expand bandwidth also attracted more U.S. imports of advanced digital equipment. U.S. producers and producers from Canada, the EU, and Japan were responsible for supplying the largest amounts of the more sophisticated network wireline equipment in the first several years of the period. However, much of the growth during the latter part of the period is attributed to movement of more production of low-margin products to low-wage countries and dramatic growth in the U.S. wireless market, much of which was supplied by foreign producers in Sweden, Finland, Mexico, and emerging Asian countries. As a result of this increased demand for foreign-made and assembled equipment, U.S. import to consumption ratios rose each year during the period from 17 percent in 1991 to 32 percent in 2000.

[47] Other less advanced Asian countries and Mexico were also beginning to increase their supply of U.S. imports of telecommunications equipment, especially lower end equipment such as traditional telephones; and later facsimile machines, and cordless and cellular telephones as well.

[48] The factors driving growth in data communications included the increase in Internet Protocol (IP) traffic over the Internet and the increased amounts of data being transported between businesses. Mark Cavalollone, "Communications Equipment," *Standard and Poor's Industry Survey*, Dec. 31, 1998, pp. 1-10, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 28, 2001.

Table 5
Telecommunications equipment: U.S. imports for consumption, by principal source, 1991 and 2000
(in thousand dollars)

Country	1991	Country	2000
Japan	1,845,190	Canada	9,065,413
Canada	694,421	Mexico	5,863,411
Malaysia	506,944	Japan	3,646,647
China	487,895	China	3,312,227
Singapore	280,556	Korea	3,182,509
Taiwan	273,796	Malaysia	2,019,047
Korea	271,263	Taiwan	1,891,293
Thailand	225,416	United Kingdom	914,119
Sweden	181,298	Israel	889,332
Hong Kong	176,646	Sweden	663,644
Israel	127,690	Thailand	487,402
Mexico	124,785	France	379,414
France	105,170	Germany	379,030
United Kingdom	101,471	Brazil	342,667
Philippines	93,678	Singapore	336,729
All other	250,709	All other	1,095,508
Total	5,746,928	Total	34,468,392
EU15	554,461	EU15	2,858,934

Source: Compiled from official statistics of the U.S. Department of Commerce.

Mirroring trade trends in EU and Japanese markets, U.S. imports increased slowly in the years just preceding the 1991-2000 period, as embedded technology and compatibility concerns may have constrained demand by U.S. telecommunications service firms for equipment from nontraditional suppliers. Most traditional telecommunications network and terminal equipment[49] continued to be supplied by major domestic producers such as AT&T[50] and Nortel Networks (Nortel),[51] whose growing presence in the U.S. market since its entry in 1971 had positioned it well to take advantage of new opportunities created by the 1984 breakup of AT&T's Bell System.[52] In that breakup, AT&T's local telephone service operating units

[49] This traditional equipment included such goods as central office switching, transmission, and even some terminal equipment.

[50] AT&T Technologies, the manufacturing arm of AT&T, would be divested by AT&T in 1996 into a separate company named Lucent Technologies (Lucent).

[51] Nortel's corporate headquarters are in Brampton, Ontario, Canada. During the decade, Nortel expanded its presence as a manufacturer in the United States and currently has approximately 25,000 U.S. employees engaged in manufacturing and R&D operations. On May 1, 2000, Bell Canada Enterprises (BCE), which had been the Canadian-owned parent of Nortel, divested the majority of its Nortel holdings and company officials state that since October 2000, Nortel has been majority owned by U.S. shareholders. SEC filings by Nortel, and telephone and email communications with U.S. industry representatives by USITC staff, Jan. 2002.

[52] For more information on the breakup of Bell System, please see Robert W. Crandall, *After the Breakup: U.S. Telecommunications in a More Competitive Era* (Washington, DC: Brookings Institution, 1991); and Michael P. Ryan, *Knowledge Diplomacy* (Washington, DC: Brookings Institution Press), p. 194.

were divested into independent Regional Bell Operating Companies (RBOCs),[53] effectively eliminating the long-term captive supply arrangement between AT&T's manufacturing equipment division and its local telephone service operating units.[54] Although this provided potential new opportunities for other U.S. and foreign-headquartered equipment manufacturers, it took several years for the newly divested RBOCs and manufacturers to adjust to the changed U.S. market situation. However, by the early 1990s, U.S. and foreign competitors, especially from Canada, the EU, and Japan, had increased their penetration of the U.S. market for higher end network transmission and switching equipment, a market previously dominated by AT&T.[55] Although AT&T's manufacturing division continued to be the primary supplier of equipment to AT&T Communications,[56] still the dominant long distance service provider in the United States, foreign suppliers to local and regional telephone companies were able to increase their shipments of network infrastructure equipment to emerging long distance competitors such as MCI and U.S. Sprint.[57]

As the decade progressed, expanded U.S. demand for telecommunications equipment and strong marketing efforts by foreign firms largely accounted for the accelerated growth in U.S. imports. Increasing challenges to AT&T's manufacturing division by domestic and foreign producers led to fierce competition with respect to both pricing and technology offerings to maintain or gain market share. In addition, in order to concentrate on development and production of higher end network and transmission equipment, traditional U.S. and foreign-based competitors increasingly moved production of lower cost items such as telephone sets and labor-intensive assembly to a number of Asian countries with low production costs and advanced manufacturing skills. For example, as previously indicated, Japan started relocating low-end production of terminal equipment to Asian countries, such as Singapore, Taiwan, Malaysia, Thailand, and China, which increased the shares of these latter countries of U.S. imports of facsimile machines and telephones.[58] The steady appreciation of the Japanese yen during 1989-95 contributed to this shift in production.

Mexico also became an increasingly important supplier of telecommunications equipment as its maquiladora program prompted U.S. producers to relocate the manufacture and assembly of labor-intensive products. Such assembly was facilitated by U.S. tariff provisions under Harmonized Tariff Schedule of the United States (HTS) subheading 9802.00.80, which provided duty preferences on imported

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[53] RBOCs are also sometimes referred to as Regional Holding Companies (RHCs), a more accurate but less commonly used description of the regional and local telephone service operations divested by AT&T.

[54] Harry M. Shooshan III, "The Bell Breakup," ch. in *Disconnecting Bell: The Impact of the AT&T Divestiture* (New York: Pergamon Press, 1984), pp. 8-22.

[55] The agreement by AT&T and the U.S. Department of Justice (often referred to as the Modified Final Judgment) to break up the Bell System monopoly allowed AT&T to continue to provide long-distance telecommunications services and manufacture telecommunications equipment, including equipment for its own long distance network. However, even though AT&T was allowed to continue to compete for equipment sales to the newly independent RBOCs, with the loss of captive control over those companies, it faced intense competition from major foreign-based firms. For more information on the AT&T breakup and its implications for telecommunications service and equipment markets, see Harry M. Shooshan III, *Disconnecting Bell: The Impact of the AT&T Divestiture* (New York: Pergamon Press, 1984), chs. 2, 3, and 4, pp. 8- 82.

[56] AT&T's long distance service division, AT&T Long Lines, was renamed AT&T Communications in 1986.

[57] These long-distance service providers had increased their presence in the U.S. market during the late 1970s and 1980s as the result of some important decisions by the U.S. Federal Communications Commission (FCC), permitting increased competition with AT&T, the traditional monopoly supplier of telecommunications services (as well as equipment) in the U.S. market.

[58] Despite the rapidly increasing share of U.S. telecommunications equipment imports held by Malaysia, Thailand, and China, the largest suppliers of U.S. imports in the mid-1990s, were Japan, Singapore, Taiwan, and Korea, together accounting for well over half of total U.S. imports in 1996.

products from Mexico containing U.S. components. The 1994-95 peso crisis in Mexico, which devalued that currency relative to the U.S. dollar, accelerated this trend of increased imports. The Mexican peso devaluation also coincided with the appreciation of the Japanese yen and directly resulted in an increase in U.S. imports from Mexico at the expense of Japan in lower end terminal equipment.

Although U.S. duty rates for telecommunications equipment at the beginning of the period were higher than the average U.S. tariffs on other IT products, a series of agreements including, but not limited to, the U.S.-Canada Free Trade Agreement, NAFTA, the WTO's Uruguay Round Agreements, and the Information Technology Agreement led to a steady reduction in, and final elimination of, U.S. customs duties for telecommunications equipment during the 1991-2000 period. Many analysts believe that the combined tariff reductions had some influence on the expansion of U.S. consumption and imports.[59] However, general growth in demand and continuing efforts to foster competition in the U.S. telecommunication services market were likely of greater importance.

Two examples of telecommunications deregulation efforts after the AT&T breakup were the 1996 Telecommunications Act[60] of the United States and the 1997 WTO Agreement on Basic Telecommunications[61] between the United States and other WTO trading partners to open their telecommunications markets to increased international competition.[62] These promoted more competition in the U.S. telecommunication services market, permitted thousands of new service providers to challenge the entrenched incumbent carriers,[63] and allowed local telephone companies, long distance carriers, and cable television operators to enter one another's markets under specified conditions.[64] These new entrants to the services market, in turn, added to the customer base for both U.S. and foreign-made telecommunications equipment producers (table 6).

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[59] Although the combined effects of these various agreements likely had some influence on increased U.S. imports during the 1991-2000 period, it is unlikely that any one agreement had particularly significant effects. For instance, NAFTA, which took effect on January 1, 1994, had a negligible effect on the almost $400 million increase in U.S. imports of telecommunications equipment from Mexico from 1993 to 1996. The average trade weighted duty for communications equipment imported from both Mexico and Canada decreased by less than 1 percentage point during 1993-96. The rise instead was primarily attributed to the sharp devaluation of the peso in 1995, a decrease in Japanese exports of such equipment to the United States, and rising demand for communications equipment in the United States, including demand for U.S. imports from Mexico that entered under HTS subheading 9802.00.80. For further information, see USITC inv. No. 332-381, *The Impact of the North American Free Trade Agreement on the U.S. Economy and Industries: A Three-Year Review*, pub. 3045, June 1997, pp. 6-183 to 6-185.

[60] P.L. 104-104, 110 Stat. 56 (Feb. 8, 1996).

[61] For a more detailed examination of this agreement, see "Examination of WTO Agreement on Basic Telecommunications," ch. in USITC, inv. No. 332-345, *Recent Trends in U.S. Services Trade: 1998 Annual Report*, pub. 3105, pp. 4-1 to 4-98.

[62] Telecommunications Industry Association (TIA), *2002 MultiMedia Telecommunications Market Review and Forecast* (Washington, DC: TIA, 2001), pp. 3-15.

[63] New U.S. entrants in local telephone services were known as competitive local exchange carriers (CLECs). According to some industry observers, CLECs and other local phone companies accounted for much of the growth in telecommunications services and became important consumers of telecommunications equipment. Ron Insana, "Can He Save Lucent," *Money*, Oct. 2001, p. 67.

[64] Ari Bensinger, "Communications Equipment," *Standard and Poor's Industry Survey*, Aug. 2, 2001, pp. 1-7, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 8, 2001.

Table 6
Telecommunications equipment: Selected producers supplying the U.S. market in 1997-98, by headquarter country and major products

Headquarter country	Company Name	Products
United States	Lucent	Wireline, wireless network and terminal equipment
	Motorola	Wireless network and terminal equipment
	Cisco	Networking equipment
	3COM	Networking equipment
Canada	Nortel Networks	Wireline, wireless network and terminal equipment
France	Alcatel	Wireline, wireless network and terminal equipment
Germany	Siemens	Wireline, wireless network and terminal equipment
Sweden	Ericsson	Wireline, wireless network and terminal equipment
Finland	Nokia	Wireless network and terminal equipment
Netherlands	Philips	Terminal equipment
United Kingdom	GPT	Wireline, wireless network and terminal equipment
Japan	NEC	Wirleine, wireless network and terminal equipment
	Fujitsu	Wireline terminal and transmission systems, wireless infrastructure and terminal equipment
	Toshiba	Wireline, network and terminal equipment
	Hitachi	Wireline network and terminal equipment
	Matsushita	Cellular telephones, telephone sets and systems, some network equipment
	Oki Electric	Wireless and wireline network and terminal equipment, including facsimile machines (largely facsimile in U.S.)
	Ricoh	Facsimile machines
Korea	Samsung Electronics	Wireless and wireline network and terminal equipment, including wireless telephones
	Daewoo Telecom	Wireline switching and transmission equipment

Sources: Reed Research, Northern Business Information, Korea Ministry of Information and Communication, company annual reports, and other sources.

The U.S. regulatory body for the telecommunications industry, the Federal Communications Commission (FCC), further promoted competition and network expansion with the subsequent opening of U.S. wireless duopolies[65] to as many as seven new competitors in each of their markets. This led to increased purchases of infrastructure and terminal equipment for such mobile services as cellular and personal communications systems (PCS).[66] Motorola, the U.S.-headquartered global pioneer in mobile communications; Lucent Technologies, the successor company to AT&T Technologies; and Nortel were all able to take advantage of this trend. In addition, EU-headquartered companies like Ericsson and Nokia, whose home countries of Sweden and Finland, respectively, were among the first in the world to establish comprehensive mobile networks, gained from their experiences at home to become strong competitors to U.S. and other foreign companies in the U.S. market. These developments resulted in increased U.S.

[65] A duopoly is a market dominated by two companies. Most local or regional cellular markets in the United States had been limited to two cellular providers until 1996.

[66] Ari Bensinger, "Communications Equipment," *Standard and Poor's Industry Survey*, Aug. 2, 2001, pp. 1-7, found at Internet address *http://www.netadvantage.standardandpoors.com,* retrieved Aug. 8, 2001.

imports of mobile infrastructure equipment and cellular telephones.[67] Korea, led by Samsung Electronics,[68] also became a major source of U.S. imports of both cellular infrastructure and terminal equipment. However, in the final years of the decade, cellular phones were increasingly manufactured in Mexico and emerging Asian countries.[69] These countries, which had become important suppliers of U.S. imports of corded and cordless telephones, began to increase production of the least costly, simplest cellular telephone handsets while Nortel, Nokia, and Ericsson concentrated their efforts on mobile infrastructure equipment and high-end terminal equipment such as multimedia PCS telephones containing web browsing software and e-mail capabilities. By 1999, U.S. imports of cellular telephones, driven by the expanding U.S. cellular market and the rapid increase in mobile telephone subscribership in the United States, replaced cordless telephone sets as the leading U.S. import of telecommunications equipment.[70]

Exports

U.S. exports of telecommunications equipment increased by an average annual rate of 18 percent during 1991-2000. Exports grew every year of the period, although they rose negligibly during 1997-98, when U.S. sales to Asian countries decreased significantly as a result of the 1997-98 Asian financial crisis. Exports as a share of U.S. shipments increased each year from 13 percent in 1991 to 22 percent in 1995, before declining slightly to 20 percent in 2000. During the period, U.S. producers benefitted from competitive advantages in the production of high technology equipment, such as networking, routing, and other data communications equipment[71] used to build up the Internet and other networks used by businesses and consumers. The United States was also regarded as the world leader in advanced fiber optic transmission equipment and higher end terminal equipment such as voice processing systems. The U.S. competitive advantage in these areas stemmed from technological developments in related information technology sectors in which the United States excelled, such as microprocessors, software, and computers, which were incorporated into digital network telecommunications equipment. Finally, U.S. exporters also profited from the continued liberalization of the formerly closed EU and Japanese telecommunications service markets throughout the period and significant efforts and expenditures by a number of emerging Asian countries to rapidly establish advanced telecommunications infrastructures. Such initiatives required imports of high-technology network and transmission equipment from U.S.-based companies specializing in that segment.

U.S. exports of telecommunications equipment to the EU increased rapidly during 1991-1995 as privatization and deregulation efforts opened EU services markets, leading to increased procurement of foreign-made equipment.[72] For instance, U.S. exports of telecommunications equipment to the United

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[67] However, previously important EU-headquartered suppliers of traditional wireline network and transmission equipment, Siemens and Alcatel, lost some of their competitiveness as telecommunications equipment suppliers due to their lack of expertise in the rapidly emerging mobile communications market.

[68] Nokia and Motorola also manufacture or contract out manufacture of cellular handsets in Korea. Korean Ministry of Information and Communications officials, interview by USITC staff, Apr. 26, 2001.

[69] For instance, Ericsson handed the task of manufacturing its ordinary cellular handsets to Flextronics in Singapore while concentrating its cellular efforts on the manufacture of more sophisticated handsets. Stephen Baker and Andy Reinhardt, "Can Nokia Keep Outrunning the Pack?" *Business Week*, Sept. 24, 2001, p. 114.

[70] Dennis H. Leibowitz and others, *The Wireless Communications Industry* (New York: Donaldson, Lufkin, and Jenrette Securities Corp., Winter 1999/2000), pp. 56-57.

[71] Other high technology equipment manufactured by U.S. companies included digital switching and cellular communications equipment.

[72] Even before the 1997 agreement among WTO members to open their telecommunications markets to international competition, formerly government-owned telecommunication services operators in the EU and Japan, (continued...)

Kingdom, Germany, the Netherlands, and France more than doubled from $671 million in 1991 to $1.6 billion in 1995 (table 7). U.S. exporters took advantage of efforts by EU countries to update older telecommunications systems with advanced digital fiber-optic systems, an area of expertise for U.S. producers. However, with the exception of several countries, overall U.S. exports to the EU declined in 1996, partly due to a general economic downturn in the EU. Some U.S. industry officials suggested that efforts of EU government officials to promote the Global System for Mobile Communications (GSM) standard adopted by the EU, rather than either of the two prevailing U.S. standards at that time, also negatively affected sales of U.S. wireless equipment in that year.[73] Due to a steady increase in the relative value of the yen compared to the U.S. dollar, U.S. exports of telecommunications equipment to Japan increased rapidly from 1991-95, but slowed somewhat in 1996, as the dollar regained value against the yen, making U.S.-equipment more expensive in Japan. U.S. exports to Japan also rose significantly during the first part of the decade as the result of a contract signed in early 1993 between Nortel and the primary Japanese telecommunications service provider, Nippon Telegraph and Telephone (NTT), in which Nortel agreed to supply NTT with digital switches from a plant in North Carolina. Finally, sales of cellular switches by other U.S. producers, such as Lucent and Motorola, also contributed to the increase in exports to Japan.[74]

Production sharing relationships between U.S. and Mexican firms over the past decade made Mexico an important destination for U.S. exports of telecommunications equipment components and parts to be assembled into finished equipment for export back to the United States. Further, as the decade progressed, Mexico increasingly became an important market in its own right for the more sophisticated telecommunications equipment manufactured in the United States. U.S. sector exports to Mexico rose consistently through the period, from almost $323 million in 1991 to $2.9 billion by 2000, dropping significantly only in 1995 due to the peso crisis, which increased the price of U.S.-made equipment in the Mexican market.[75] U.S. exports to Canada rose consistently throughout the period, including exports of telecommunications equipment and subassemblies produced by Nortel in its U.S. manufacturing facilities.

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[72] (...continued)
which had long favored procurement from traditional national suppliers, were either in the process of privatization, or in the case of the United Kingdom, had completed privatization. In connection with the privatization, major EU countries, including Germany and France, began allowing gradual entry of new competitors with the national services suppliers. This resulted in new customers for equipment and also increased pressures on the once-dominant national carriers to upgrade their telecommunications networks with the latest technology. This advantaged North American manufacturers such as AT&T's equipment division (later divested and renamed Lucent) and Nortel, which were able to profit from their expertise in advanced digital and fiber optic network technology. For more information, see chs. 2 and 5, USITC, inv. No. 332-301, *Global Competitiveness of U.S. Advanced Technology Manufacturing Industries: Communications Technology and Equipment*, pub. 2439, Oct. 1991, p. 4-71; and USITC, *Telecommunications Equipment: U.S. Performance in Selected Major Markets*, Staff Research Study 24, pub. 3150, Dec. 1998, pp. 3-11 to 3-13.

[73] For further information, see USITC, inv. No. 332-380, *Advice Concerning the Proposed Modification of Duties on Certain Information Technology Products and Distilled Spirits*, pub. 3031, Apr. 1997, pp. 4-6 and 4-7.

[74] For further information on expanding U.S. exports to Japan, see USITC, inv. No. 332-345, *U.S. Trade Shifts in Selected Industries*, 1993 Annual Report, pub. 2805, p. 140.

[75] U.S. exports of telecommunications equipment also declined negligibly during 1998-99, primarily reflecting assignment of more manufacturing responsibilities by a U.S. firm to its Mexican production sharing partner. However, U.S. exports to Mexico picked up significantly again in 2000, increasing by 22-percent from the previous year, as the Mexican market increasingly became an important final market in its own right for U.S.-made telecommunications equipment, in addition to remaining an important partner in U.S.-Mexican production sharing trade.

Table 7
Telecommunications equipment: U.S. domestic exports, by principal market, 1991 and 2000
(in thousand dollars)

Country	1991	Country	2000
Canada	635,593	Canada	2,784,650
Japan	501,263	Mexico	1,942,456
Mexico	322,938	Japan	1,863,035
United Kingdom	288,887	United Kingdom	1,091,368
Taiwan	190,696	Korea	1,016,665
Korea	187,658	Netherlands	906,399
Italy	187,590	Germany	689,172
Germany	183,556	Brazil	674,722
Netherlands	105,015	China	581,025
Hong Kong	99,082	Ireland	437,522
France	92,558	Taiwan	423,315
China	75,716	Australia	410,326
Spain	67,560	Argentina	399,381
Saudi Arabia	67,194	Hong Kong	359,167
Singapore	61,969	France	339,543
All Other	1,077,313	All Other	4,104,272
Total	4,144,589	Total	18,023,018
EU15	1,118,757	EU15	4,582,003

Source: Compiled from official statistics of the U.S. Department of Commerce.

In 1993, U.S. exports to Asia began to grow significantly to Korea, Taiwan, Hong Kong, Singapore, Thailand, Malaysia, and especially China, as all of these countries engaged in efforts to improve telecommunications infrastructure and increase main telephone line penetration ratios to reach more people.[76] For example, China began implementing an ambitious program to expand its networks with the goal of reaching 100 million telephone lines by the year 2000, and Korea opened its telecommunication equipment procurement to foreign competition in 1993, allowing AT&T to provide almost 20 percent of the equipment Korea procured in that year.[77] Further growth in U.S. exports to Asian markets continued unabated throughout the period, except for a short downturn in 1998 as a result of the Asian financial crisis.[78]

U.S. exports to South America expanded for similar reasons, as countries in that region began modernizing their communications infrastructures with a significant amount of U.S. equipment. For example, Brazil, which has the largest telecommunications market in Latin America, received almost

[76] For further information on expanding U.S. exports to Asia, see USITC, *U.S. Trade Shifts in Selected Industries*; *1993 Annual Report*, inv. No. 332-345, pub. 2805, pp. 139-140.

[77] See USITC, inv. No. 332-345, *U.S. Trade Shifts in Selected Industries: 1993 Annual Report*, pub. 2805, Sept. 1994, p. 140.

[78] Countries most affected by the Asian financial crisis included Indonesia, Korea, Malaysia, the Philippines, and Thailand.

30 percent of its telecommunications equipment imports from the United States.[79] U.S. telecommunications equipment manufacturers especially benefitted from Brazilian government reforms that encouraged major foreign and domestic investment in the telecommunication services sector which led to increased purchases of U.S.- and other foreign-made telecommunications equipment.[80]

As the decade progressed, pioneer companies in the development and manufacture of Internet routing, switching, and other data communications equipment, including Cisco, 3Com, U.S. Robotics, and Bay Networks, as well as key developers of mobile communications technology, such as Motorola, joined Lucent and Nortel as major U.S. exporters of telecommunications equipment.[81] The increased demand for data communications products was due to continued rapid growth and popularity of data-intensive applications, such as Internet access, real-time data backup, electronic mail, video conferencing, multimedia file transfers, movement of large blocks of stored data, and digital cable television systems.[82]

Balance of Trade

The U.S. trade balance for telecommunications equipment began as a deficit during the early part of the 1991-2000 period. However, the deficit gradually declined each year until 1995, when the U.S. trade balance improved to a U.S. surplus of $1.3 billion, with the surplus peaking at $1.6 billion in 1997. The deficit declined in the early part of the period due to increased opportunities for sales of U.S.-made equipment in more liberalized EU and Japanese markets and in developing Asian and Latin American economies that had embarked on major programs to improve their telecommunications infrastructures.

The U.S. trade balance began a downward trend into deficit again beginning in 1998, reaching $6.4 billion by 2000. The Asian financial crisis that led to increased U.S. imports and declining exports to that part of the world in 1998, also accelerated the decade-long movement of terminal equipment production to Asia. Another major factor contributing to the rise in the U.S. deficit during the latter part of the period was the significant rise in domestic demand for cellular telephones, which spurred U.S. imports from Mexico and Asia. As a result of these trends, US. imports more than doubled from 1998-2000, while U.S. exports increased by just 32 percent.

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[79] The increased U.S. exports to these countries and other developing countries establishing new telecommunications networks consisted primarily of repeaters and central office switches, which are basic requirements for telecommunications networks. Other products exported by U.S. companies were parts for central office switches and other telephone apparatus, including PBXs, internal switching systems used in office telephone systems. In recent years, wireless equipment has become a more significant portion of U.S. exports to these markets.

[80] For more information on these reforms and growth of the Brazilian telecommunications equipment market, see USITC, *Telecommunications Equipment: U.S. Performance in Selected Major Markets*, Staff Research Study 24, pub. 3150, Dec. 1998, p. 2-7; and USDOC, International Trade Administration, National Trade Data Bank, "Brazil: Leading Sectors for U.S. Exports and Investments," *Stat-USA Database*, found at Internet address *http://www.stat-usa.gov*, retrieved Sept. 26, 2001.

[81] During 1993-97, the combined revenues for Cisco, 3Com, and Bay Networks grew from $3 billion to $11 billion, and increased at an average annual rate of 50 percent through the end of the decade. Bay Networks was acquired by Nortel in August 1998 (Lucent had previously acquired a data communications equipment supplier, Octel, in 1996). USITC, *Telecommunications Equipment: U.S. Performance in Selected Major Markets*, Staff Research Study 24, pub. 3150, Dec. 1998, pp. 2-5 to 2-6; "The Electronic Business Top 200," *Electronic Business*, July 1998, July 1999, July 2000, and July 2001; and U.S. investment analyst, telephone interview by USITC staff, Sept. 20, 2001.

[82] U.S. government and industry representatives, telephone interviews by USITC staff, Mar. 15-23, 2001.

During the 1991-2000 period, Canada replaced Japan as the country with which the United States had the largest trade deficit in telecommunications equipment. In 1991, the U.S. trade deficit with Japan was over $1 billion, while the United States experienced a negligible deficit with Canada. However, by 2000, the U.S. deficit with Canada had reached over $6 billion, while the U.S. deficit with Japan had declined to less than $50 million. These changes were largely due to the rising presence as important players in the U.S. market of Nortel, JDS Uniphase, and a number of smaller optical networking, component and equipment firms with manufacturing operations in both the United States and Canada. In addition, while Japan was still a significant supplier of U.S. imports of higher end switching and fiber optics transmission equipment, a large portion of its production of facsimile machines, telephones, and other low-end terminal equipment had shifted to Taiwan, Malaysia, China, and other low-cost Asian countries as the period progressed. Another major shift occurred in the U.S. trade balance with Mexico, which changed from a modest U.S. surplus in 1991 to an almost $4 billion deficit in 2000. This shift resulted to a large extent from steadily increasing production-sharing between the two countries throughout the period as U.S. firms outsourced labor-intensive manufacturing activities to Mexico while retaining more advanced manufacturing operations in the United States in efforts to improve their international competitiveness by lowering production costs. In South America, increased expenditures by the Brazilian government on telecommunications enabled the United States to achieve a modest surplus with that country by 2000.

Throughout the period, the United States maintained significant surpluses in trade with the EU. The U.S. surplus with Germany more than tripled as that country modernized telecommunications services in its previously communist eastern states.[83] The United States also maintained trade surpluses with most of the other EU countries, including such important markets as the United Kingdom and France. However, one major exception was Sweden, whose surplus in telecommunications equipment trade with the United States continued to grow rapidly throughout the period, largely due to Ericsson's success in serving the growing U.S. market for wireless equipment.

Shipments

Despite rapidly growing U.S. imports, culminating in the U.S. industry's largest trade deficit ever in 2000, U.S. shipments increased every year, almost tripling during the period to over $90 billion (figure 4). Such growth represented an average annual rate of increase of over 12 percent during 1991-2000, with a rise in shipments of almost 21 percent during the last year of the period. Employment in the industry declined moderately every year during 1991-94, as U.S. companies were able to increase manufacturing efficiencies in the production of high technology equipment, while discontinuing much of the production of commodity equipment.[84] However, U.S. employment turned upward in 1995 and, except for declines in

[83] As a result of intensive capital expenditures by Germany on telecommunications since reunification, "the formerly backward system of the eastern part of the country has been modernized and integrated with the western part," Central Intelligence Agency, "Germany", *World Factbook 2001*, p. 8, found at Internet address *http://www.cia.gov*, retrieved Oct. 14, 2001.

[84] See USITC invs. No. 332-345, *U.S. Trade Shifts in Selected Commodity Areas: 1992 Annual Report*, pub. 2677, table B-6, Sept. 1993, p. 210; *U.S. Trade Shifts in Selected Industries: 1993 Annual Report*, pub. 2805, table B-5, Sept. 1994, p. 229; *U.S. Shifts in U.S. Merchandise Trade in 1996*, pub. 305, table B-9, Sept. 1997, p. B-54; *Shifts in U.S. Merchandise Trade in 1998*, pub. 3220, table B-9, Sept. 1999, p. 56; and *Shifts in U.S. Merchandise Trade in 2000*, table C-9, July 2001, p. C-47.

1998 and 1999, continued to rise throughout the rest of the period due to substantial demand in U.S. and overseas markets for U.S. telecommunications technology.[85]

The rapid acceleration in domestic demand for digital, data, and mobile communications equipment, areas in which U.S. companies excel, influenced the increases in U.S. shipments of telecommunications equipment.[86] To a somewhat lesser but still significant extent, the steady increase in U.S. shipments during the period also resulted from increased demand in foreign markets for U.S.-made equipment, as U.S. exports more than quadrupled during the period. In addition, some industry experts assert that completion of tariff-reduction agreements, such as the ITA, also influenced sales of U.S. equipment in certain overseas markets.[87] The growing importance of U.S. exports to U.S. manufacturers of telecommunications equipment is reflected by the increase in the ratio of exports to shipments from 13 percent in 1991 to 20 percent in 2000.

As was the case with increased U.S. imports and exports, increasing deregulation of U.S. and foreign telecommunications service markets and the advanced technological capabilities of U.S. companies, particularly in digital switching, transmission, and Internet routing equipment, contributed to the consistent growth in U.S. shipments during the period.[88] Lucent's technological developments in its world-renowned Bell Laboratories and innovations by relative newcomers to the telecommunications equipment industry, such as Cisco and 3Com in data communications, enabled those companies to prosper during the period.

Despite intense competition from Scandinavian producers like Ericsson and Nokia in mobile communications, Motorola's pioneering role in mobile and cellular telecommunications technology also contributed to increased U.S. shipments of telecommunications equipment. Mobile communications, which were influenced by steadily declining prices, advanced services, and rapidly increasing coverage, grew at an increasing rate during the final years of the period,[89] as the number of wireless subscribers in the United States more than tripled to over 50 million during 1993-97,[90] then doubled to 100 million by 2000.[91] Such

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[85] Employment fell slightly in 1998, as the Asia financial crisis led to reduced U.S. exports in that year, and again in 1999, before firms had an opportunity to expand capacity again in 2000 to meet rapidly expanding U.S. and foreign demand for telecommunications equipment. See USITC invs. No. 332-345, *Shifts in U.S. Merchandise Trade in 1996*, pub. 305, table B-9, Sept. 1993, p. B-54; *Shifts in U.S. Merchandise Trade in 1998*, pub. 3220, table B-9, Sept. 1999, p. 56; and *Shifts in U.S. Merchandise Trade in 2000*, table C-9, July 2991, p. C-47.

[86] Mark Cavalollone, "Communications Equipment," *Standard and Poor's Industry Survey*, Dec. 31, 1998, pp. 1-10, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 28, 2001.

[87] Pradip Bhatnager, "Telecom Reforms in Developing Countries and Outlook for Electronic Commerce," *Journal of Economic Law*, (1999), pp. 695-717; and U.S. industry official, written communication to USITC staff, Jan. 2002.

[88] According to one information technology industry expert, "From a producer's standpoint, deregulation has bolstered the US comparative advantage in the telecommunications industry." John Sullivan Wilson, "Telecommunications Liberalization: The Goods and Services Connection," *Unfinished Business: Telecommunications after the Uruguay Round*, Gary Clyde Hufbauer and Erika Wada, eds. (Washington, D.C.: Institute for International Economics, Dec. 1997), p. 65.

[89] Donaldson, Lufkin & Jenrette, *The Global Wireless Communications Industry* (New York: 2000), pp. 4- 7.

[90] Multimedia Telecommunications Association (MMTA), *1998 Multimedia Telecommunications Market Review and Forecast* (Arlington, VA: MMTA, 1998), p. 64; and MMTA, 1997, *MultiMedia Telecommunications Market Review and Forecast*, p. 39. For further information on growth in the cellular market see USITC,

(continued...)

growth in usage drove accelerating demand for cellular and PCS equipment. U.S. manufacturers benefitted from their competitive strengths in those technologies to take advantage of the increased demand for that equipment.

Semiconductors[92]

Overview

The United States and Japan were the world's leading semiconductor manufacturers throughout 1991-2000.[93] As the decade progressed, the United States largely maintained its position while Japan's weakened and the EU, Korea, and others rose in importance. Generally, U.S. companies were leaders in the production of certain technology- and design-intensive semiconductors such as microprocessors, digital signal processors, and specialty logic devices.[94] The EU industry, though much smaller than its U.S. counterpart, was also generally strongest in non-commodity products. In contrast, Japanese companies were strongest in the production of commodity memory products such as dynamic random access semiconductors (DRAMs) and static random access memory semiconductors (SRAMs) as well as less design-intensive logic semiconductors.[95] Korea emerged during the period as a leading manufacturer of commodity memory products, competing with and taking substantial global market share from its Japanese competitors.

During 1991-2000, the U.S. semiconductor industry experienced extraordinary growth accompanied by significant changes in its patterns of trade. A number of factors affected U.S. trade and production during the period including the tremendous growth in worldwide demand for semiconductors, the continuing use of production-sharing operations by U.S. semiconductor producers, the globalization of electronics production, pricing, external economic shocks, and duty-reduction agreements. The extraordinary growth in U.S. and global demand for semiconductors was the single most important factor affecting trade and shipments. During the period, U.S. consumption more than tripled while global demand

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[90] (...continued)
Telecommunications Equipment: U.S. Performance in Selected Major Markets, Staff Research Study 24, pub. 3150, Dec. 1998, p. 2-12.

[91] Philip D. Wohl, "Telecommunications: Wireless," *Standard and Poor's Industry Survey*, Dec. 28, 2000, p. 1, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Sept. 21, 2001.

[92] For the purposes of this paper, semiconductors include integrated circuits as well as discrete devices. Integrated circuits include analog products, mixed signal devices (analog and digital), and digital items such as microprocessors, logic, and memory. Discrete semiconductors include items such as transistors, diodes, and thyristors. Semiconductors are covered under HS 8541and 8542, NAICS 334413, and SIC 3674.

[93] Elsevier Advanced Technology, *Yearbook of World Electronics Data* (Oxford, UK: Elsevier Science, Ltd., various editions), and Reed Electronics Research, *The Yearbook of Electronic Data* (UK: Reed Business Information, Ltd., various editions).

[94] David C. Mowery and Richard R. Nelson (Eds.) *Sources of Industrial Leadership: Studies of Seven Industries*, Chapter 2, "Semiconductors," by Richard Langlois and Edward Steinmuller (New York: Cambridge University Press, 1998). A noteable exception is Micron Technology, a U.S.-headquartered company that is among the global leaders in production of commodity memory semiconductors. However, on the whole, the United States is a large net importer of these items.

[95] USITC, *Industry & Trade Summary: Semiconductors*, pub. 2708, Dec. 1993, pp. 10-14. During the decade, many Japanese semiconductor firms made efforts to shift the concentration of their product offerings from memory to logic and microcomponents.

rose nearly four-fold.[96] Demand for semiconductors is primarily driven by demand for the products into which they are incorporated. The principal consumers of semiconductors were the industries that manufactured electronic equipment such as computers, telecommunications and data networking equipment, and consumer electronics, as well as automobiles and industrial machinery. As noted earlier in this paper, these industries experienced an explosion of growth and product innovation during the decade including the development of the affordable PC, the Internet, data communications, and wireless telecommunications. In addition to the growth in electronic equipment production, electronic equipment also became increasingly semiconductor intensive (a rising percentage of production/input costs were accounted for by semiconductors), further fueling demand for semiconductors.[97]

During the period, U.S. semiconductor producers continued to rely heavily on production-sharing partners, and, as a result, trade with these partners accounted for a large portion of overall U.S. semiconductor trade. Essentially, semiconductor production-sharing occurred when unfinished semiconductors fabricated in the United States were sent abroad, primarily to locations in East Asia, for the finishing stages of assembly and testing. After finishing, the semiconductors were usually re-exported to the United States or a third-country market for consumption.[98] U.S. companies established production-sharing facilities abroad largely to take advantage of lower labor costs in the partner countries during the relatively more labor-intensive assembly stage of production.[99] Because most U.S. companies make use of these arrangements, roughly one-half of U.S. exports are of unfinished items and, in turn, a significant quantity of U.S. imports are of U.S.-originated product.[100]

The continuing globalization of electronics production, both for semiconductors and other IT products, had a significant impact on the composition of U.S. trade partners as well as their relative importance. During the period, the number of semiconductor manufacturing countries expanded, thereby increasing the available sources of U.S. supply. Chief among these emerging producers were Korea, Taiwan, and Singapore. These producers had long hosted assembly operations, but "graduated" into large scale semiconductor fabrication during the late 1980s and the 1990s, and increased their relative importance as U.S. import sources. Semiconductor trade patterns were also affected by a shift of production capacity for electronic equipment from traditional manufacturers such as the United States, Japan, and the EU to lower wage rate countries. During the decade, a number of Asia-Pacific locales developed large electronic equipment manufacturing industries and, as a result, became major markets for U.S. semiconductor exports.

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[96] Semiconductor Industry Association (SIA), "Stats: World Market Shares and Sales, 1991-2000," found at Internet address *http://www.semichips.org*, retrieved Nov. 13, 2001.

[97] Bill McLean, "Chip Market Edges Forward," *EETimes*, May 27, 1998, found at Internet address *http://www.techweb.com*, retrieved July 6, 1998.

[98] During the decade, many U.S. production-sharing partners also became significant markets for U.S. products.

[99] See, USITC, *Production Sharing: Use of U.S. Components and Materials in Foreign Assembly Operations, 1992-1995*, Apr. 1997. According to data provided by the SIA, production activities in the United States by U.S.-headquartered companies are generally considered high value-added manufacturing while the assembly work performed in Asia is considered low value-added. In 2000, 57 percent of U.S.-headquartered companies' workforce and 68 percent of labor expenses were in the United States. SIA representatives, email to USITC staff, Jan. 14, 2002.

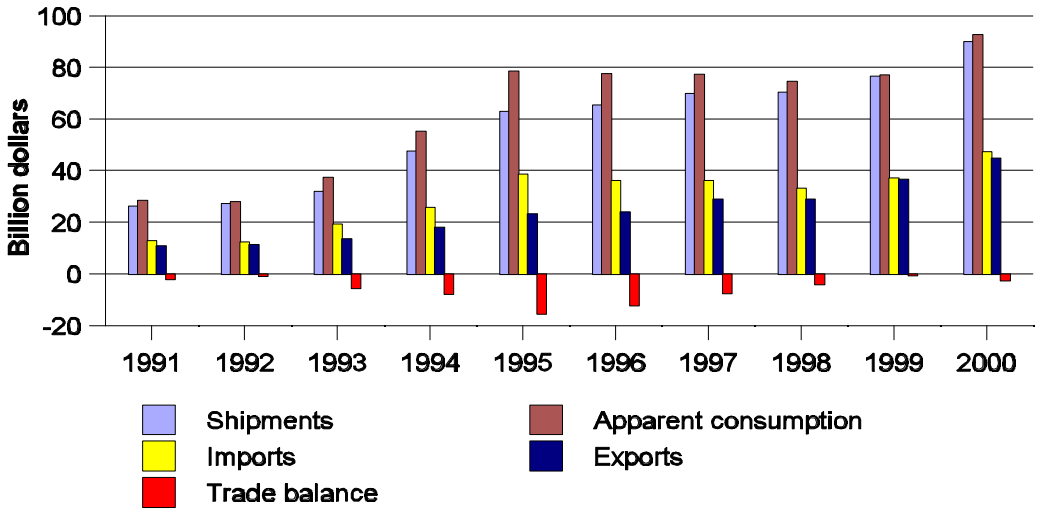
[100] Because of this relationship, growth in U.S. exports of unfinished semiconductors may be an indicator of strong domestic demand as many of these products, after foreign assembly, are ultimately re-exported to the United States for consumption. Unfinished semiconductors accounted for between 49 and 53 percent of exports during 1991-96, rose to 56 percent during 1997-99, and declined back to 52 percent in 2000.

Semiconductor pricing, regional economic shocks, and the reduction of semiconductor tariffs by a number of important trading partners also impacted U.S. trade during the period. Volatile pricing for semiconductors, particularly for commodity memory products, significantly affected markets and the value of trade and shipments. In certain years, commodity memory products suffered sufficient price erosion to result in negative value growth for U.S. imports. The Asian financial crisis, the primary regional economic shock, resulted in depressed demand for electronic equipment in that region, negatively affecting U.S. semiconductor exports to the area in 1997-98. Tariff reduction agreements such as the 1997 Information Technology Agreement likely made a small contribution to the level of U.S. semiconductor exports following its implementation. However, U.S. participation in a number of such agreements during the decade likely had no impact on U.S. import levels because the United States had already ceased collecting import duties on semiconductors in the 1980s.[101]

Imports

Fueled by the strong rise in domestic semiconductor consumption, U.S. imports surged nearly four-fold to $47 billion during 1991-2000 (figure 5). U.S. import trends largely mirrored global

Figure 5
Semiconductors: Selected U.S. economic data, 1991-2000



Source: Official statistics of the U.S. Department of Commerce.

[101] U.S. bound rates for all semiconductors were officially reduced to zero under the Uruguay Round commitments on Jan. 1, 1999. However, the United States had ceased applying duties on nearly all semiconductor imports in the 1980s. In 1991, the aggregate U.S. trade-weighted average duty for semiconductors was less than 0.1 percent ad valorem.

consumption patterns as both experienced a tremendous expansion from 1991-95, a decline during 1996-98, and a strong recovery in 1999-2000.[102] Throughout most of the decade, growth in U.S. semiconductor demand and imports was closely tied to U.S. computer industry production. However, during the last several years, the domestic telecommunications and data networking equipment industries also became demand drivers for semiconductors[103] and accounted for an increasing share of U.S. imports and consumption.

Driven primarily by demand from the domestic computer industry, U.S. semiconductor imports nearly tripled during 1991-95 to $39 billion.[104] In the early 1990s, extreme price competition in the PC market made PCs affordable to larger segments of the business and consumer populations and resulted in rapidly increasing domestic demand for, and production of, computer hardware. In turn, demand expanded for both the commodity (DRAMs and SRAMs) and non-commodity semiconductors (i.e., microprocessors) that are integral components for computers. The United States was largely dependent upon Japan and Korea for commodity semiconductors, and, as a result, imports of these items soared. Because of the high demand, pricing for commodity memory products was quite strong and further boosted the value of imports. Production-sharing imports of non-commodity products also rose substantially during the period, and accounted for a large portion of overall semiconductor imports.[105]

During 1995-98, the value of U.S. imports declined by 14 percent to $33 billion. This decline was due largely to supply imbalances that caused severe price declines for commodity memory products, particularly DRAMs and SRAMs.[106] Price erosion was so significant that although U.S. imports of commodity semiconductors continued to grow on a volume basis, the value of those imports declined sharply. Because DRAMs and SRAMs were such a large portion of U.S. semiconductor imports at the time, the overall value of U.S. semiconductor imports experienced several years of decline and did not surpass the 1995 total until 2000.[107] In contrast, production-sharing imports remained relatively strong during 1996-98, reflecting continued growth in U.S. semiconductor production and domestic demand for U.S.-made products.

U.S. imports experienced a strong rebound during 1999-2000, rising to $47 billion, a 43 percent increase over the total for 1998. The recovery was due in part to a relative stabilization in prices for commodity products as well as strong growth in domestic demand for specialized logic and analog semiconductors used in telecommunications and data networking equipment. Much of the growth in

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[102] SIA, *World Market Sales and Shares for 1991-2000*, found at Internet address *http://www.semichips.org*, retrieved Sept. 19, 2001.

[103] SIA "Semiconductor Industry Association Reports Global Semiconductor Market Tops $200 Billion Mark for First Time," Feb. 5, 2001, found at Internet address *http://www.semichips.org*, retrieved Sept. 19, 2001.

[104] Integrated Circuit Engineering (ICE), Bill McLean, ed., *Mid-Term 1998, A Report on the Integrated Circuit Industry* (Scottsdale, AZ: ICE, 1998) McLean, ed., *Mid-Term 1998*, p. 1-18, and USITC, *Industry & Trade Summary: Semiconductors*, pub. 2708, Dec. 1993, p. 18.

[105] USITC, *Industry & Trade Summary: Semiconductors*, pub. 2708, Dec. 1993, p. 20.

[106] McLean, ed., *Mid-Term 1998*, p. 1-4.

[107] The unit price of DRAMs, the principal semiconductor memory devices employed in computers, declined by as much as 70 percent in 1996. The price decline was primarily due to global production expanding at a faster rate than demand. Increased demand from PC manufacturers caused tremendous growth in the global DRAM market in 1995 (74 percent) that led to expectations of similar expansion in 1996. As a result, existing DRAM manufacturers added production capacity, while additional firms entered the market. Although the PC market experienced strong growth in 1996, the growth fell short of expectations and the increase in DRAM production led to oversupply and a severe drop in unit prices. These extreme price declines continued into 1997-98.

imports for commodity products were traditional imports from Japan and Korea while imports of semiconductors for telecommunications and data networking purposes were often U.S.-originated items returning from offshore production-sharing operations.

Changes in the composition of U.S. import suppliers closely mirrored shifts in production-sharing partners for the United States and the development in East Asia[108] of indigenous semiconductor manufacturing (table 8). In the beginning of the decade, the principal production-sharing partners for the United States were Malaysia, Canada, Korea, Singapore, the Philippines, and Taiwan, with Malaysia playing the dominant role.[109] In recent years, due in large part to foreign investment in assembly facilities, locales such as the Philippines and Thailand have risen in importance. These countries offer low wage rates, the availability of skilled labor, government incentives, and, in the case of the Philippines, English language speakers.[110] As a result of its recent strong growth, the Philippines is currently challenging Malaysia as the leading U.S. production-sharing location. In contrast, both Singapore and Canada have declined in relative importance as production-sharing locations, likely as a result of rising labor rates in those countries

Table 8
Semiconductors: U.S. imports for consumption, by principal source, 1991 and 2000 *(in thousand dollars)*

Country	1991	Country	2000
Japan	3,574,552	Japan	8,044,785
Korea	1,778,542	Korea	7,478,707
Malaysia	1,584,345	Malaysia	6,296,658
Canada	1,419,743	Philippines	5,531,519
Singapore	1,172,933	Taiwan	5,073,665
Taiwan	672,819	Singapore	3,316,451
Philippines	650,286	Canada	2,110,235
Thailand	382,477	Mexico	1,511,219
Mexico	333,612	Thailand	1,394,727
Hong Kong	276,253	Hong Kong	1,175,654
Germany	253,775	Germany	798,504
United Kingdom	228,211	China	716,081
Israel	143,980	France	572,080
France	117,215	Israel	497,653
Ireland	74,516	United Kingdom	480,285
All Other	264,881	All Other	2,449,499
Total	12,928,139	Total	47,447,721
EU15	838,603	EU15	3,030,507

Source: Compiled from official statistics of the U.S. Department of Commerce.

[108] Not including Japan, which had long been a location of semiconductor fabrication.

[109] Japanese and EU-based companies also use assembly facilities in Southeast Asian countries such as Malaysia, Singapore, and the Philippines. As such, not all U.S. semiconductor imports from these locales are of U.S.-originated products.

[110] Craig Addison, "Economic Slump Makes Southeast Asian Emerging Markets More Competitive," *Channel Magazine*, found at Internet address *http://www/semi.org*, retrieved May 29, 1998 and Craig Addison, "Shifting Patterns of Semiconductor Production," *Channel Magazine*, found at Internet address *http://www/semi.org*, retrieved May 29, 1998.

In the early 1990s, the vast majority of traditional or non-production sharing U.S. imports were from Japan, Korea, and the EU. At that time, Japan was the world's leading semiconductor producer and the dominant source of U.S. imports. However, as mentioned earlier, Japan's position both as a world producer and supplier to the United States experienced significant weakening throughout the period. While Japan supplied 28 percent of U.S. imports in 1991, that figure declined to 17 percent by 2000. In contrast, Korea developed its semiconductor production, particularly of commodity memory products, and strengthened its position in the U.S. market. In addition, new producers have emerged such as Taiwan and Singapore.[111] Largely the result of tremendous capital investments in recent years, Taiwan emerged as the world's largest supplier of "foundry" semiconductor manufacturing services and is currently one of the fastest growing producers overall.[112]

Exports

U.S. semiconductor exports more than quadrupled during the decade to nearly $45 billion. Export growth was impressive from 1991-95, moderated during 1996-98, and rose strongly again in 1999-2000. During the period, generally about one-half of U.S. exports were unfinished semiconductors shipped to production-sharing locations. Exports of finished semiconductors were often specialized items such as microprocessors, mixed signal products, certain analog devices, and digital signal processors. Because many of these latter semiconductors are essential components in telecommunications, data networking, and computer equipment, U.S. exports benefitted significantly from the strong growth in global demand for these items.[113]

U.S. exports more than doubled from 1991-95 to $23 billion, driven largely by growth in the global and U.S. computer industries. A large portion of U.S. exports were unfinished production-sharing items that were ultimately re-exported to the United States after foreign assembly and consumed by the domestic computer industry. In addition, the United States was the dominant supplier to foreign computer manufacturers of certain integral semiconductors, principally microprocessors.[114]

U.S. export growth slowed during 1996-1998, rising to $29 billion, a relatively modest 21 percent increase over the 1995 total. During this time the global semiconductor market declined by nearly 5 percent, due largely to slower than expected growth in global computer production and depressed

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[111] Jeff Dorsch, "All Eyes Turn to Southeast Asia," *Electronic Business*, July 1, 2000, found at Internet address *http://ebnonline.com*, retrieved, Sept. 27, 2001.

[112] During the decade, companies in Taiwan built a number of semiconductor fabrication facilities in which they produce semiconductors for customers on a contract basis. Many of the customers are U.S. semiconductor design firms that cannot afford the capital expense associated with building and equipping a fabrication facility. Typically, customers supply a product design and the Taiwan foundry produces the semiconductor to that design. The final product is shipped to the United States or a third market for consumption. Although the development of the foundry business model was a relatively recent occurrence, it quickly gained adherents and currently represents a sizable and growing portion of total semiconductor manufacturing. A significant portion of Singapore's fabrication industry is foundry based as well.

[113] Thomas Walter Smith and Erick Scheminske, "Semiconductors," *Standard & Poor's Industry Surveys*, May 17, 2001, May 17, 2001.

[114] USDOC, *U.S. Industrial Outlook 1994*, p. 15-5. Many of these exports were also unfinished products that were assembled abroad before being shipped to their ultimate location of consumption.

consumption in East Asia resulting from the 1997-98 Asian financial crisis.[115] East Asia had been the fastest growing market for semiconductors during the first half of the decade. The continued growth in U.S. exports during a time of global semiconductor recession reflected the relatively stable demand for design-intensive products such as microprocessors, of which the United States was the dominant producer.

U.S. exports returned to a pattern of impressive growth in 1999-2000, rising to $45 billion, a 54 percent increase over 1998. In particular, exports to East Asian markets rose strongly as those economies recovered from the financial crisis (table 9).[116] U.S. exports to several important markets, including the EU, may also have benefitted during this period from the phase-in of duty-elimination commitments resulting from the 1997 Information Technology Agreement.[117] Demand for semiconductors remained healthy from computer manufacturers, while demand associated with the telecommunications and data networking equipment industries accelerated tremendously.[118] U.S. semiconductor producers are leading suppliers of the specialized items required by these industries, and

Table 9
Semiconductors: U.S. domestic exports, by principal market, 1991 and 2000 *(in thousand dollars)*

Country	1991	Country	2000
Malaysia	1,581,259	Korea	5,435,274
Canada	1,343,005	Malaysia	5,030,203
Singapore	1,091,078	Philippines	4,694,596
Japan	1,048,197	Mexico	4,487,737
Taiwan	887,214	Taiwan	3,845,048
Korea	740,480	Canada	3,302,162
United Kingdom	681,456	Japan	3,295,506
Philippines	536,163	Singapore	2,977,516
Hong Kong	534,083	Thailand	2,099,641
Thailand	476,606	Hong Kong	1,904,789
Mexico	403,220	United Kingdom	1,405,185
Germany	336,593	Germany	1,042,321
France	287,390	France	801,200
Netherlands	143,576	China	685,815
Italy	132,361	Brazil	629,738
All Other	608,122	All Other	3,188,545
Total	10,830,804	Total	44,828,274
EU15	1,810,816	EU15	4,956,301

Source: Compiled from official statistics of the U.S. Department of Commerce.

[115] SIA press release, "1999 is the Year of Recovery for the Global Semiconductor Industry; Industry Gains Double Digit Growth," June, 1999, found at Internet address *http://www.semichips.org*, retrieved Nov. 14, 2001, and USDOC, *U.S. Industry and Trade Outlook 2000*, p. 16-10.

[116] Reed Electronics Research, *Yearbook of Electronics Data 2000*, vol. 2 (UK: Reed Business Information, Ltd., 2000), pp. 7, 9, and 10.

[117] Japan, an important market throughout the decade, eliminated semiconductor tariffs in the 1980s.

[118] USDOC, *U.S. Industry and Trade Outlook 2000* p. 16-9 to 16-11.

as such, U.S. exports benefitted substantially. Exports became increasingly important to U.S. producers in the latter half of the decade as the export to shipment ratio rose from a low of 37 percent in 1995 to a high of 50 percent in 2000.

From 1991 to 2000, changes in the composition of U.S. export markets generally reflected the shifting locations of electronic equipment production worldwide as well as changes in the mix of U.S. semiconductor production-sharing partners. While the list of leading U.S. export markets did not vary significantly during the period, there was substantial change in their relative importance. In general, Mexico and East Asian locales outside of Japan exhibited strong growth in electronic equipment production and became increasingly prominent export markets for the United States.[119] In contrast, Japan lost importance worldwide as a production location for electronic equipment and its domestic market grew at a much slower rate as a number of Japanese electronics corporations relocated production facilities to China and other countries in East Asia in order to lower production costs.[120] As a result, Japan's share of U.S. exports declined throughout the period, falling from 10 percent in 1991 to 7 percent in 2000. In contrast to Japan, emerging electronics producing counties such as Korea and Mexico accounted for larger proportions of U.S. semiconductor exports. Korea's share of U.S. exports rose from 7 percent in 1991 to 12 percent in 2000 as Korea grew in significance both as a location for electronic equipment production as well as in its role as a production-sharing partner for the United States.[121] With regard to production-sharing exports, throughout most of the period Malaysia maintained its position as the leading partner for the United States and was the chief recipient of U.S. exports of unfinished semiconductors. However, the Philippines challenged Malaysia's position and in 1999 became the top destination for these U.S. exports. Other countries that rose in importance as destinations for U.S. exports of unfinished semiconductors include Thailand, Taiwan, and Mexico.

Balance of Trade

In the first half of the decade, the United States ran an increasingly large semiconductor trade deficit, peaking at over $15 billion in 1995. Although export growth was strong during this period, imports rose at a much faster rate largely because of the tremendous demand growth in the United States for commodity memory products such as DRAMs and SRAMs on which the United States was highly import dependent. However, during 1996-98, commodity memory products experienced worldwide oversupply and extreme price erosion. Because these items accounted for such a large proportion of U.S. semiconductor imports, the severe decreases in their unit prices led to several years of decline in the value of total semiconductor imports. While the global market for semiconductor memory softened during much of the late 1990s, demand for products such as microprocessors, digital signal processors, and other U.S.-produced semiconductors remained relatively strong. As a result, U.S. exports continued to grow and the deficit narrowed to near zero by 1999. In 2000, both imports and exports experienced strong growth with imports increasing more than exports, causing the deficit to expand once again.

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[119] Bloomberg News "Short Take: Huge Growth Forecast in Asian Contract Manufacturing," CNET News.com, found at *http://news.cnet.com/news/0-1003-200-2400747.html*, retrieved June 15, 2001.

[120] USDOC, *U.S. Industrial Outlook 1994*, p. 15-7.

[121] The two principal Korea-headquartered semiconductor manufacturers, Samsung and Hynix, both constructed large fabrication facilities in the United States in the late 1990s. These plants fabricate unfinished DRAMS that are exported to Korea for assembly and then often re-exported to the United States for consumption.

During the period, the United States generally ran a trade deficit with partners in East Asia and a surplus with its NAFTA partners and the EU. The largest U.S. trade deficit was with Japan, peaking at over $8 billion in 1995 during the height of the global DRAM surge. However, by 2000 the deficit fell to less than $5 billion as the value of U.S. imports from Japan generally declined in concert with the drop in global memory prices. By comparison, deficits with Korea and Taiwan rose during the decade to roughly $2 billion and $1 billion, respectively, as these producers became increasingly prominent U.S. and global suppliers. While the United States ran a slight trade surplus with each of its future NAFTA partners in 1991, by 2000 Mexico accounted for the largest U.S. surplus at nearly $3 billion. Much of this burgeoning surplus can be attributed to rising demand for U.S. semiconductors from Mexico's growing electronics industry, primarily maquiladoras and contract manufacturers. By 2000, the U.S. surplus with Canada had risen to more than $1 billion as U.S. exports increased to meet demand from Canadian electronics manufacturers, particularly telecommunications equipment companies.

Shipments

U.S. semiconductor shipments rose by 240 percent during the period. The largest increase occurred in 1991-95 (140 percent), due largely to the tremendous growth in U.S. and global semiconductor consumption attributable to computer equipment manufacturing. During 1996-98, exports began to account for a growing portion of shipments. At this time, shipments experienced a small increase while domestic consumption declined, reflecting continued demand abroad for U.S. products. Exports continued to grow in importance during 1999-2000, a period when U.S. shipments rose by nearly 30 percent. During the decade, the U.S. industry experienced tremendous gains in labor productivity as employment rose by 23 percent as compared to the 240 percent increase in shipments.[122]

IT Industry Outlook

The growth in global IT consumption was so extraordinary during 1991-2000 that many producers and industry investment analysts were caught by surprise by a dramatic drop in demand in 2001 that led to sharp decreases in U.S. trade and shipments.[123] Through the first three-quarters of 2001, U.S. imports of IT products declined by 18 percent and exports by 17 percent when compared to the same period in 2000.[124] Most U.S. and global producers have experienced weakened financial performance and many have laid off substantial portions of their workforce. While nearly all of the IT sector has been negatively affected by the downturn, the telecommunications equipment and semiconductor segments have been especially hard

[122] According to the U.S. Department of Labor, U.S. employment in the semiconductor industry rose from 232,000 in 1991 to 294,000 in 2000.

[123] "Lehman Brothers Industry Update: Semiconductors & PC Hardware," *Lehman Brothers Equity Research*, 2001, pp. 1-2; Ari Bensinger, "Communications Equipment: Current Environment," *Standard and Poor's Industry Survey*, Aug. 2, 2001, pp. 1-7, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 8, 2001; and U.S. industry analysts, telephone interviews by USITC staff, Sept. 14-16, 2001.

[124] Official statistics of the U.S. Department of Commerce. Similar partial-year shipment data was not available.

hit. With regard to semiconductors, the global market is forecast to fall by nearly one-third in 2001 while the North American market alone is expected to decrease by over 40 percent.[125]

The current industry downturn has been attributed to a number of causes including a weak global economy, dampening end-user demand, maturing PC and wireless equipment markets, a current lack of new "must have" technologies, and excess semiconductor production capacity.[126] Much of the decline may be associated with unmet, and perhaps unrealistically positive industry expectations.[127] During the last few years of the decade, many important consumers[128] of IT equipment projected continued dramatic growth in demand for advanced technology services and invested heavily in expanded network capacity to deliver such services.[129] However, with slowing demand in an increasingly sluggish economy it became apparent toward the end of 2000 that major telecommunications and other IT service providers would have difficulty recouping their capital investments in equipment.[130] As a result, investment market capital funding that had been readily available in the previous few years began to dry up, requiring service providers to manage their capital outlays more conservatively.[131] The newly competitive local telecommunications exchange carriers were also affected since they had planned on taking market share from incumbent carriers by rapidly building out data-oriented networks. Compounding the problem, other major IT service providers had overbuilt their networks.[132]

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[125] SIA press release, "Semiconductor Industry Association Forecasts Semiconductor Recovery for 2002-2004," Nov. 7, 2001, found at Internet address *http://www.semichips.org*, retrieved, Nov. 16, 2001.

[126] "Market Researcher Expects Chip Market Will Shrink in 2002," *Electronic Buyers' News*, Nov. 7, 2001, found at Internet address *http://www.ebnonline.com*, retrieved Nov. 9, 2001, and "Other Priorities Send PC Market Tumbling," *CyberAtla*s, Sept. 10, 2001, found at Internet address *http://cyberatlas.com*, retrieved Oct. 10, 2001.

[127] Ari Bensinger, "Communications Equipment: Current Environment," *Standard and Poor's Industry Survey*, Aug. 2, 2001, pp. 1-7, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 8, 2001; Craig Shere, and Katherine Dorr Abreu, "Telecommunications Wireline: Current Environment," *Standard and Poor's Industry Survey*, May 31, 2001, pp. 1-13, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 28, 2001; and "Tough Talk on Telecom: T. Rowe's Rob Gensler Sorts out the Winners and Losers in the Embattled Sector," *Money*, Oct. 2001, pp. 52-54.

[128] Examples include wireline and wireless communications service companies, independent Internet service and access providers, enterprise networking integrators, digital cable TV companies, and a host of other IT service providers as well as business and household consumers.

[129] Ari Bensinger, "Communications Equipment: Current Environment," *Standard and Poor's Industry Survey*, Aug. 2, 2001, pp. 1-7, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 8, 2001; and U.S. industry analysts, telephone interviews by USITC staff, Sept. 14-16, 2001.

[130] Ari Bensinger, "Communications Equipment," *Standard and Poor's Industry Surveys*, Aug. 2, 2001, pp. 1-7, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 8, 2001; Ron Insana, "Can He Save Lucent?" *Money*, Oct. 2001, pp. 67-71; and U.S. industry analysts, telephone interviews by USITC staff, Nov. 13-14, 201.

[131] Ari Bensinger, "Communications Equipment," *Standard and Poor's Industry Survey*, Aug. 2, 2001, pp. 1-7, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 8, 2001; and U.S. industry analysts, telephone interviews by USITC staff, Nov. 13-14, 201.

[132] Ron Insana, "Can He Save Lucent?" *Money*, Oct. 2001, pp. 67-71; Ari Bensinger, "Communications Equipment," *Standard and Poor's Industry Surveys*, Aug. 2, 2001, pp. 1-7, retrieved Aug. 8, 2001, at Internet address *http://www.netadvantage.standardandpoors.com;* and U.S. industry analysts, telephone interviews by USITC staff, Nov. 13-14, 201.

Given slower network build-outs and network overcapacity, overall spending on telecommunications and other IT equipment, including related semiconductors, dropped precipitously from the end of 2000 through 2001.[133] The abrupt drop in sales left telecommunications and other IT producers, which had erroneously predicted continued strong spending levels for their equipment, with huge inventories and oversized cost structures.[134] Due to the slower network construction and network overcapacity, excess inventories, and a slowing U.S. and global economy, industry analysts project that overall spending for U.S. and foreign telecommunications equipment will continue to decline into at least 2002 or 2003 while demand for services and new product cycles catches up.[135]

However, despite the dramatic downturn in IT services and equipment markets, most industry analysts believe that long-term prospects for the IT industry remain optimistic.[136] Although there continues to be uncertainty concerning the present economic outlook in the United States and in the rest of the world, few analysts disagree that at some point businesses will have to replace aging equipment to retain their competitiveness. Much of the productivity gains that allowed the economy to expand at a relatively rapid pace in the 1990s were the product of increasing computerization, and improved communications, networking, and Internet capabilities.[137] A number of experts believe that as the economy recovers, companies will expand the reach of their computer and communications networks outside of their own enterprise, improving their interface with customers and suppliers to automatically generate orders and invoices. This in turn will increase demand for more effective communications technologies and advanced computers and storage devices to store rapidly increasing amounts of data. Finally, demand will also increase for the microprocessors and other advanced semiconductors that will enable this to be accomplished.[138]

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[133] "Lucent Technologies," *Argus Company Report*, Argus Research Corp., Sept. 28, 2001, pp. 1-4; Ari Bensinger, "Communications Equipment," *Standard and Poor's Industry Surveys*, Aug. 2, 2001, pp. 1-7, retrieved Aug. 8, 2001, at Internet address *http://www.netadvantage.standardandpoors.com;* David M. Reimer, "Telecom Services," *Value Line Investment Survey*, Value Line Publishing, Inc., 2001, pp. 1-4; and U.S. industry analysts, telephone interviews by USITC staff, Nov. 13-14, 2001.

[134] Ari Bensinger, "Communications Equipment," *Standard and Poor's Industry Survey*, Aug. 2, 2001, pp. 1-7, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 8, 2001.

[135] "Tech Recovery in 2002: A Different Beast," *Forrester Research*, 2001, p. 1; and U.S. industry analysts, telephone interviews by USITC staff, Aug. and Nov. 2001.

[136] George Rho, "Telecom. Equipment," *Value Line Investment Survey*, Value Line Publishing, Inc., 2001; George A. Niemond, "Computer & Perip.," *Value Line Investment Survey*, 2001, pp. 1-2; "Technology News Lifts Stock Indexes," *Washington Post*, Nov. 2, 2001, p. E03; "Lucent Technologies Inc." *Argus Company Report*, Sept. 28, 2001, p. 2; Telecommunications Industry Association, *2001 MultiMedia Telecommunications Market Review and Forecast*, 2001, pp. 3-15; U.S. industry analysts, telephone interviews by USITC staff, Nov. 13, 2001; and Megan Graham-Hacket, "Computers: Hardware: Industry Profile: The Internet Ushers in a New Age," *Standard and Poor's Industry Survey*, May 10, 2001, pp. 1-8, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 28, 2001.

[137] Alessandra Colecchia and Paul Schreyer, *Investment and Economic Growth in the 1990s: Is the United States a Unique Case? A Comparison of Nine OECD Countries* (Paris: OECD, Oct. 25, 2001), pp. 5 and 15; and George A. Niemond, "Computer & Perip.," *Value Line Investment Survey*, 2001, pp. 1-2.

[138] George A. Niemond, "Computer & Perip.," *Value Line Investment Survey*, 2001, pp. 1-2; Telecommunications Industry Association, *2001 MultiMedia Telecommunications Market Review and Forecast*, 2001, pp. 3-15; and U.S. industry analysts, telephone interviews by USITC staff, Nov. 13, 2001.

The fastest growth in demand for IT products has been predicted for markets[139] outside of the United States, and should offer increased export opportunities for U.S. information technology providers. For example, telecommunications penetration is low in many countries and leaves much room for growth, particularly for wireless and Internet services. A recent survey of a leading IT industry trade association projects international telecommunications services to grow by a nearly 15-percent compound annual rate, rising to $1.2 trillion by 2004.[140] Such growth would require the international IT equipment market to also grow in order to provide the infrastructure required to supply such services. Both advanced and less developed countries are aware that if they are to maintain or achieve economic success in domestic and international markets, it is essential that they make significant investments in efficiency enhancing IT technologies provided by the computer hardware, semiconductor, telecommunications, and other IT sectors. Due to its decade-long dominance and experience in developing and producing these technologies, the U.S. IT industry is in an excellent position to take advantage of such enhanced international opportunities as the global economy recovers from its current sluggishness.

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[139] Telecommunications Industry Association, *2001 MultiMedia Telecommunications Market Review and Forecast*, 2001, pp. 3-15.

[140] Telecommunications Industry Association, *2001MultiMedia Telecommunications Market Review and Forecast*, 2001, pp. 3-15; Katherine Dorr Abreu, "Telecommunications Wireline: Current Environment," *Standard and Poor's Industry Survey*, May 31, 2001, pp. 1-8, found at Internet address http://www.netadvantage.standardandpoors.com, retrieved Aug. 28, 2001; Megan Graham-Hacket, "Computers: Hardware: Industry Profile: Industry Trends," *Standard and Poor's Industry Survey*, May 10, 2001, pp. 1-6, found at Internet address *http://www.netadvantage.standardandpoors.com*, retrieved Aug. 28, 2000. Based on anticipated growth in electronics equipment demand, the Semiconductor Industry Association is forecasting the beginning of a recovery for the global semiconductor market in 2002. SIA press release, "Semiconductor Industry Association Forecasts Semiconductor Recovery for 2002-2004," Nov. 7, 2001, found at Internet address *http://www.semichips.org*, retrieved, Nov. 16, 2001.