Industry & Trade Summary

Computers, Peripherals, and Computer Components

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PREFACE

In 1991 the United States International Trade Commission initiated its current *Industry and Trade Summary* series of informational reports on the thousands of products imported into and exported from the United States. Each summary addresses a different commodity/industry area and contains information on product uses, U.S. and foreign producers, and customs treatment. Also included is an analysis of the basic factors affecting trends in consumption, production, and trade of the commodity, as well as those bearing on the competitiveness of U.S. industries in domestic and foreign markets.[1]

This report on computers, peripherals, and computer components covers the period 1989 through 1993 and represents one of approximately 250 to 300 individual reports to be produced in this series during the first half of the 1990s. Listed below are the individual summary reports published to date on the electronic equipment and technology sector.

USITC publication number	*Publication date*	*Title*
2445	January 1992	Television receivers and video monitors
2648	July 1993	Measuring, testing, controlling, and analyzing instruments
2674	September 1993	Medical goods
2708	December 1993	Semiconductors
2730	February 1994	Navigational and surveying instruments
2820	October 1994	Telecommunications equipment
2821	October 1994	Computers, peripherals, and computer components
2822	October 1994	Audio and video recording and reproducing equipment

[1] The information and analysis provided in this report are for the purpose of this report only. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under statutory authority covering the same or similar subject matter.

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INTRODUCTION

The dynamic, rapidly changing computer hardware industry includes products such as personal computers (PCs), workstations, mainframe and minicomputers, supercomputers, peripherals, and computer components.[1] This $207 billion global industry accounts for approximately 4 percent of total U.S. trade. The products in the industry are proliferating as firms develop new technologies. This report examines the computer hardware[2] industry during 1989-93, and includes discussions on U.S. and foreign computer industries, tariff and nontariff trade measures, U.S. and foreign markets, and the U.S. trade balance in computers.

Computers receive, process, store, and transmit information. Different types of computers serve different functions and can be classified by processing ability, price, and applications (figure 1). For instance, supercomputers, used for highly technical, complicated calculations, have faster and more complex processing capabilities than personal computers, which are used mainly for word processing and spreadsheet calculations. However, as technological developments continue, capabilities of individual products increasingly overlap, blurring the boundaries between computer types and increasing competition as products encroach upon one another's market niches.

Computer and computer peripheral assembly is labor intensive, while component production is largely automated. Firms mass produce computers and peripherals using labor-intensive assembly line techniques for everything except supercomputers. Certain automated processes allow components to be reduced to sizes too small for human manipulation.

Several trends in the computer hardware industry affect the competitiveness of all computer hardware firms. The commoditization of personal computers has increased price competition, highlighting the importance of cost controls. Computer platform[3] downsizing is reducing mainframe and minicomputer sales and increasing sales of PCs and workstations.[4] Last, the push toward open systems[5] is creating more competition in markets previously dominated by proprietary systems.

Types of Computers

Personal computers are the least powerful and least expensive computers. PCs comprise desktop models, laptop computers, and notebook computers. These computers have the ability to perform word processing, financial analysis, and various other functions, and are popular for commercial and personal use. Many businesses have installed local area networks (LANs), which connect many PCs to one or more servers[6] to provide word processing and data management capabilities.[7] Both laptop and notebook computers are portable, with notebook computers being smaller, weighing seven pounds or less. Many portables have the same processing capabilities as desktops.

Workstations are similar in appearance to PCs but contain greater and faster processing capabilities, which make them desirable servers as well as stand-alone machines. Workstations were developed for use in engineering, to provide advanced technical analysis, computing, and graphic imaging. Many workstations still provide these functions, but are often connected to networks, in similar configurations as networks of PCs. Manufacturing firms use workstations for computer-aided design (CAD), computer-aided manufacture (CAM), and computer-aided engineering (CAE) to increase plant efficiency. As servers, high-end workstations distribute data among networks of PCs or other workstations. Most workstations support networks of 20-40 users, although more powerful workstations support many more users.

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[1] These items are included in the Harmonized Tariff Schedule under heading 8471 and subheading 8473.30. The corresponding Standard Industrial Classification (SIC) numbers are 3571-3577.

[2] For the remainder of the report, computer hardware refers to all computer peripherals, computer parts, and computers, unless otherwise specified. Computer hardware is synonymous with computer products.

[3] All technical terms are defined in a glossary found in appendix B. A computer platform is the hardware architecture on which computer systems are based, and is often defined by the processing power available at each terminal. Computer users are moving from mainframe-based computer platforms that process all information at a central location, to client-server platforms, which distribute processing capabilities to individual users.

[4] Computer platform downsizing involves the replacement of mainframes, minicomputers, or supercomputers with smaller, often less powerful machines, that are attached to a server through a network. The migration to smaller machines is made possible by the migration of applications from mainframes to workstations and PCs.

[5] Open systems are computer platforms designed to be fully compatible with other platforms, so that companies may easily use the same software on various machines throughout their institutions. Users are encouraging the development of open systems, especially in workstations, which currently have a variety of proprietary architectures.

[6] A server is one of the central computers in a network that distributes information to and from several users, acting as a "traffic cop" by directing information and communication within the network. Any computer can act as a server as long as it has the required processing and memory capabilities to manage the data needs of its network.

[7] LANs allow employees to access shared software programs on servers and facilitate communication between computers, while the PCs give added flexibility through processing and memory capabilities on the desktop.

Figure 1
Characteristics of computer market segments, ranked by price[1]

Market segment	Price range	Processing speed	Principal function
Personal computers	$700–$10,000	20-50 Million instructions per second (MIPS)	Desktop applications such as wordprocessing, spreadsheets, and small databases.
Workstations	$5,000-$60,000	20-350 MIPS	Desktop applications such as high resolution graphics simulations, and computations.
Mainframes and minicomputers	$25,000-$500,000	50-375 MIPS	Central processors for data from linked terminals.
Supercomputers	$500,000 and up	up to 26,000 MIPS	Numerical processing for problems involving massive amounts of data.

[1] Price ranges are reported in 1993 dollars.
Source: USITC staff.

Mainframes and minicomputers support hundreds of users at one time and are typically used for general-purpose applications such as payroll, accounting, and database management in large organizations. Multiple applications can run on these computers at the same time, allowing several users to access them through "dumb" terminals. These terminals act as input/output mechanisms only, with no processing capabilities.

Supercomputers feature rapid processing, vast memory, and generally higher prices than mainframe computers.[8] Because of the ability to process massive amounts of data, supercomputers perform tasks such as weather forecasting and data-intensive scientific research. For example, Abbott Laboratories, a pharmaceutical producer, employs supercomputers to simulate theoretical chemical reactions.[9] Companies also increasingly use supercomputers to do such things as create special effects in motion pictures, and to design automobiles and aircraft. Supercomputers furnish detailed imaging, facilitate product adaptations without requiring models, and provide immediate feedback to the user.

Types of Computer Peripherals

Computer peripherals are external input/output devices that are used with a computer to augment the computer's capabilities. The specific peripherals that are combined with computers depend on the computers, the users, and the applications. The many types of input/output devices include[10]:

- Displays - The most common computer displays use cathode ray tubes (CRTs), but liquid crystal displays (LCDs) are becoming more popular as computers are miniaturized to become more portable.
- Keyboards - Keyboards are the input devices most often used for data entry in word processing. However, pen-based input devices are becoming increasingly popular with the smallest portable computers.
- Mice - Mice are pointing devices most commonly used in conjunction with graphic interface software such as the Windows

[8] Supercomputers can process information approximately 5 times faster than mainframes, can store up to several hundred million 64-bit words, and cost between $1 million and $40 million.

[9] For more information on the use of supercomputers, see Institute of Medicine and National Research Council, *Supercomputers: Directions in Technology and Applications* (Washington DC: National Academy Press, 1989), or National Research Council, *Supercomputers: Directions in Technology and Applications* (Washington DC: National Academy Press, 1989), pp. 22-23.

[10] Modems, communication devices used in computers to transfer data over telephone lines, are not included in the report's definition of computer products. Because they are communications devices, modems are discussed in the industry and trade summary on telecommunications equipment.

operating environment. A user moves a mouse on a flat surface and a corresponding movement occurs on the computer screen.

- Printers - Printers transfer information from the computer (usually displayed on the screen) onto paper or transparencies.
- Scanners - Scanners allow users to capture an image from paper and reproduce the same image on the computer screen, through graphics software. One of its most popular uses is converting a printed document into an electronic version that can be edited on the computer screen.

Computer Components

The global computer component industry constitutes a large portion of computer production and trade, accounting for over 55 percent of U.S. trade in computer related items in 1993. Most computers are made up of the same components — disk drives, power sources, printed circuit boards (PCBs), and microprocessors,[11] surrounded by box-like frames called housings, made of metal or plastic.[12]

The disk drives and power sources inside the computer are distinct components that are specifically identified in the U.S. Harmonized Tariff Schedule (HTS). Disk drives store information on spinning disks coated with magnetic or optical media, allowing users to store data on removable or fixed disks between computer uses. Fixed disk drives, also known as hard disks, store information internally and are not readily removed from the computer after each use. Floppy disk drives save data to media (floppy disks) that can be removed from the computer. CD-ROM (compact-disk read only memory) drives[13] use optical technology to read information off CD-ROM disks and have larger storage capacities than floppy disks. Power sources, used for many years in various electronic devices, are important to computers because they convert household or battery electric power to the voltage each component needs.

[11] Microprocessors are installed in computers after being placed on printed circuit boards. The printed circuit board that holds the microprocessor is called the motherboard.

[12] Some large-scale computers have free standing power source boxes that are not incorporated in the housing unit.

[13] CD-ROM disk drives are becoming popular among personal computer users. Although, as their name implies, CD-ROM disk drives do not have the capability to save information on a disk, they can hold much more information than floppy disk drives. Approximately 650 million bytes (megabytes) of information will fit on a CD-ROM, compared with 1.2 megabytes on a 5.25 inch floppy disk, and 1.44 megabytes on a 3.5 inch floppy disk.

Printed circuit boards contain the components that process information and relay information between other components, such as the disk drives and the power source. Semiconductors, transistors, capacitors, and resistors are all attached to PCBs in specific patterns, designed to maximize the number of components on each PCB. Microprocessors serve as the "brains" of computers. Attached to the PCBs, these vital components control communication between components and carry out all calculations. Personal computers use one microprocessor, while more powerful computers use several.

Significance of Products

In 1993, computers accounted for over 53 percent of all computer hardware shipments in the United States, followed by components (27 percent), and peripherals (20 percent). U.S. trade in computer hardware is dominated by components, comprising over 55 percent of computer trade, while peripherals accounted for 24 percent, and computers 21 percent of the total. U.S. computer firms, producing in the United States and abroad, continually balance production, imports, and exports to deliver finished goods and components to their customers worldwide.

U.S. INDUSTRY PROFILE

Industry Structure

Structure

Although there are nearly 1,000 computer hardware manufacturers in the United States, the ten largest firms account for over 50 percent of the U.S. market. The number of computer companies with 10 or more employees in the United States fell from 952 in 1989 to 906 in 1990, but increased to an estimated 1,044 in 1993.[14] Shipments of computer hardware in the United States, estimated at $55 billion in 1993, have increased at a 3-percent average annual rate since 1989.[15]

Computer production in the United States is concentrated in California, Massachusetts, New York, and Minnesota. Producers in the first three states have the advantage of being in close proximity to major export facilities, technologically educated labor forces, and technological research centers. Several computer

[14] United States International Trade Commission (USITC) staff estimates on the basis of information provided in U.S. Department of Commerce (DOC), Bureau of the Census, "Computers and Office and Accounting Machines," *Current Industrial Reports*, MA-35R, Nov. 1990-Nov. 1993.

[15] USITC estimates on the basis of data provided by the Department of Commerce, Bureau of the Census, *Computers and Office and Accounting Machines*, Oct. 1993, p. 1.

firms, such as Control Data Corporation (Control Data) and Cray Research (Cray), have historical ties to the state of Minnesota and have chosen to continue operating there.[16] In addition, Texas is attracting high-tech investment because of its proximity to component suppliers and its technologically educated labor force. Several PC producers, such as Dell Computer (Dell), CompuAdd and AST Research (AST), as well as a number of semiconductor firms have started operations in Texas.

While many U.S. computer hardware firms specialize in one particular product, some larger companies offer products from every computer market segment. For instance, International Business Machines (IBM) sells everything from portable computers to supercomputers, including certain computer peripherals and components, while Dell and AST specialize in PCs. The number of companies that offer a full line of computer products has diminished as competition has intensified and necessitated specialization.

Vertical integration

Vertical integration no longer appears to be the model for successful computer hardware firms. The constant restructuring of previously vertically integrated firms such as IBM, Digital Equipment Corp. (DEC), and Unisys demonstrate this phenomenon. Intense price competition and quickly changing technologies have driven computer firms to outsource many of their components from suppliers in the United States and abroad.

Outsourcing provides computer manufacturers with low-cost components and greater flexibility as new technologies are developed. Often it is also less expensive to purchase mass-produced components from higher-volume manufacturers. For these reasons, despite attempts to maximize in-house capabilities, 40 percent of the parts in IBM's Personal System/2 line of desktops came from sources outside of IBM in 1987.[17] In addition, a company's agility may improve if the burden of adapting production processes to new technologies is placed on outside component manufacturers. Firms such as IBM, Compaq, Dell, and Apple rely upon outside providers of microprocessors for their PCs. These firms often have close relationships with their suppliers so that they can quickly incorporate the latest technological advances into new PC designs.

There are many incentives to source components from overseas. Firms increasingly purchase low-cost, low-technology inputs from low-wage countries and focus their resources on computer design. In addition, multi-national companies often find it easier to source their components close to overseas manufacturing facilities. Furthermore, local sourcing fosters good relations with foreign governments in overseas operations.[18] Some firms procure specific technologies from sole-source producers overseas. This strategy has worked well for many firms, including Hewlett-Packard, which purchases all of the motors for its laser printers from Japan-based Canon Corp.[19]

Outsourcing of components has become commonplace in spite of firms' fear of overdependence on outside suppliers. Even today, some U.S. industry sources claim that Japanese component producers deliberately delay shipments of important parts to give a competitive advantage to the Japanese firms that they supply.[20] Recent supply shortages of workstation microprocessors have increased U.S. companies' concerns regarding foreign production of critical components.[21] Companies attempt to establish multiple sources for critical components in order to minimize such risks. However, some components, such as flat panel displays, are only available from a limited number of suppliers.

Ease of market entry

The declining importance of vertical integration has increased the ability of firms to enter the computer market. Start-up companies can now offer PCs similar to those of established firms by outsourcing key components, including microprocessors, disk drives, PCBs, and power supplies. Workstation manufacturers have begun to grant licenses for their microprocessor technologies, thereby increasing the ability of new firms to enter the workstation market without substantial R&D. In addition, new firms can assemble

[16] Minnesota-based computer firms, interviews with USITC staff, Minneapolis, Apr. 28-29, 1993.

[17] Norm Alster, "PS/2: Surface Mount Makes it an Inside Job," *Electronic Business*, Sept. 1, 1987, p. 44. IBM sources say that they now cannot accurately estimate the "U.S. content" of any product because components are bought from different worldwide sources each week, depending on price and availability.

[18] U.S. computer firms in Japan, Singapore, and Hong Kong, interviews with USITC staff, East Asia, Oct. 1992.

[19] Hewlett-Packard representative, phone interview with USITC staff, July 30, 1992.

[20] Specific instances of problems associated with relying on one country for a particular component are discussed in William R. Nester, *Japanese Industrial Targeting* (New York: St. Martin's Press, 1991), p. 200. Differing views on component sourcing and the importance of computer manufacturing in the United States can be found in "Should the U.S. Abandon Computer Manufacturing?," *Harvard Business Review*, Sept./Oct. 1991, pp. 140-161.

[21] Tim Miles, "Workstation Case Study," appendix B of U.S. DOC, International Trade Administration (ITA), *U.S. Electronics Sector from Materials to Systems*, Apr. 1990.

peripherals by purchasing key components of displays, keyboards, printers, and other peripherals.

Entry into the mainframe, minicomputer, supercomputer, and high-end peripheral markets remains difficult, however, because production requires advanced in-house technology, a large capital investment, and close customer/supplier relationships. Unlike the PC market, brand name and reputation are important in the markets for advanced technologies. However, the advent of parallel processing[22] and the current push for open Unix operating systems may decrease future barriers to entry.

Employment

The commoditization of PCs, computer platform downsizing, and the onset of open systems all have contributed to recent employment fluctuations. U.S. firms are laying off both sales and manufacturing employees in the United States and overseas. U.S. employment in the computer industry dropped from approximately 228,000 in 1989 to 196,000 workers in 1993.[23] Both Apple and IBM have announced plans to continue worldwide workforce reductions, by 16 percent or 2,500 jobs at Apple, followed by 20 percent, or 60,000 jobs at IBM, by the end of 1994 (table 1). Between 1989 and 1992, the average nominal hourly wage for U.S. production workers increased an average of 4-percent per year from $11.39 to $13.03. In real terms, however, wages increased by less than one percent each year.[24]

Since 1990, employment has decreased in all sectors of the U.S. computer industry, including R&D scientists. However, the link between profits and technological advances, coupled with product life cycles of less than 18 months, has encouraged firms to reduce R&D employment levels more slowly than overall staff reductions. As a result, the proportion of R&D scientists and engineers in the U.S. computer industry workforce has increased over this period. In 1989, R&D researchers made up 32 percent of total employment, and in 1992 they accounted for 34 percent of the total.[25]

Computer product R&D is heavily dependent on human resources because of the experimental nature of the work. Not only has R&D remained labor intensive, it continues to require skilled engineers and designers to develop new computer systems and increase processing abilities.

Pricing and Marketing

Companies must reduce the prices of PCs as cost increasingly becomes the deciding factor in PC sales. Over the last five years, computer hardware costs have declined as a result of technological advances, commoditization, and computer platform downsizing. In 1986, it was estimated that computer processor prices were .01 percent of what they were in 1953.[26] In other words, a $2,000 computer in 1986 (the average price for a PC and its peripherals) would have cost around $20 million in 1953. During the recent economic downturn, many firms attempted to increase market share by reducing prices. Although sales increased for several firms, lower prices caused profit margins to plummet. In the spring of 1992, DEC cut PC prices by up to half, Apple reduced its prices by up to 37 percent, and IBM cut prices on several PCs by 20 to 31 percent. In October 1993, IBM announced further price reductions of up to 20 percent on its PS/2 line of personal computers.

While prices in the PC market are falling, the capabilities of networked PCs continue to increase. In many cases, networked PCs[27] can compete against minicomputers and mainframes in terms of price and performance. This competition from below has forced minicomputer and mainframe producers to reduce prices. For instance, prices for IBM and plug-compatible[28] mainframes dropped by more than 30 percent in 1992.[29] Profits of firms that are dependent on mainframe and minicomputer sales are therefore declining. Amdahl, DEC, Fujitsu, and IBM all posted losses for 1993. Some firms, such as Wang Laboratories, Inc. (Wang), have even declared bankruptcy as a result of such losses and have reorganized to become more competitive. Both Wang and Control Data Corp. have stopped manufacturing

[22] Parallel processing divides a problem into several parts and distributes the work among processors or computers. This often allows many smaller computers to perform functions that only mainframes and supercomputers previously could perform.

[23] USITC staff estimates based on information in U.S. DOC, ITA, *U.S. Industrial Outlook 1993*, January 1994, p. 26-1 and U.S. DOC, Economics and Statistics Administration, Bureau of the Census, *Current Industrial Reports, Computers and Office Accounting Machines*, MA-35R, 1993.

[24] Phone conversation with an official of the U.S. Department of Labor, Bureau of Labor Statistics, Oct. 20, 1993. The wage rates were deflated by the Consumer Price Index to calculate real growth rates.

[25] National Science Foundation, *Selected Data on Research and Development in Industry: 1991*, Oct. 1993, p. 26, table SD-13.

[26] For more information on this estimate and Hedonic price indexes see Jack E. Triplett, "Price and Technological Change in a Capital Good: A Survey of Research on Computers," ch. in Dale W. Jorgenson and Ralph Landau, *Technology and Capital Formation* (London: MIT Press, 1986).

[27] A network is a system of interconnected computers, usually PCs attached to a server (local area network), or multiple computer systems connected through phone lines to a central server and information distributor (wide area network).

[28] Plug-compatible machines are IBM-compatible and often run alongside IBM mainframes.

[29] Ira Krepchin, "Will Cheaper Mainframes Slow Downsizing?" *Datamation*, Oct. 1, 1993, p. 63.

Table 1
Number of worldwide employees at the leading U.S. computer firms, 1989-92

Company	1989	1990	1991	1992
IBM	372,297	362,586	338,339	303,764
DEC	125,900	121,100	119,500	102,100
Hewlett-Packard	52,640	55,566	59,988	65,118
Unisys	82,300	75,300	60,300	54,300
AT&T	63,000	61,690	54,488	52,000
Apple	14,550	15,057	14,450	14,900
Sun Microsystems	10,869	11,961	12,800	12,900
Compaq	9,600	11,300	10,000	9,400
Amdahl	8,200	8,700	9,400	8,764
Dell	1,554	1,897	2,900	4,300

Source: Gartner Group, *Yardstick: Top 100 U.S.*, 1993.

and now concentrate on more profitable aspects of the computer industry.[30]

As prices become more important, low cost distribution systems are replacing specialized computer stores. Today, PCs can be found in almost any type of retail outlet, from department stores such as Montgomery Ward and Sears, to warehouse outlets such as Price Club.[31] Dell and CompuAdd sell computer hardware successfully through the mail, with low overhead costs enabling them to sell computer products at prices 30 percent lower than those of competitors. IBM, too, has changed distribution methods and now accounts for 19 percent of PC sales in non-computer retail stores.[32] In addition, IBM has announced the availability of two PS/2 models through mail order.

In contrast, the corporate customers of more powerful computer products require different distribution channels. Workstations are usually obtained through resellers, system integrators, or through contracts with the manufacturers. Supercomputers, mainframes, and minicomputers still require routine service, and the necessarily close relationship between manufacturer and customer has preserved traditional distribution systems.

Research and Development

Research and development (R&D) in the computer hardware industry is changing as the industry matures. Government R&D has shifted its focus from military applications toward civilian applications. In addition, corporate spending on R&D continues to yield technological advances. Regardless of the source of funding, R&D remains important to competitiveness in the computer hardware industry.[33]

In 1993, the U.S. Government spent an estimated $812 million on computer research.[34] Over 90 percent of Federal obligations for research in computer sciences is disbursed through the Department of Defense (DOD), Department of Energy (DOE), National Aeronautics and Space Administration (NASA), and National Science Foundation (NSF) (see figure 2).[35] These agencies distribute grants to institutions for research in specific fields.

Recently, increased competition from Japanese computer firms has caused a resurgence in the U.S. Government's participation in non-military computer research. In the spring of 1994, the Government announced plans to provide matching R&D funds for companies that research and produce flat-panel displays (FPDs).[36] The High Performance Computing Act of 1991 (Public Law 102-194) provides funds for research in advanced computer technologies to nine federal agencies. The program is divided into five components:

- High Performance Computing Systems
- National Research and Education Network
- Advanced Software Technology and Algorithms

[30] Control Data Corp. split into two separate companies in 1992. Control Data Corp. became Ceridan, specializing in outsourcing and consulting. Wang also has entered the computer services market.

[31] William H. Davidson, *The Amazing Race: Winning the Technorivalry with Japan* (New York: John Wiley & Sons, 1984), p. 117.

[32] IBM representative, telephone interview with USITC staff, Nov. 1993.

[33] Shrinking product life cycles puts added pressure on companies to keep R&D expenditures high so that they can introduce new products more often. In 1991, 37 percent of computer products had product life cycles of one year or less. The percentage is predicted to reach 47 percent by 1995. Estimates by the Computer Systems Policy Project as presented in "Product Cycles Shrink," *Electronics*, June 14, 1993, p. 14.

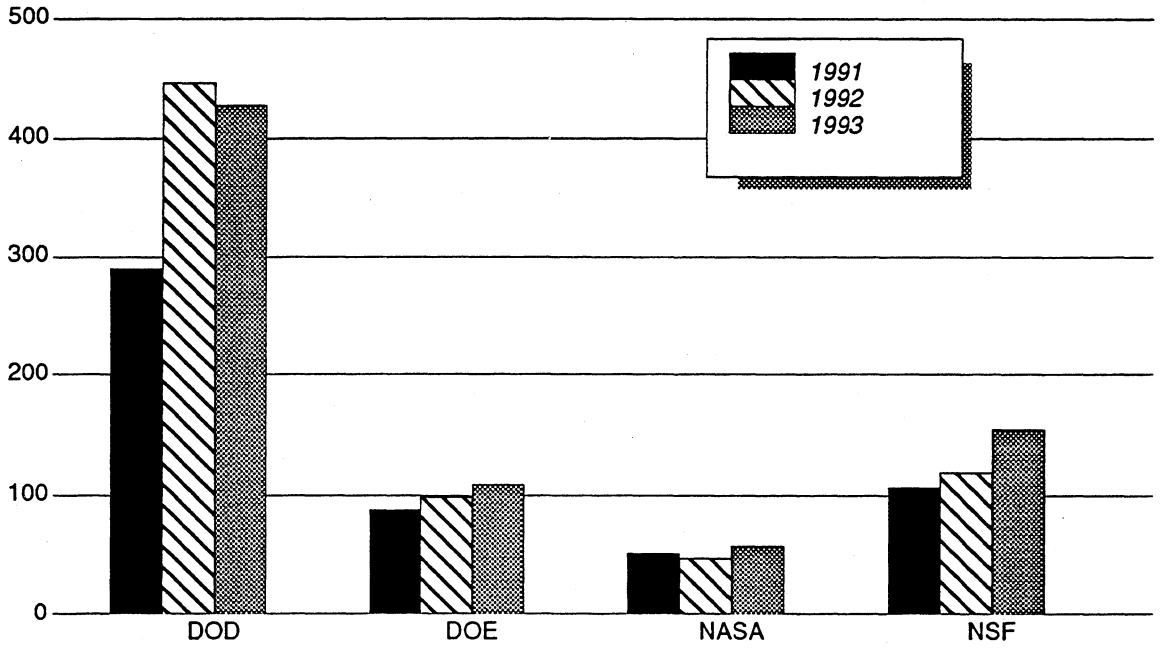
[34] Computer-related data on development funds by industry, which account for over 60 percent of total Government expenditures for R&D, are not available. National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1991, 1992 and 1993 Vol. XLI*, NSF 93-323 (Arlington, VA, 1993), p. 102.

[35] National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993*.

[36] Patricia Panchak, "DOD Rides to U.S. FPD Industry's Rescue," *Electronics*, May 9, 1994, p. 14.

Figure 2
Federal computer research funding by agency, 1991-93

Million dollars



Source: National Science Foundation, *Federal Funds for Research and Development*, FYs 1991, 1992, and 1993, Vol. 34, NSF 93-323, tables C-31, 32, 33.

- Information Infrastructure Technology and Applications[37]
- Basic Research and Human Resources.

The program has provided $2.3 billion during 1992-94 and has a proposed budget of $1.2 billion for FY-1995.[38]

As Government R&D expenditures have moved away from defense-related projects, firm specific R&D has become instrumental in the development of technological advances, such as flat panel display technology and handwriting recognition displays, which are used in new portable computers. For instance, flat panel display technology is critical to the weight, readability, and battery life of portable computers. Handwriting recognition, also called tactile display technology, is essential to portable computers without keyboards. R&D funding from non-government sources has stayed relatively constant over the past five years. Non-governmental source spending reached its highest level at $11 billion in 1990, but fell to $10.7 billion in 1992.[39] R&D as a percent of net sales increased to 15.3 percent in 1990, partly as a result of declining net sales among computer hardware producers, before falling back to 13.8 percent in 1992.[40]

Not surprisingly, as a result of the link between technological advances and new products, the ratio of R&D to net sales in the computer hardware industry tends to be higher than those in other manufacturing industries. For fiscal year 1993, U.S. firms' R&D expenditures as a percentage of net sales ranged from 2 percent for Dell to 22 percent for Cray Research.[41] The disparity in R&D spending between computer

[37] This component was added in 1994.

[38] Executive Office of the President, Office of Science and Technology Policy, *High Performance Computing and Communications: FY 1995 Implementation Plan*, Apr. 1994, pp. 5-15.

[39] National Science Foundation, *Selected Data on Research and Development in Industry: 1991*, Oct. 1993, table SD-4, p. 8; and update by USITC staff telephone interview with the National Science Foundation, Sept. 7, 1994.

[40] These data do not include government R&D spending. National Science Foundation, *Selected Data on Research and Development in Industry: 1991*, Oct. 1993, Table SD-9, p. 18; and update through USITC staff telephone interview with National Science Foundation, Sept. 7, 1994.

[41] Dell Computer Corporation Annual Report 1993, p. 27; and Cray Research, "Cray Research Reports Improved Fourth Quarter and Year-End Results," Cray Research News Release, Jan. 31, 1994, p. 3.

products is directly related to the importance of technological innovation to product sales. While many PC producers stay competitive by minimizing costs and prices, supercomputer firms gain customers by supplying unique processing capabilities.

Globalization

Global Production and R&D

Joint ventures, collaborative research programs, and specific product development alliances have proliferated in recent years. In many instances, U.S. computer hardware firms have allied themselves with foreign competitors (table 2). One of the primary reasons for establishing cooperative alliances is to share the costs and risks associated with research and product development. Companies competing within the same product segment occasionally form alliances to conduct pre-competitive research. For example, IBM has formed a joint research venture with Toshiba and Siemens-Nixdorf (SNI) to develop a new generation of memory chips. In other cases, companies look beyond their immediate competitors and cooperate with firms capable of supplying complementary technology. For example, Apple Computer combined its computer design skills with Sony's expertise in manufacturing and miniaturization to produce the 3-pound PowerBook notebook computer.[42]

Global Sales

Although historically the United States has been the world's largest supplier of computer products, worldwide competition has increased significantly during the last decade, resulting in fierce battles for global market share. Ranked by revenues, global market leaders in 1992 were IBM (19 percent), Fujitsu (8 percent), and NEC (6 percent).[43] Perhaps IBM best exemplifies a globalized computer hardware firm. At the inception of the computer industry, almost all of IBM's sales were domestic; today, 60 percent of its revenues come from overseas.[44] Other U.S. companies have followed IBM's lead, with most establishing a presence in all major world markets.

Strategic marketing alliances can increase a company's involvement in and knowledge of a foreign market. Because consumer demands and expectations may vary in different markets, many firms prefer to enter new geographic markets by forming alliances with companies having a long-standing regional presence. IBM, for instance, has entered into a marketing alliance with Hitachi to distribute IBM notebook computers in Japan, a country in which long-standing distributor contacts are reportedly essential.[45]

In order to sell computer products successfully worldwide, producers must take foreign tastes and cultures into account. For instance, the characters in the Japanese and Chinese languages require computer graphics capabilities and special keyboards. Personal computers in Japan run on a unique "double-byte" system,[46] that is necessary to accommodate the multitude of characters in the Japanese language. Companies also adapt power source boxes in computers to account for differences in electrical outlet voltages.

Consumer Characteristics and Factors Affecting Demand

Consumers

A wide variety of consumers purchase computer products, from individuals and small firms to large corporations and government agencies. Consumers in the United States and Europe lead the world in computer hardware purchases, followed closely by Japan. These three regions account for over 80 percent of the 1993 global computer hardware market (figure 3). In each market, buying patterns are similar.

The type of product purchased depends on the computing requirements of the user. Each type of computer and peripheral enables specific applications. For instance, while a PC would satisfy the need for someone to perform word processing, automobile companies would need supercomputers to simulate the impact of different crashes. Individuals and small firms usually purchase PCs and workstations, while larger institutions tend to use all types of computers for processing massive quantities of information, and supporting multi-user applications and computer networks. High prices limit the customer base for minicomputers, mainframes, and supercomputers to institutions with sizeable funding.

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[42] This PowerBook manufacturing alliance between Apple and Sony is no longer in force. Apple computer representative, telephone interview with USITC staff, Nov. 8, 1993.

[43] The top 10 companies, by hardware revenue in 1992 were IBM, Fujitsu, NEC Hitachi, HP, Apple, DEC, Siemens-Nixdorf, Compaq, and Canon. Gartner Group, *Yardstick Top 100 Worldwide*, 1993.

[44] IBM 1993 Annual Report, p. 61.

[45] This alliance focuses on systems software, printers, and the distribution of IBM notebook computers in Japan. Gene Gregory, "The Irresistible Case for Strategic R&D Alliances," *Asia Management Journal*, June/July 1993, p. 20.

[46] While eight bits usually comprise a byte, the Japanese language requires more character sets than available using this system. Consequently, the double-byte, 16-bit system was developed in 1984 to accommodate the Japanese language.

Table 2
Joint ventures and alliances

U.S. company	Allied firm	Headquarters	Product	Place	Year
Apple	General Magic	U.S.	Networking and software interfaces	U.S.	1993
	IBM	U.S.	Multimedia and software	U.S.	1991
	Motorola & IBM	U.S.	Power PC chip	U.S.	1991
	Sharp	Japan	Palmtop computers	Japan	1992
	Sony	Japan	Notebooks and personal data assistants	Japan	1991[1]
AT&T/NCR	General Magic	U.S.	Networking and software interfaces	U.S.	1993
	Sierra On-Line	U.S.	Video game networks	U.S.	1993
Cadense Design Systems	Fujitsu and NEC	Japan	IC technology for CAD	Japan	1992
Chips and Technologies	Summit Systems	C.I.S.	PC production	C.I.S.	1990
Compaq	Intel	U.S.	Mobile companion	U.S.	1993
Control Data (Ceridan)	Intergraph	U.S.	CAD/CAM/CAE	U.S.	1992
	Structural Dynamics Research Corp.	U.S.	Metaphase Technology (market product data management software)	U.S.	1992
Convex	Hewlett-Packard	U.S.	Workstations and massively parallel systems	U.S.	1992
Cray Research	Bolt Beranek	U.S.	MPP computers	U.S.	1991
	Motorola	U.S.	Application specific ICs	U.S.	1992
	Sun	U.S.	Software	U.S.	1992
	Yokogawa	Japan	Supercomputers	Japan	1992
Digital Equipment Corp.	Cray Research	U.S.	Supercomputer/mini-computer interfaces	U.S.	1992
	Eucom	Germany	Network services	Europe	1992
	Fluent Inc.	U.S.	Hardware and software for sending video images over a NetWare LAN	U.S.	1992
	MasPar	U.S.	Massively parallel computers	U.S.	1991
	Mitsubishi	Japan	Alpha AXP processors	Japan	1993
	Olivetti	Italy	PC-DECnet interface Alpha mktg. agreement	Italy	1992
Hewlett-Packard	Analog Devices	U.S.	Mixed digital and analog chips	U.S.	1992
	Convex	U.S.	Workstations and massively parallel systems	U.S.	1992
	TV Answer	U.S.	Interactive TV	U.S.	1992
	Oki Electric Industry Co., LTD	Japan	PA-RISC chips and mobile communi-cations	Japan	1992
	Hitachi	Japan	PA-RISC chips	Japan	1992
	Samsung	Korea	PA-RISC chips/ workstations	Korea	1990

See footnotes at end of table.

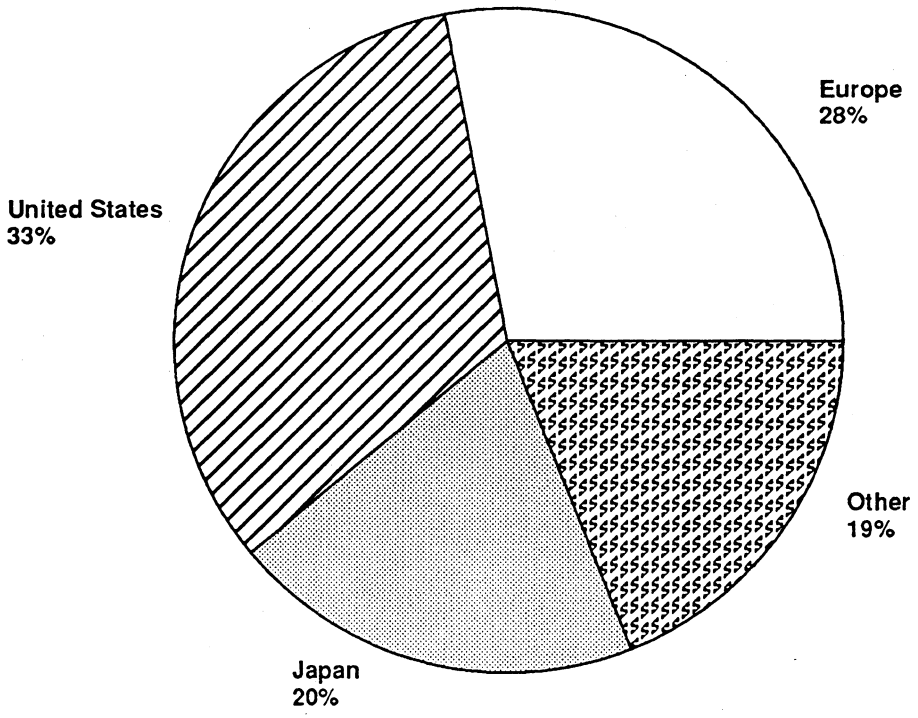
Table 2—Continued
Joint Ventures and Alliances

U.S. Company	Allied Firm	Headquarters	Product	Place	Year
IBM	Apple	U.S.	Multimedia and software	U.S.	1991
	Canon	Japan	Portable computers and printers	Japan	1992
	Digital	U.S.	Disaster recovery	U.S.	1992
	Groupe Bull	France	Workstations	U.S.	1992
	Intel	U.S.	Microprocessors	U.S.	1991
	Motorola	U.S.	Phoneless modems	U.S.	1990
	Motorola & Apple	U.S.	Power PC chips	U.S.	1991
	Motorola	U.S.	Semiconductors	U.S.	1989
	National Semiconductor Corp.	U.S.	LAN products	U.S.	1992
	Picturetel	U.S.	Video conferencing	U.S.	1991
	Siemens-Nixdorf AG	Germany	Semiconductors	France	1991
	Thinking Machines	U.S.	Massively parallel computers	U.S.	1991
	Toshiba	Japan	Flat panel displays and portable computers	Japan	1991
Intel	IBM	U.S.	Microprocessors	U.S.	1991
	Sharp	Japan	Flash memory chips	Japan	1992
Motorola	Cray Research	U.S.	Application specific ICs	U.S.	1992
	IBM	U.S.	Phoneless modems	U.S.	1990
	IBM & Apple	U.S.	Power PC chips	U.S.	1991
	Samsung	Korea	Wireless pen PC	Korea	1992
	Toshiba	Japan	Memory chips	Japan	1987
	Unisys	U.S.	Semiconductors	U.S.	1992
Packard Bell	Zenith Data Systems	France	Portable computers	U.S.	1993
Silicon Graphics/Mips	Daewoo	Korea	RISC architecture	U.S.	1990
	NEC and Toshiba	Japan	RISC architecture	U.S.	1993
Sun	Fujitsu	Japan	SPARC chips	Japan	1986
	Kalpana	U.S.	LAN technology	U.S.	1992
	Moscow Center of Sparc Technology	Russia	Workstation software	Russia	1992
	Taligent	U.S.	Workstation software	U.S.	1992
	Texas Instruments	U.S.	RISC technology	U.S.	1993
Tandy (TE Electronics)	Casio Computer	Japan	Hand held computers	Japan	1992
Texas Instruments	Acer	Taiwan	Memory chips	Taiwan	1991
	Hitachi	Japan	Memory chip design	Japan	1988
			Memory chip design	Japan	1991
Unisys	KPMG Peat Marwick	U.S.	Software	U.S.	1991
	Motorola	U.S.	Semiconductors	U.S.	1992

[1] This alliance was dissolved in 1993.

Source: USITC Staff.

Figure 3
Worldwide computer markets, 1993



Source: USITC staff estimates.

Consumer knowledge of computing has skyrocketed and there are many widely available computer product publications. This sophisticated consumer base is a major reason for continued competition in the industry as firms attempt to offer new technologies at competitive prices. Although firms continue to be the largest customers, household purchases account for an increasing percentage of computer hardware sales. Households are expected to account for 40 percent of PC purchases in 1994.

Downsizing Computer Platforms

Consumers that have previously purchased large-scale systems have begun to "downsize" computer platforms, replacing traditional mainframes and minicomputers with client-server networks[47] of less expensive workstations and PCs. Platform downsizing is the mechanism by which price competition in the PC market has spread to the markets for minicomputers and mainframes.

Platform downsizing became feasible as the processing capabilities of PCs and workstations expanded. Today's 486-based[48] personal computers offer the same amount of computing power as a 1960s-vintage mainframe, at a fraction of the cost. In 1993 Intel released its new Pentium chip, which is estimated to be 100 times more powerful than the chip inside the first IBM PC.[49] Workstations, meanwhile, are built around increasingly powerful reduced instruction set computing (RISC) microprocessors.[50] RISC processors are even more powerful than Intel's Pentium microprocessor. The increasing capabilities of these smaller, microprocessor-based computers are enabling many firms to downsize computer platforms without reducing processing power.

Pressure to downsize computer platforms also has come from users that no longer want to depend entirely on a central computer to run programs and store data.

[47] Client-server networks link a number of "clients" (usually PCs or workstations), to a central server computer.

[48] 486 refers to the standard Intel-compatible based microprocessor currently available.

[49] Tom R. Halfhill, "Intel Launches Rocket in a Socket," *Byte* (May 1993), p. 94.

[50] Recent R&D on the use of RISC chips in PCs will further blur the boundary between workstations and PCs.

PCs linked to a network, unlike "dumb terminals" attached to mainframes, have their own memory and processing capabilities, and can function without the help of servers.[51] Independence from a central computer provides users with added flexibility and control.

The result of downsizing computer platforms is that price-sensitive PCs and relatively inexpensive workstations are competing directly with mainframes and minicomputers. Figure 4 contrasts declining revenues in the mainframe and minicomputer market with increasing revenues in the PC and workstation markets.

Open Systems

Computer hardware typically has been built around proprietary technologies, complicating the task of networking machines manufactured by different firms. The ease of constructing PC-based networks from IBM-compatible machines has led purchasers of all types of computer products to demand more compatible "open systems," wherein computers manufactured by different firms are more easily interconnected. In response, manufacturers are forming joint ventures to coordinate product development strategies and engineer more open computer architectures. Workstation manufacturers have made significant progress in terms of establishing open operating systems. Minicomputer manufacturers have also charted a course toward open systems, with an estimated one-quarter of minicomputers sold during 1992 incorporating nonproprietary architecture. Mainframe manufacturers, although heavily dependent on proprietary architectures, are making similar efforts to design and market open systems.

FOREIGN INDUSTRY PROFILE

The U.S. industry's foreign competitors are principally based in Japan, Singapore, Taiwan, and Europe. Table 3 lists the major competitors based in each of these markets. Although production in Singapore, Taiwan, and Europe is quite high, U.S. manufacturing facilities in these countries account for a large share of foreign-based production.

Japan

The Japanese industry is made up of several large computer hardware firms, each of which specializes in a different segment of the computer market. Fujitsu and Hitachi produce mainframes, Canon concentrates on printers, while NEC and Toshiba account for most of the PC production in Japan. No Japanese firm has experienced success in the workstation market, although many resell machines made by U.S. companies. Profit margins among Japanese firms are declining and Japanese firms are beginning to reduce employment levels. For example, in 1993 Fujitsu began a two-year program to reduce its workforce by 11 percent.[52]

Because the Japanese domestic market has lagged behind the U.S. and European markets in terms of computer platform downsizing, Japanese corporations have been slow to abandon the so-called "mainframe mentality." In 1993, mainframes and minicomputers accounted for 44 percent of total computer hardware production in Japan; the comparable figure in the United States is 33 percent.[53] NEC, which accounts for over 50 percent of PC sales in Japan, derives only 34 percent of its computer product revenues from PCs; mainframes and minicomputers account for 42 percent.[54]

Japanese firms that sell PCs focus almost solely on the home market. Reliance on domestic PC sales has created inertia in Japanese firms while global demand for PCs evolves and price competition becomes preeminent.[55] To date, Japanese firms have not engaged in intense price competition, leaving Japanese PC prices 50 percent higher than comparable Taiwanese products.[56] However, Japanese firms are gradually becoming less insulated from the outside world as U.S. firms such as Apple, Dell, and Compaq introduce price competition to the Japanese market.

Despite these problems in the computer market, Japanese firms have been remarkably successful in the computer parts and peripherals category. In particular, Japanese firms have captured approximately 95 percent of the world market for flat panel displays.[57] In

[51] Programs that are stored locally in the desktop computer's internal drive run independently of the file server.

[52] "Sayonara to the Lifetime Job in Japan," *Electronic Business Buyer*, May 1994, p. 32.

[53] These percentages were derived by using computer shipment data, not including parts or peripherals. USITC staff estimates are based on data presented in Electronic Industries Association of Japan (EIAJ), *Facts and Figures on the Japanese Electronics Industry; 1993 Edition* (Tokyo: EIAJ, 1994), pp. 50-51; and U.S. Department of Commerce, Bureau of the Census, "Computers and Office and Accounting Machines," *Current Industrial Reports*, MA-35R, Oct. 1993.

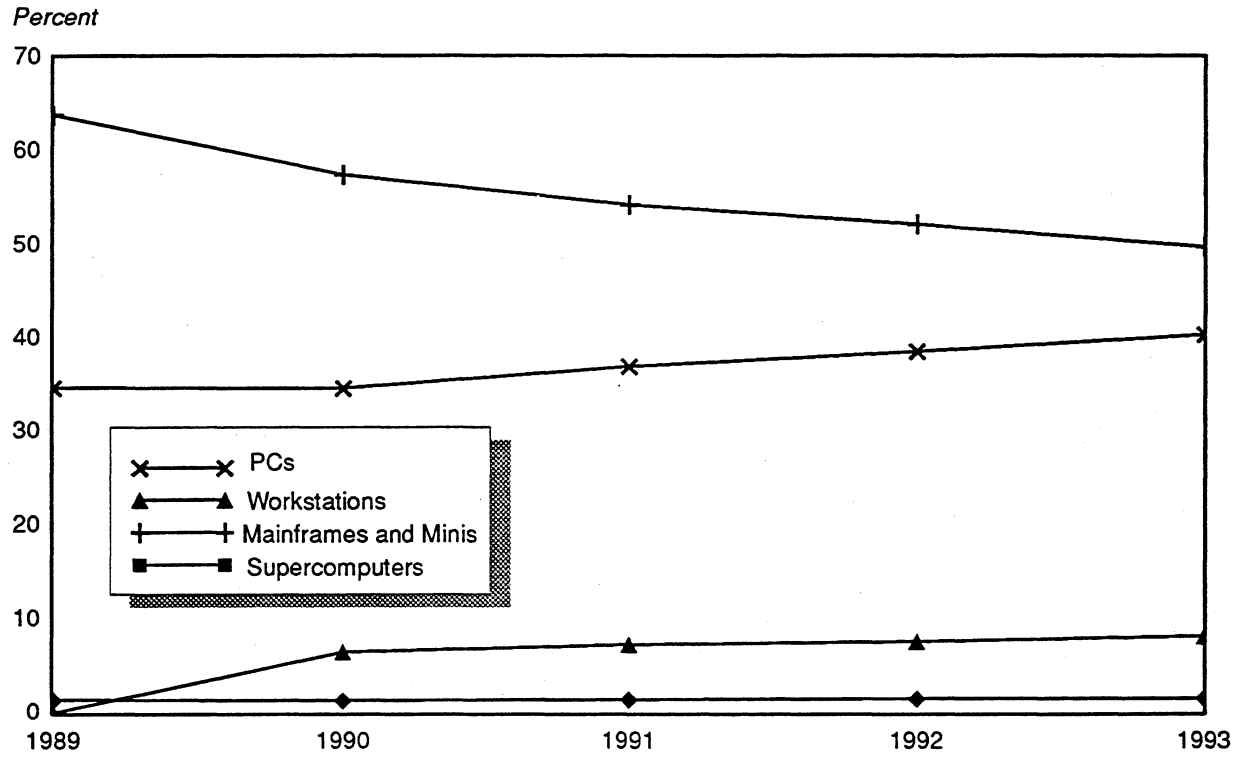
[54] Domicity Ltd., *NEC: A Strategic Analysis* (Toronto: Domicity, 1993), p. 7-11.

[55] For instance, NEC (88 percent), Hitachi (72 percent), and Fujitsu (70 percent) all sell over 50 percent of their products to the domestic market. *NEC: A Strategic Analysis* (Toronto: Domicity, 1993), p. 7-11; *Hitachi: A Strategic Analysis*, (Toronto: Domicity, 1992), p. 7-10; and *Fujitsu Annual Report*, 1992, p. 25.

[56] Nomura Research Institute, interviews with USITC staff, Japan, Oct. 1992.

[57] USITC staff estimates using data provided in "Sharp Raises Flat Panel LCD Ante," *Electronic News*, Jan. 17, 1994, p. 6.

Figure 4
Computers: percent of wold market by product category, 1989–93



Source: Data compiled by USITC staff.

Table 3
Foreign competition by headquarter region

Europe	Japan	Singapore	Taiwan
Groupe Bull (France)	Canon	Creative Technologies	Acer
Olivetti (Italy)	Fujitsu	IPC	Mitac
Siemens-Nixdorf (Germany)	Hitachi	Wearnes Technolgy	Tatung
	NEC		
	Toshiba		

Source: USITC staff.

addition, Japanese firms traditionally rank among the top printer suppliers to the world market.

Japanese labor costs are approximately equal to those in the United States. Wages in Japan's electronic equipment industries rose at an average annual rate of 7 percent from 1988 to 1991, reaching an average of $12.64 per hour in 1991.[58] In response, Japanese firms are moving labor-intensive manufacturing to Asian countries with lower wage rates. In addition, Japanese firms are attempting to develop products containing new technologies that will command higher profit margins. Like their U.S. counterparts, Japanese firms are entering into joint ventures and licensing agreements to commercialize existing technology and acquire new technology.

The Japanese Government continues to fund research and development despite disappointing results. Recent government computer policies reportedly have been expensive and largely ineffective.[59] In June 1992, the Ministry of International Trade and Industry (MITI) discontinued its 5th-generation computer project to develop advanced reasoning technologies. This project did not accomplish its stated objectives and cost more than ¥50 billion ($371 million).[60] The current approach by the Japanese Government focuses on new product development, including the Real World Computing Project. This $450-million, 10-year, program was launched in 1992 to conduct joint R&D on massively parallel processing.[61]

Taiwan

In contrast to the highly concentrated Japanese industry, Taiwan has 1,200 firms producing computers and peripherals, and 1,000 firms producing components, each averaging less than 20 employees.[62] The top three domestic PC suppliers[63] in Taiwan—Acer, DTK and Copam—account for only 38 percent of Taiwan's market. The top 20 companies account for only 54 percent of PC production.[64] An abundance of component suppliers combined with the small size of firms has contributed to a flexible, low-cost manufacturing base. For this reason, Taiwan is a key global producer of motherboards, monitors, mice, and many other computer components and peripherals (figure 5).

In 1991, production of computer products in Taiwan equalled approximately $6.4 billion, 89 percent of which was exported.[65] Much of this total was manufactured by subsidiaries of foreign companies located in Taiwan. In 1990, 26 percent of microcomputer exports, 65 percent of printer exports, 85 percent of hard disk drive exports, and 32 percent of monitor exports from Taiwan were produced by foreign subsidiaries.[66] Many Taiwan-based firms sell products to other companies, which resell the items under their own brand names. These shipments to name brand computer firms accounted for 47 percent of computer hardware exports in 1990 (figure 6).[67]

Although Taiwan-based companies are competitive in the PC, peripheral and certain component sectors, they do not have the technology to produce more sophisticated computer products. Taiwan's computer industry has emerged within the last ten years, focusing on already developed products. Only now are R&D expenditures increasing as the industry seeks to become more technologically sophisticated. Consequently, Taiwan's R&D has been relatively small compared to R&D expenditures by U.S. firms. As a result, joint ventures between foreign and Taiwan-based firms have been encouraged to promote technology transfer. Some ventures reportedly may endeavor to manufacture high-performance workstations.[68]

Although Taiwan continues to lag behind the United States and Japan technologically, its labor costs continue to increase, reducing its competitive advantage in labor-intensive goods such as low-end

[58] U.S. Department of Labor, Bureau of Labor Statistics, Mar. 1993.

[59] Discussions of the problems associated with the fifth-generation project and Japanese Government attempts to bolster the computer industry can be found in Harvey P. Newquist, "Innovation - Coincidence or Government Plot?" *AI Expert*, July 1993, pp. 49 (3); and Japanese policy disappointments are discussed in Charles H. Ferguson and Charles R. Morris, *Computer Wars: How the West Can Win in a Post-IBM World* (N.Y.: Random House, 1993), p. 230.

[60] According to the *Federal Reserve bulletin*, May 1992, in 1991 the average exchange rate was ¥134.59 per dollar. However, the exchange rate fluctuated over the life of the project.

[61] For further discussion on this topic, see USITC, *Global Competitiveness of U.S. Advanced-Technology Industries: Computers* (investigation No. 332-339), USITC publication 2705, Dec. 1993.

[62] China External Trade Development Council (CETRA), interviews with USITC staff, Taiwan R.O.C., Oct. 1992.

[63] Based on domestic installed base.

[64] Taiwan industry representative, telephone interview with USITC staff, Nov. 1992.

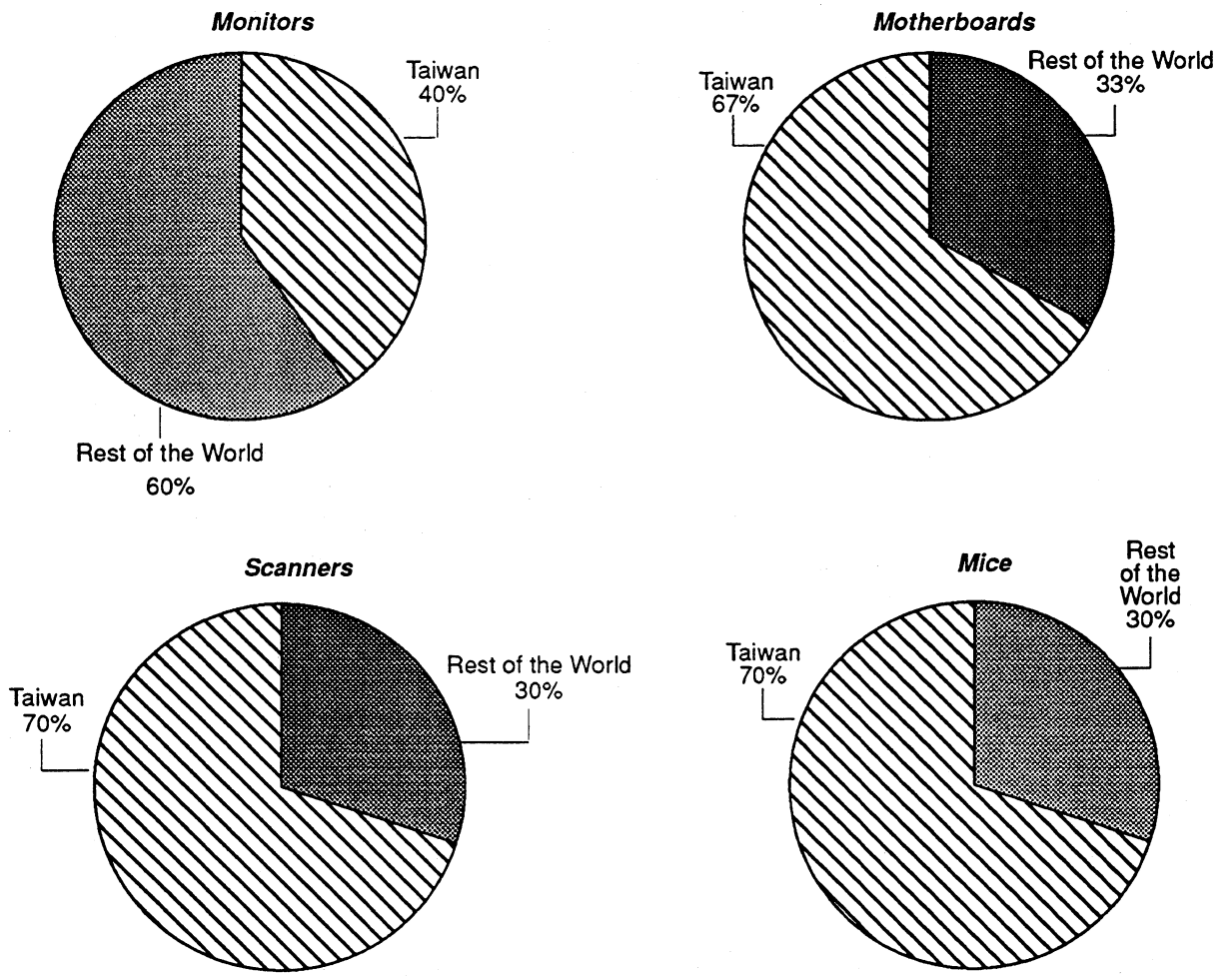
[65] Taiwan's Personal Computer Industry Report: Hardware/Software Strategies and Trends - 1992 Edition (Taipei: Institute for Information Industry (III), Market Intelligence Center, 1992); and USITC staff estimates from Taiwan trade data.

[66] Taiwan's Personal Computer Industry Report: Hardware/Software Strategies and Trends - 1991 Edition (Taipei: III, 1991).

[67] Taiwan's Personal Computer Industry Report: Hardware/Software Strategies and Trends - 1991 Edition, p. 19.

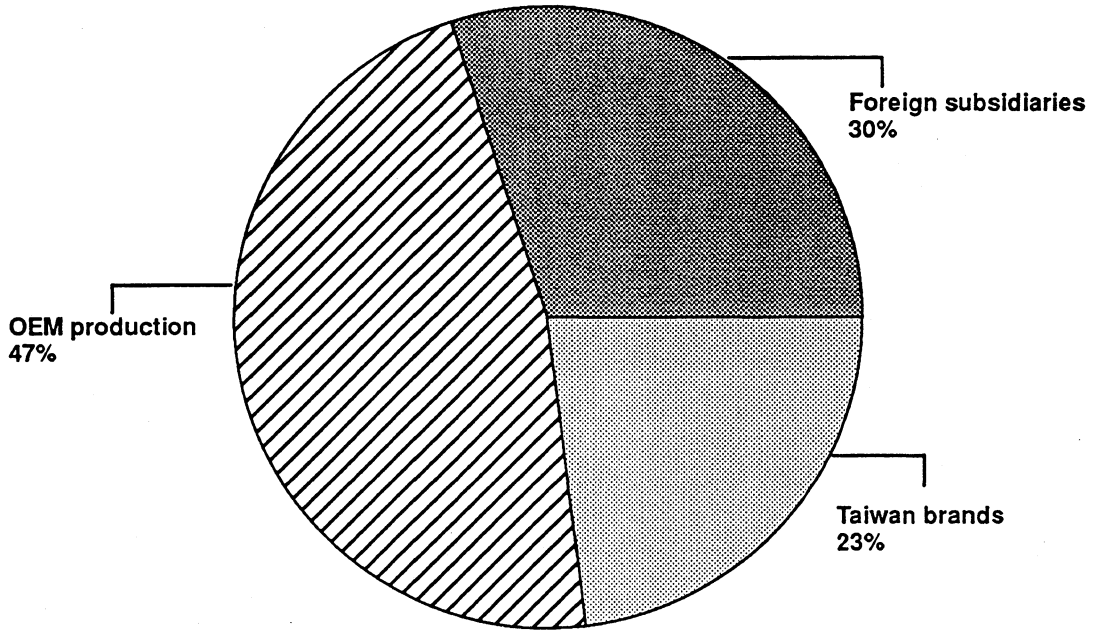
[68] U.S. DOC, ITA, *Market Research Reports: Taiwan - Foreign Support for High-Tech Sought*, Sept. 26, 1991.

Figure 5
Taiwan's percent of world market (units) for selected computer components and peripherals, 1991



Source: MIC/ITC, 1992.

Figure 6
Composition of Taiwan's computer exports, 1990



Source: MIC, p.19.

computer components.[69] Hourly wages increased at a 14 percent average annual rate during 1988-91, reaching $3.75. These wages currently exceed labor costs in most neighboring countries.[70] In response, many companies are increasing automation and moving labor-intensive production to places such as China and Thailand.[71]

The distribution system in Taiwan is similar to that in the United States. Most mainframe computers are distributed through direct sales, while PCs are usually sold through retail outlets.[72] For instance, Computerland Taiwan, a subsidiary of the U.S. firm Merisel, has five outlets in Taiwan that sell personal computers.[73]

Singapore

The tiny island of Singapore, with less than 3 million people, has become one of the world's leading computer product suppliers by encouraging investment from multinational corporations (MNCs). In 1992, computer hardware production in Singapore was estimated at $10.9 billion, with much of that output produced by U.S. firms at facilities in Singapore.[74] Personal computers, disk drives, subassemblies, and other components account for over 83 percent of production, while mainframe and minicomputer production remains negligible.[75]

[69] Industry representatives in East Asia, USITC staff interviews, Oct. 1992. For a discussion on Taiwan Companies' dependance on other firms for certain technologies, see Michael Borrus, *Reorganizing Asia: Japan's New Development Trajectory and the Regional Division of Labor* (Berkeley, CA: Berkeley Roundtable on the International Economy, 1992), working paper 53, p. 24.

[70] U.S. Department of Labor, Bureau of Labor Statistics, Mar. 1993.

[71] For company reactions to the labor situation see "Outlook 1992: Taiwan," *Asian Sources Computer Products*, Jan. 1992, pp. 112-122.

[72] U.S. DOC, ITA, *Market Research Reports: Taiwan - Mainframes*, Apr. 1993.

[73] The American Institute in Taiwan, *1991-92 Directory of U.S. Firms in Taiwan*, p. 37.

[74] Export numbers are used to represent production because over 90 percent of total production in Singapore is exported. Embassy of the United States of America, *Singapore Computer Industry Report*, Apr. 1993, p. 1.

[75] "Singapore's Computer Product Exports Bounce Back," *Asian Sources Computer Products*, Aug. 1993, p. 32.

Multinational corporations account for over half of Singapore's computer hardware output. U.S. firms such as Seagate, Conner Peripherals, Maxtor, and Western Digital produce most of the disk drives in Singapore, accounting for 11 percent of Singapore's GDP and supplying over 50 percent of world demand in 1992.[76] The largest PC manufacturers in Singapore are Apple, Compaq, and Hewlett-Packard, all of which are U.S. firms. Principal Singapore companies, including Wearnes Technology, IPC, and Creative Technologies have focused sales efforts on European or other foreign markets to survive the intense price competition in the home market.[77]

MNCs are drawn to Singapore for several reasons, including proximity to growing markets, a disciplined and well educated workforce, well developed infrastructure, and tax incentives.[78] The Government of Singapore plays a vital role in the computer hardware industry as it actively encourages capital investment and attempts to move labor-intensive production to neighboring countries where labor costs are less then in Singapore.[79] Tax incentives are designed to encourage high value-added production, and include tax holidays for 5 to 10 years for investments that meet certain research requirements.[80]

Average hourly wages reached $3.54 per hour in 1990, after averaging 13 percent annual growth from 1988 in Singapore dollars.[81] In order to meet the need for production workers, companies are allowed to hire workers from Malaysia, but pay a "foreign worker levy" of up to S$430 per month per person.[82] Foreign workers account for 30 percent of a typical PC firm's production staff.[83]

Singapore has a large re-export market in which companies import components from various countries,[84] assemble them into computers, and ship them to offshore markets. Sometimes re-exports are large enough to make total exports exceed production figures. The United States received 47 percent of Singapore's total exports of computer products in 1992 and over 50 percent of disk drive exports in 1991. Europe is Singapore's second largest export market, accounting for 25 percent of Singapore's computer product exports.[85]

Computer products are sold through local distributors and foreign subsidiaries. Over 700 outlets provide computer hardware in the Singapore market. Local distributors sell many brands of computer products while foreign subsidiaries generally sell only their own brands.[86]

Europe[87]

European companies accounted for 9 percent of world computer hardware production in 1993, with an estimated $19 billion in global hardware revenues.[88] Output from Germany, France, the United Kingdom, Italy, and Ireland accounts for 88 percent of total European computer hardware production.[89] Although Europe is one of the largest markets for computer products in the world, production in the region supplies only 67 percent of European demand.[90] U.S.-owned facilities in Europe account for 60 percent of European production.

European companies remain heavily reliant on sales of mainframes and minicomputers.[91] While Europe supplied 88 percent of its demand for mainframe and minicomputers in 1990, European producers supplied only 28 percent of the PCs sold in the European market. The chief suppliers of PCs to the European market are three U.S. firms,[92] followed by Ing. C. Olivetti & Cie SpA (Olivetti) of Italy, with 7.5 percent of the PC market. European companies have yet to gain a significant foothold in the supercomputer and workstation markets. U.S. firms

[76] Embassy of the United States of America, *Singapore Computer Industry Report*, Apr. 1993, p. 4.

[77] Embassy of the United States of America, *Singapore Computer Industry Report*, Apr. 1993, pp. 3-4. Singapore Economic Development Board, interviews with USITC staff, Singapore, Oct. 1992.

[78] U.S. Department of State, "USITC Investigation on Economic Integration in East Asia: Singapore," message reference No. 254670, prepared by U.S. Embassy, Singapore, Sept. 1992.

[79] Industry representatives in Singapore, interviews with USITC staff, Singapore, Oct. 1992; and Singapore Economic Development Board, interviews with USITC staff, Singapore, Oct. 1992.

[80] Singapore Economic Development Board, interviews with USITC staff, Singapore, Oct. 1992.

[81] U.S. Department of Labor, Bureau of Labor Statistics, Mar. 1993.

[82] The exchange rate in 1993 was S$1.53 to $1.

[83] U.S. computer firm, USITC staff interviews, Singapore, Oct. 1992.

[84] Leading exporters of components to Singapore are Taiwan, Thailand, and Malaysia.

[85] "Singapore's Computer Product Exports Bounce Back," *Asian Sources Computer Products*, Aug. 1993, pp. 33-34; and Singapore Trade Development Board, *Singapore Trade Statistics*, 1992.

[86] U.S. DOC, ITA, *Market Research Reports: Singapore - Microcomputers*, May 1991.

[87] For the purposes of this report, Europe includes the EU-12 nations. The EU countries are the biggest producers of computer products in the entire region.

[88] USITC staff estimates using data from Gartner Group, *Yardstick Top 100 Worldwide*, 1993, pp. II-4,II-14; "The Datamation 100," *Datamation*, June 15, 1993, p. 13; and company annual reports.

[89] EUROBIT, *European Information Technology Observatory 93*, (Frankfurt: *European Information Technology Observatory*, 1993) p. 247.

[90] EUROBIT, *European Information Technology Observatory*, p. 28.

[91] Graham Vickery, "European Electronics at the Crossroads," the *OECD Observer*, Oct./Nov. 1991, p. 10.

[92] The leading PC firms in Europe are IBM, Compaq and Apple.

accounted for 93 percent of workstation production in Europe in 1991.[93]

Each of the three largest European computer hardware manufacturers, Groupe Bull (France), Olivetti (Italy), and SNI (Germany), had operating losses in excess of $200 million in 1993. SNI and Bull have sustained losses for five and four years, respectively, while Olivetti had five years of declining earnings before its operating losses in 1991, 1992, and 1993.[94] The Government of France, which owns over 70 percent of Groupe Bull, provided a $446 million loan to the company in February 1993, and in October 1993 announced another cash infusion of $1.2 billion.[95] ICL (United Kingdom), has managed to remain profitable with the assistance of Fujitsu, which has taken an 84 percent interest in the company.[96]

The difficulties of European producers have occurred despite reported preferential government procurement policies and grants to help promote the success of "national champions."[97] Such policies reportedly have had the unintended effect of limiting each European firm's sales in the European market, thereby making it virtually impossible for European producers to obtain the economies of scale necessary to operate profitably in the European Market.[98] The diversity of European technical standards also has contributed to diseconomies of scale.[99] Differing product standards inhibit long production runs, thereby increasing production costs.

Although European computer hardware firms have matched U.S. and Japanese competitors by spending approximately 10 percent of their revenues on R&D, they have fallen behind their competition in technological innovation.[100] The largest European firms purchase certain components comprising the most advanced technology from U.S. or Japanese firms. For instance, Bull uses CPUs from NEC in its mainframes,[101] and IBM RS/6000 processors in its minicomputers. Olivetti sells mainframes made by Hitachi, while ICL sells Fujitsu's mainframes. Reportedly, a lack of qualified researchers contributes to this handicap. Together, Germany and France have approximately the same population as Japan, yet while Japan trains 80,000 engineers per year, Germany and France jointly train 41,000 engineers.[102] European universities also contribute much less to technological innovation than their U.S. counterparts.[103]

Several EU-wide R&D programs concentrate on new technologies. The European Union and individual national governments have earmarked over $700 million to the Joint European Submicron Silicon Initiative (JESSI) to research new generations of computer chips.[104] The European Strategic Program for Research in Information Technology (ESPRIT), in existence for more than 10 years, is credited with the seven-fold increase in international research agreements by European companies between 1983 and 1986.[105] However, marketable technological developments have yet to surface as the result of these programs.

U.S. companies have a visible presence in Europe and recently have increased their investments. In August 1990, Hewlett-Packard moved the headquarters of its PC line from Sunnyvale, California to Grenoble,

[93] U.S. DOC, ITA, *U.S. Industrial Outlook 1992*, p. 27-10.

[94] After losing $494 million in 1990, Nixdorf Computer AG joined the information business unit of Siemens-Nixdorf to form Siemens-Nixdorf Informationsysteme AG in 1991. Siemens expanded its control of the merger to 100 percent from its previous 51-percent share in March of 1992, and had hoped SNI would turn a profit in 1992. However, officials at SNI now hope to break even in 1996. Mick Elliott, "Siemens Issues Profit Warning," *Electronics Weekly*, Jan. 19, 1994; "Siemens Swallows all of SNI," *Datamation*, Feb. 1, 1992, p. 17; and Gartner Group, *Yardstick Top 100 Worldwide*, 1993, p. VIII-4.

[95] The European Commission is investigating capital infusions not approved by the body and is blocking further assistance until the matter is resolved. A decision by the European Commission is not expected until winter 1994. Nigel Tutt, "EC Seeks Third Party to Evaluate Bull Restructuring Plan," *Electronics*, July 11, 1994, p. 10. Denise Claveloux, "EU Halts Bull Aid," *Electronics*, Feb. 14, 1994, p. 14; and Denise Claveloux, "Bull Gets Last Chance," *Electronics*, Oct. 25, 1993, p. 1.

[96] ICL's purchase by Fujitsu gave ICL financial stability it previously lacked. Frederick V. Guterl, "The Datamation 100: European 25," *Datamation*, July 1, 1992, p. 71.

[97] European governments often express a financial or strategic interest in particular computer firms, referred to as national champions. These firms supply a large percentage of the domestic market, and consequently rely upon the domestic market for most revenues.

[98] The European Electronics and Information Technology Industry: State of Play, Issues at Stake and Proposals for Action, March 1991, p. 4.

[99] For further discussion on differing standards and EU attempts to alleviate the problem, see Bruno Lamborghini, "Information Technology in Europe: The Industry View," in EUROBIT, *European Information Technology Observatory*, 1993, pp. 19-20.

[100] For further information on European difficulties in computer technological innovation, see Michel Carpentier, "Information Technology in Europe: EC Commission's View," in EUROBIT, *European Information Technology Observatory*, 1993, pp. 10-11.

[101] "What Next in Computers?" *Electronics*, June 1991, p. 33.

[102] The European Electronic Component Manufacturers Association, *The European Electronics and Information Technology Industry: State of Play, Issues at Stake and Proposals for Action*, March 1991, p. 5.

[103] Ibid, p. 5.

[104] Barbara N. Berkman, "Start Up No More, Jessi gets Down to Business," *Electronic Business*, May 18, 1992, p. 69.

[105] Nigel Tutt, "Europe's Computer Industry Prepares for 1992," *Industry Report/Computers*, March 1989, p. 24.

France. Companies like Hewlett-Packard produce computer products in Europe for various reasons. Europe is the second largest computer market in the world. It is a gateway to Central Europe, and if product standardization results from the EC 1992 program, the Western European market will be more inviting to nearly all firms.[106]

U.S. TRADE MEASURES

Tariff Measures

Column-1 general tariff rates for computers, peripherals, and parts, range from free, for parts not incorporating CRTs, to 4.9 percent ad valorem for hybrid or analog computers (see table 4). Digital computers are dutiable at 3.9 percent, while parts and peripherals either enter free or at 3.7 percent general tariff rates. Analog or hybrid ADP machines have a column-2 tariff of 40 percent, while all other computer products have a column-2 tariff of 35 percent. All classifications applicable to computer products allow duty-free imports under the Generalized System of Preferences, the North American Free Trade Agreement, the Caribbean Basin Economic Recovery Act, the United States-Israel Free Trade Area, and the Andean Trade Preference Act. The Agreement on Trade in Civil Aircraft grants duty-free status to imports of all computer products except power supplies and certain miscellaneous components.[107] See appendix A for an explanation of tariff and trade agreement terms. Taking duty-free imports under these agreements into account, the average tariff rate for computer products in 1993 was 1.3 percent.

The recently completed (December 1993) GATT Uruguay Round (URA) of trade negotiations may result[108] in further reductions in U.S. and foreign duties on the articles covered by this summary. The U.S. GATT offer reduces most tariffs on computers to zero. The highest tariff (on analog or hybrid computers) was reduced from 4.9 percent to 2.4 percent, and continues to be the highest tariff rate of all computer product tariffs. The URA's effect on U.S. industry will most likely be negligible because fierce price competition and decreasing product life cycles overshadows any minor changes in U.S. trade policies.

The North American Free Trade Agreement (NAFTA), as implemented by the North American Free Trade Agreement Implementation Act (Public Law 103-182, approved Dec. 8, 1993), provided for the elimination of U.S. duties, effective January 1, 1994, on all computer products imported from Mexico. Mexico eliminated its duties on imports of some computer products from the United States effective January 1, 1994, and is obligated to phase out the remaining duties over a 5-year period. The NAFTA became effective for both the United States and Mexico on January 1, 1994. Canada previously reduced its duties on computer products to zero under the Canada Free Trade Agreement.

With respect to duty classification, inconsistencies may appear in distinguishing between computer parts and incomplete computers.[109] Higher tariffs for incomplete computers than for computer parts encourage importers to enter products as duty-free parts. Customs does not specify the exact guidelines it uses to distinguish an incomplete computer to minimize the avoidance of tariffs.[110]

From 1987-91, U.S. imports of notebook computers from Japan were subject to 100 percent-tariffs in response to Japanese non-compliance with portions of the Bilateral Semiconductor Agreement of 1986. As noted, some Japanese companies, including Matsushita Electric Industrial Co. (Matsushita) and Toshiba, moved production to the United States allegedly to avoid the tariff.

Nontariff Measures

There are very few nontariff measures that significantly affect U.S. imports of computer products. However, both U.S. and foreign computer hardware producers report that U.S. Government reliance on two separate rules of origin for procurement contracts sometimes poses problems in selling to the Government. The Buy American Act of 1933 stipulates that the U.S. Government can only purchase products made in the United States having U.S. content of 50 percent or greater. The high content of foreign components in all computer products reportedly makes compliance with this rule of origin difficult.[111] In contrast, the Trade Agreements Act (TAA) of 1979 uses "substantial transformation"[112] as its determinant

[106] Michel Carpentier, p. 12.

[107] Specifically, items that are included under HTS subheadings 8471.99.34, and 8471.99.90.

[108] The legislation currently awaits ratification by the U.S. Congress.

[109] U.S. Customs officials, phone interviews with USITC staff, Jan. 1993.

[110] This is in an effort to discourage the practice of assembling parts overseas right up to the defined cut-off point between parts and assembled product. U.S. Customs official, USITC staff telephone interview, Nov. 1993.

[111] Computer and Business Equipment Manufacturers Association, *Issue Brief: Buy American Act/Rule of Origin*, May 29, 1990.

[112] Substantial transformation is the process of sufficiently changing an imported good to produce a different final product. In the NAFTA, substantial transformation often is distinguished by a change in tariff classification. This method of determining substantial transformation is supported by the U.S. computer industry. Industry representatives, USITC staff phone interviews, March 1-10, 1994; and Computer and Business Equipment Manufacturers Association, *Issue Brief: Buy American Act/Rule of Origin*, May 29, 1990.

Table 4
Computer hardware: Harmonized tariff schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1994; U.S. exports, 1993; and U.S. imports, 1993

HTS & export subheading	Description	Col. 1 rate of duty As of Jan. 1, 1994 General	Special[1]	U.S exports, 1993	U.S. imports, 1993
				Million dollars	
8471.10.00	Analog or hybrid data automatic processing machines	4.9%	Free (A,C,CA,E,IL,J,MX)	348	10
8471.20.00	Digital automatic data processing machines, containing in the same housing at least a central processing unit and an input and output unit, whether or not combined	3.9%	Free (A,C,CA,E,IL,J,MX)	1,708	2,445
8471.91.00	Digital processing units, whether or not entered with the rest of a system, which may contain in the same housing one or two of the following types of units: storage units, input units, output units	3.9%	Free (A,C,CA,E,IL,J,MX)	5,584	3,059
8471.92.10	Combined input/output units	3.7%	Free (A,C,CA,E,IL,J,MX)	367	148
8471.92.20	Keyboards	Free		159	417
8471.92.30	Display units without cathode-ray tube (CRT), having a visual display diagonal not exceeding 30.5 cm	Free		(2)	614
8471.92.32	Other display units with color cathode-ray tube (CRT)	3.7%	Free (A,C,CA,E,IL,J,MX)		(3)
8471.92.34	Other display units	3.7%	Free (A,C,CA,E,IL,J,MX)		(3)
8471.92.36	Laser printer units capable of producing more than 20 pages per minute incorporating at least the media transport, control and print mechanisms	3.7%	Free (A,C,CA,E,IL,J,MX)	(4)	(3)
8471.92.38	Other laser printer units incorporating at least the media transport, control and print mechanisms	3.7%	Free (A,C,CA,E,IL,J,MX)	(4)	(3)
8471.92.40	Other display units	(5)		356	4,448
8471.92.42	Light bar electronic type printer units incorporating at least the media transport, control and print mechanisms	3.7%	Free (A,C,CA,E,IL,J,MX)	(4)	(3)
8471.92.44	Ink jet printer units incorporating at least the media transport, control and print mechanisms	3.7%	Free (A,C,CA,E,IL,J,MX)	(4)	(3)
8471.92.46	Thermal transfer printer units incorporating at least the media transport, control and print mechanisms	3.7%	Free (A,C,CA,E,IL,J,MX)	(4)	(3)
8471.92.48	Ionographic printer units incorporating at least the media transport, control and print mechanisms	3.7%	Free (A,C,CA,E,IL,J,MX)	(4)	(3)
8471.92.50	Display units without cathode-ray tube (CRT)	(6)		120	(7)
8471.92.52	Other assembled printer units incorporating at least the media transport, control and print mechanisms	3.7%	Free (A,C,CA,E,IL,J,MX)	(4)	(3)
8471.92.54	Other laser printer units capable of producing more than 20 pages per minute	Free		(4)	(3)
8471.92.56	Other laser printer units	Free		(4)	(3)
8471.92.58	Other light bar electronic type printer units	Free		(4)	(3)
8471.92.62	Other ink jet printer units	Free		(4)	(3)
8471.92.64	Other thermal transfer printer units	Free		(4)	(3)
8471.92.65	Printer units: assembled units incorporating at least the media transport, control and print mechanisms	3.7%(5)		(8)	2,256
8471.92.68	Other ionographic printer units	Free(5)		(4)	(3)
8471.92.70	Other printer units	Free(5)		(8)	1,079
8471.92.72	Other printer units	Free		(4)	(3)
8471.92.75	Printer units	(6)		1,438	(7)

See footnotes at end of table.

Table 4—Continued
Computer hardware: Harmonized tariff schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1994 U.S. exports, 1993; and U.S. imports, 1993

HTS & export subheading	Description	Col. 1 rate of duty As of Jan. 1, 1994 General	Special[1]	U.S exports, 1993	U.S. imports, 1993
				Million dollars	
8471.92.80	Other input or output units suitable for physical incorporation into automatic data processing machines or units thereof	Free		(8)	32
8471.92.84	Optical scanners and magnetic ink recogniton devices	3.7%	Free(A,C,CA,E,IL,J,MX)	(9)	(3)
8471.92.88	Other input or output units not suitable for physical incorporation into automatic data processing machines or units thereof	3.7%	Free (A,C,CA,E,IL,J,MX)	(8)	(3)
8471.92.90	Other input or output units, whether or not entered with the rest of a system and whether or not containing storage units in the same housing	3.7%(5)		341	505
8471.92.95	Other input and output devices	(6)		452	(7)
8471.93.10	Magnetic disk drive units for a disk of a diameter exceeding 21 cm without read-write unit assembled therein; read-write units separately entered	Free		(10)	6
8471.93.15	Magnetic disk drive units for a disk of a diameter exceeding 21 cm: units for physical incorporation into automatic data processing machines or units thereof	Free		(10)	129
8471.93.20	Other magnetic disk drive units for a disk of a diameter exceeding 21 cm	3.7%	Free (A,C,CA,E,IL,J,MX)	(10)	129
8471.93.25	Magnetic disk drive units for a disk of a diameter exceeding 21 cm	(6)		328	(7)
8471.93.30	Other magnetic disk drive units not assembled in cabinets, and without attached external power supply	Free		(10)	7,420
8471.93.40	Other magnetic disk drive units	3.7%	Free (A,C,CA,E,IL,J,MX)	(10)	279
8471.93.45	Other magnetic disk drive units	(6)		1,857	(7)
8471.93.50	Other storage units, not assembled in cabinets for placing on a table, desk, wall, floor or similar place	Free		(11)	1,167
8471.93.60	Other storage units	3.7%	Free (A,C,CA,E,IL,J,MX)	(11)	197
8471.93.65	Other storage units	(6)		918	(7)
8471.99.15	Control or adapter units	Free		805	883
8471.99.30	Power supplies	(6)		136	(7)
8471.99.32	Power supplies suitable for physical incorporation into automatic data processing machines or units thereof	Free		(12)	834
8471.99.34	Other power supplies	3%	Free(A,CA,E,IL,J,MX)	(12)	101
8471.99.60	Other units suitable for physical incorporation into automatic data processing machines or units thereof	Free		(13)	105
8471.99.90	Other units not suitable for physical incorporation into automatic data processing machines or units thereof	3.7%	Free (A,CA,E,IL,J,MX)	(13)	107
8471.99.95	Other automic data processing machines and units thereof	(6)		572	(7)
8473.30.00	Parts and accessories of the machines of heading 8471	(6)		9,909	(7)
8473.30.10	Printed circuit assemblies for ADP machines, other than for power supplies for automatic data processing machines	Free		(14)	(3)
8473.30.20	Parts and accessories of ADP machines including face plate and lock latches, of printed circuit assemblies	Free		(14)	(3)

See footnotes at end of table.

Table 4—Continued
Computer hardware: Harmonized tariff schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1994 U.S. exports, 1993; and U.S. imports, 1993

HTS & export subheading	Description	Col. 1 rate of duty As of Jan. 1, 1994 General	Special[1]	U.S exports, 1993	U.S. imports, 1993
				Million dollars	
8473.30.30	Other parts for printers, specified in additional U.S. note 2 to this chapter	Free		(14)	(3)
8473.30.35	Other parts of power supplies for automatic data processing machines: printed circuit assemblies	Free		(14)	(3)
8473.30.40	Parts and accessories of the machines of heading 8471: Not incorporating a cathode ray tube	Free(5)		(13)	11,385
8473.30.45	Other parts of power supplies for automatic data processing machines Not incorporating a cathode-ray tube (CRT): other than printered circuit assemblies	Free		(14)	(3)
8473.30.50	Parts and accessories of the machines of heading 8471: Not incorporating a cathode-ray tube (CRT): other than parts of power supplies for automatic data processing machines	Free		(14)	(3)
8473.30.80	Other parts and accessories of machines of heading 8471	3.9%(5)		(13)	153
8473.30.60	Parts and accessories of the machines of heading 8471: other parts for printers, specified in additional U.S. note 2 to this chapter	Free		(14)	(3)
8473.30.90	Other parts and accessories of the machines of heading 8471	Free		(14)	(3)

[1] Programs under which special tariff treatment may be provided, and the corresponding symbols for such programs as they are indicated in the "Special" subcolumn, are as follows: Generalized System of Preferences (A and A*); Automotive Products Trade Act (B); Agreement on Trade in Civil Aircraft (C); Caribbean Basin Economic Recovery Act (E); United States-Israel Free Trade Area (IL); Andean Trade Prefeerence Act (J and J*); and North American Free Trade Agreement, Goods of Canada (CA), Goods of Mexico (MX).

[2] Exports of all display units without cathode-ray tube (CRT) are recorded under export subheading 8471.92.50.

[3] These are new tariff classifications as of Jan. 1, 1994 and no trade occurred under these subheadings in 1993.

[4] All exports of printer units use the export classification 8471.92.75.

[5] This tariff classification was removed as of Jan. 1, 1994. However, imports during 1993 used this subheading.

[6] There is no Col. I rate of duty for this classification because it is an export number only.

[7] No HTS subheading exists for this export classification.

[8] All exports of input/output units use the export classification number 8471.92.95.

[9] All exports of optical scanners and magnetic ink recognition devices use the export classification number 8471.92.90

[10] All exports of magnetic disk drive units use the export classification number 8471.93.25 or 8471.93.45.

[11] All exports of other storage units use the export classification number 8471.93.65.

[12] All power supplies use the export classification number 8471.99.30.

[13] All exports of other ADP machines and units use the export classification number 8471.99.95.

[14] All exports of parts and accessories of the machines of heading 8471 use export classification number 8473.30.00.

Source: U.S. exports and imports compiled from official statistics of the U.S. Department of Commerce.

of origin. Recent protests have resulted in adherence tothe TAA method, but the two laws remain unchanged.[113]

U.S. Government Trade-Related Investigations

The U.S. International Trade Commission has instituted several investigations in recent years on computer products. The USITC completed a factfinding investigation under section 332 of the Tariff Act of 1930 on the competitiveness of the U.S. computer hardware industry in December 1993,[114] made a final determination in the antidumping investigation with regard to certain flat panel displays from Japan in 1991 (this determination is currently in litigation), and has instituted three unfair import practice investigations under section 337 of the Tariff Act of 1930 (table 5).

In August 1991, the USITC determined that a domestic industry was materially injured by reason of imports of certain high-information content flat panel displays and display glass from Japan. Prior to this, the U.S. Department of Commerce had found that these displays were being sold in the United States at less than fair value (LTFV). Following the USITC's determination, Commerce issued antidumping duty orders and imposed antidumping duties of 62.67 percent and 7.02 percent ad valorem, respectively, on imports of active matrix liquid crystal displays (AMLCDs) and electroluminescent (EL) displays from Japan.[115] The Commission's determination was appealed to the U.S. Court of International Trade. The court remanded the case to the USITC and directed that the USITC consider the effects of dumped imports of ELs and AMLCDs separately. On remand, the Commission found that a domestic industry was materially injured by reason of imports of AMLCDs from Japan, but not by reason of imports of EL displays.[116] Meanwhile, the U.S. Department of Commerce independently revoked the antidumping duty order on AMLCDs, but retained the EL antidumping duty.

The USITC has recently conducted three section 337 investigations with respect to computer hardware, including *Certain Sputtered Carbon Coated Computer Disks and Products Containing Same, Including Disk Drives* (investigation No. 337-TA-350),[117] *Certain Removable Hard Disk Cartridges and Products Containing Same* (investigation No. 337-TA-351), and *Certain Personal Computers with Memory Management Information Stored in External Memory and Related Materials* (investigation No. 337-TA-352). The first two investigations were terminated on the basis of a license agreement and settlement agreement, respectively. The third investigation has been terminated as the result of a judgment in a similar case in the Texas courts (Cyrix Corp. v. Intel Corp. v. Texas Instruments, No. 4:92cv52 (E.D. Texas, Sherman Division)).

FOREIGN TRADE MEASURES

Tariff Measures

Tariffs on computers, peripherals, and components are low in most countries. Singapore and Japan impose no duties, whereas the EU imposes a duty of 4.9 percent ad valorem.[118] Taiwan's duties vary from 5 to 7.5 percent, plus a .5 percent harbor tax.[119]

Only a few countries impose significant duties on computer products. Brazilian tariffs now range from 30 to 35 percent,[120] and existing fees can increase import costs by an additional 40 percent.[121] China is reducing its tariffs in 1994 from 50 percent to 20 percent, and experts predict further reductions this year.[122] Some of India's effective tariffs on computer products reached 113 percent in November 1993. India's budget for 1994-95 reduces the maximum tariff from 85 percent to 65 percent. However, there have been no reductions in India's excise taxes, which increase effective tariff rates by 30-50 percent.

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[113] Industry representatives, USITC staff phone interviews, March 1-10, 1994; and Computer and Business Equipment Manufacturers Association, *Issue Brief: Buy American Act/Rule of Origin*, May 29, 1990.

[114] U.S. International Trade Commission, *Global Competitiveness of U.S. Advanced-Technology Industries: Computers*, investigation No. 332-339, USITC publication 2705, Dec. 1993.

[115] Flat panel displays are critical to reducing the size and weight of laptop and notebook computers. USITC, *Certain High-Information Content Flat Panel Displays and Display Glass Therefor from Japan* (investigation No. 731-TA-469 (Final)), USITC publication 2413, Aug. 1991.

[116] See USITC, *Certain High-Information Content Flat Panel Displays and Display Glass Therefor from Japan; views on remand in investigation No. 731-TA-469 (Final)*, USITC publication 2610, Mar. 1993.

[117] USITC, *Certain Sputtered Carbon Coated Computer Disks and Products Containing Same, Including Disk Drives: Commission Opinion Denying Summary Determination on Jurisdiction*, investigation No. 337-TA-350, USITC publication 2701, Nov. 1993.

[118] The EU duty may decrease as a result of the GATT Uruguay Round of trade negotiations. Japan suspended its official tariff rates on computer products in 1986 and currently charges no duties on computer imports. The GATT round of negotiations may decrease Japan's official tariff rates on computers, but will have no tangible effect on actual duties collected.

[119] U.S. DOC, ITA, *Market Research Reports: Taiwan - Mainframes*, Apr. 1993.

[120] U.S. DOC, ITA, Office of Latin America, phone interview with USITC staff, Nov. 3, 1993.

[121] U.S. DOC, ITA, *Guide to Computer Hardware and Software in Latin America*, July 1990: update, table 4.1.

[122] U.S. DOC, ITA, "China - Computer Import Profile," *Market Research Reports*, Sept. 25, 1993.

Table 5
U.S. International Trade Commission investigations related to trade in computers, peripherals, and components, 1989-93

Date	Type of investigation	Product	Petitioner/ requester	Respondent/source country	Final outcome
1990[1]	Antidumping (731-TA-469)	Flat panel displays	Advanced Display Manufacturers of America	Japan	Affirmative vote, but the decision was overturned and is now in litigation.[2]
1992	General factfinding (332-339)	Computer hardware	Senate Committee on Finance	Not applicable	The report concluded that the U.S. industry remains competitive.[3]
1993	Unfair practices in import trade (337-TA-350)	Certain sputtered carbon coated computer disks and products containing same, including disk drives	Harry E. Aine	Akashic Memories Corp, San Jose, CA; Asahi Komag Co., Ltd., Tokyo, Japan; Conner Peripherals, Inc., San Jose CA.; Denki Kagaku Kogyo K.K., Tokyo, Japan; Digital Equipment Corp., Maynard, MA; HMT Technology Corp., Freemont, CA; Hoya Electronics Corp., San Jose, CA; Komag, Inc., Milpitas, CA; Maxtor Corp., San Jose, CA; Micropolis Corp., Chatsworth, CA; Mitsubishi Kasei Corp., Tokyo, Japan; Nashua Corp., Nashua, NH; Nippon Sheet Glass Co., Ltd., Tokyo, Japan; Quantum Corp., Milpitas, CA; Seagate Technology, Inc., Scotts Valley, CA; Toshiba Corp., Tokyo Japan; Tosoh Corp., Tokyo, Japan; Trace Storage Technology Corp., Hsinchu, Taiwan; Western Digital Corp., Irvine, CA; Yamaha Corp., Shizuokaken, Japan.	The investigation was settled on March 16, 1994 on the basis of a settlement agreemnet[4]
1993	Unfair practices in import trade (337-TA-351)	Certain removable hard disk cartridges and products containing same	Syquest Technology, Inc.	Nomai S.A., France and Iomega Corp., U.S.	The investigation was terminated on March 7, 1994 on the basis of a consent order agreement and a proposed consent order.

See footnotes at end of table.

Table 5—Continued
U.S. International Trade Commission investigations related to trade in computers, peripherals, and components, 1989-93

Date	Type of investigation	Product	Petitioner/ requester	Respondent/source country	Final outcome
1993	Unfair practices in import trade (337-TA-352)	Certain personal computers with memory management information stored in external memory and related materials	Intel Corp.	Twinhead Computer Corp., Taiwan; Cyrix, Inc., United States; and Advanced Micro Devices, Inc., United States	The investigation was terminated on June 6, 1994 because of the district court judgement in a related case, *Cyrix Corp. v. Intel Corp. v. Texas Instrument,* No 4:92 cv 52 (E.D. Texas, Sherman Division).

[1] Investigation was completed in 1991, but is under appeal.

[2] U.S. International Trade Commission, *Certain High-Information Content Flat Panel Displays and Display Glass Therefor from Japan*, Investigation No. 731-TA-469 (Final), USITC publication 2413, Aug. 1991; and U.S. International Trade Commission, *Certain High-Information Content Flat Panel Display and Display Glass Therefor from Japan; Views on Remand in Investigation*, investigation No. 731-TA-469, USITC publication 2610, March 1993.

[3] U.S. International Trade Commission, *Global Competitiveness of U.S. Advanced Technology Industries: Computers*, investigation No. 332-339, USITC publication 2705, Dec. 1993.

[4] Eight respondents, including Conner, Hoya, Nippon Sheet Glass Co., Seagate, Toshiba, Tosoh, Trace and Yamaha, settled previously and information on the agreement can be found in U.S. International Trade Commission, *Certain Sputtered Carbon Coated Computer Disks and Products Containing same, including Disk Drives*, investigation No. 337-TA-350, Publication 2701, Nov. 1993.

Nontariff Measures

Japan

Government procurement

The major nontariff measure present in Japan has been an informal "buy Japanese" computer-hardware policy within the Japanese Government, resulting in Japanese firms' domination of the public computer hardware market.[123] In 1985 Japan declared the public sector market fully open to competitive foreign bids. Nevertheless, there are allegations that the Japanese Government continues to source computer products predominantly from Japanese firms.[124]

Possibly as a result of this alleged practice, foreign firms have a much lower market share in Japan's public sector market than in Japan's private sector market. While non-Japanese companies account for 41 percent of Japan's private sector mainframe market, they account for less than 1 percent of the public market.[125] In 1992, U.S. firms accounted for 27 percent of the installed base of supercomputers in Japan's private sector, compared with a 10 percent share of the public sector market.[126] In fact, between 1985 to 1990, only three of 47 supercomputer purchases by the Japanese Government went to U.S. firms.[127]

In 1990, Japan and the United States modified the 1987 Supercomputer Agreement, to create the Revised Supercomputer Agreement.[128] As part of the revised agreement, the Japanese Government stated that it would "make maximum efforts" to obtain sufficient funds in its 1990 budget to ensure fair and competitive bids for supercomputers in the public sector.[129] U.S.

[123] United States Trade Representative, *1993 National Trade Estimate Report on Foreign Trade Barriers*, 1993, p. 154.

[124] Computer Systems Policy Project, *Perspectives on U.S. Technology and Trade Policy: The CSPP Agenda for the 103rd Congress*, Oct. 1, 1992, p. 10.

[125] U.S. Trade Representative (USTR), *1993 National Trade Estimate Report on Foreign Trade Barriers* (Washington D.C.: Government Printing Office (GPO), 1993), p. 154.

[126] USITC staff estimates with data from industry sources. Supercomputer purchases are much rarer than PC or mainframe installations and involve contracts of $500,000 and above.

[127] U.S. DOC, Technology Administration, *Global Markets for Supercomputers: The Impact of the U.S.-Japan Supercomputer Procurement Agreement*, Oct. 1992, p. 37.

[128] U.S. DOC, ITA, *Global Markets for Supercomputers: The Impact of the U.S.-Japan Supercomputer Procurement Agreement*, Oct. 1992, p. 36.

[129] Ryohei Murata, Ambassador of Japan, letter to Ambassador Hills dated June 15, 1990, footnoted by USITC, *Operation of the Trade Agreements Program*, USITC publication 2403, July 1991, p. 119.

supercomputer sales in the Japanese public sector have increased since the agreement, with Cray Research winning three of nine Japanese Government supercomputer contracts during 1990-91.[130]

The United States and Japan exchanged letters in January 1992 to further liberalize the Japanese public computer hardware market. The agreement, which went into effect in April 1992, is designed to give foreign and domestic firms equal access to pre-bid information, prevent Japanese suppliers from submitting unreasonably low bids, and improve non-Japanese firms' understanding of the bidding process. The agreement also encourages governments to make impartial purchasing specifications, so that they do not favor current computer hardware suppliers.[131]

Despite these agreements, U.S. firms continue to question the willingness of Japanese public agencies to buy U.S. computer products. In October 1992, Cray Research appealed to the government of Japan over Japan's National Institute for Fusion Research decision to lease an NEC supercomputer rather than a Cray supercomputer. In September 1993, Compaq filed a complaint with Japan's Ministry of International Trade and Industry to protest Japanese Government procurement practices in the personal computer market.[132]

Cultural differences

U.S. producers have had difficulty entering the Japanese computer hardware market for two additional reasons.[133] U.S. firms have been slow to develop computer products capable of imputing and processing the intricate characters used in the Japanese language.[134] Special keyboards, displays, and microprocessors are now offered by U.S. firms to accommodate the complex Japanese language. In addition, many Japanese firms continue to use proprietary computer products, which are not compatible with U.S. standards. U.S. computer hardware firms have adapted hardware to work within these proprietary standards. Japanese consumers are slowly embracing open systems, but will continue to rely upon proprietary systems for the near future.[135]

Brazil

The Government of Brazil opened its computer hardware market to imports in October 1993 by implementing a new Informatics Law. However, it is presently unclear whether proposed legislation on government procurement will allow preferential treatment of Brazilian computer hardware manufacturers to continue.[136] U.S. firms reportedly are waiting to see if this legislation, once enacted, substantially liberalizes government procurement.

U.S. MARKET

Consumption

U.S. consumption of computer products is estimated at $68 billion in 1993, averaging 8 percent average annual growth from $49 billion in 1989.[137] Because many components and most labor intensive computer peripherals such as keyboards and other input/output units are produced overseas, the U.S. import penetration ratio is quite high. Imports accounted for 56 percent of total consumption in 1993, an increase from 43 percent in 1989.[138] See table 6 for trends in production, consumption, and imports.

Computer platform downsizing is affecting competition in the U.S. industry. As noted, consumers are reducing their purchases of mainframes and minicomputers and increasing purchases of networked workstations and PCs. Because PCs are easily and inexpensively produced overseas, imports have increased over the past 5 years. Increasing competition

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[130] U.S. Department of Commerce, Technology Administration, *Global Markets for Supercomputers: The Impact of the U.S.-Japan Supercomputer Procurement Agreement*, Oct. 1992, p. 37.

[131] The previous information was compiled from several sources, although "Washington Sees Gains on Other Trade Issues," *Japan Economic Survey*, Feb. 1992, p. 4, includes a summary of the agreement.

[132] "Compaq Appeals to MITI," *Electronics Weekly*, Sept. 22, 1993, p. 10.

[133] Charles Ferguson discussed cultural factors that have diminished the use of computers in Japan at a USITC computer futures roundtable discussion on July 21, 1993.

[134] This Japanese "advantage" in the Japanese market is discussed in David B. Yoffie ed., *Beyond Free Trade: Firms, Governments, and Global Competition* (Boston, Harvard Business School Press, 1993), pp. 100-101.

[135] A discussion of competing standards and joint ventures between U.S. and Japanese computer producers to set the next operating system standard can be found in U.S. DOC, ITA, "Japan-Personal Computers," *Market Research Reports*, Jan. 1993.

[136] U.S. DOC, phone interview with USITC staff, Nov. 12, 1993.

[137] Shipment figures may overstate consumption because shipments of computer parts that remain in the United States are also included in the value of finished computer shipments. For instance, parts producers report the value of their production to the Bureau of Census. Computer manufacturers do the same, but included in the value of the completed computer is the value of the parts, which may have been purchased from one of the reporting parts producers. This double counting is impossible to avoid when analyzing shipments in both finished computer products and computer parts. USITC estimates using data presented in U.S. DOC, *U.S. Industrial Outlook*; and Bureau of the Census, *Current Industrial Reports, Computers and Office and Accounting Machines*, MA-35R, Oct. 1993.

[138] USITC staff estimates derived from data in U.S. DOC, Economics and Statistics Administration, Bureau of the Census, *Current Industrial Reports, Computers and Office and Accounting Machines*, MA-35R, Oct. 1993.

Table 6
Computer hardware products: U.S. producers' shipments, exports of domestic merchandise, imports for consumption, and apparent consumption, 1989-93

Year	Producers' Shipments[1]	Exports	Imports	Apparent consumption	Ratio of imports to consumption
	Million dollars				*Percent*
1989	49,385	21,422	21,356	49,319	43.3
1990	50,310	23,005	22,928	50,233	45.6
1991	51,967	24,001	25,986	53,952	48.2
1992	50,946	24,985	31,564	57,525	54.9
1993	55,053	25,397	37,906	67,562	56.1

[1] Estimated by the staff of the U.S. International Trade Commission.

Source: Compiled from official statistics of the U.S. Department of Commerce, except as noted.

from domestic and foreign firms has decreased the market shares of the leading U.S. computer hardware firms, as small firms worldwide take sales away from established companies. In 1993, the leading U.S. firms in the PC market, IBM, Apple, Compaq, and Dell, accounted for only 31 percent of the global market,[139] compared with a 44 percent share in 1988.[140]

Production

As a result of increasing demand for PCs and workstations, U.S. firms have reduced mainframe and minicomputer production. Increasing price sensitivity has motivated many U.S. firms to move production overseas and purchase components from foreign suppliers. These changing production patterns underlie the negative balance of trade during the past 3 years.

While intense price competition has resulted in significantly increased unit shipments of PCs and workstations, the value of total U.S. computer product shipments has increased only slightly from 1989 to 1993. Shipments of computer products reached $55 billion in 1993, a slight increase from $49 billion in 1989, averaging an annual growth rate of 3 percent. However, from 1989 to 1992 the value of PC and workstation shipments increased at an average annual rate of 7 percent while unit shipments of computer products increased by a 12 percent average compounded annual rate.[141]

U.S. Imports

Although the value of imports has risen, the composition of imports between computers, peripherals, and parts has not changed significantly since 1989. As demand for PCs and components for PCs has increased, so have imports from the countries that produce PCs and PC components. Because of established supplier networks and standard assembly operations, computer components, including disk drives and input/output devices, account for over 80 percent of total computer product imports. Trade data on each type of computer are not available because the HTS classifies all computers under the same subheading (8471.91), except portable computers, which enter the customs region under the subheading 8471.20.

Imports of portable computers, although comprising only 6 percent of total imports in 1993, have increased by an average of over 75 percent each year since 1991. Although several U.S. firms produce portable computers, many domestic firms assemble them in overseas facilities.[142] For instance, IBM's portable computers are produced in Japan by a joint venture with Toshiba. Apple claims that it manufactured its PowerBook 170 in Cork, Ireland,[143] as a result of the 63 percent tariff imposed on AMD flat panel displays from Japan. When the tariff was revoked by the Department of Commerce in 1993, Apple moved production back to its Colorado facility.[144]

[139] InfoCorp data as presented in "In PCs, Big Blue is Red Hot," *Washington Post*, Sept. 9, 1993, p. B11.

[140] International Data Corp data as presented in "Computers and Office Equipment," *Standard and Poor's Industry Surveys*, vol. 158 (June 28, 1990), p. C78.

[141] These estimates use shipment data for computers under $15,000 and therefore may include some low-cost minicomputers. USITC estimates using data presented in U.S. Department of Commerce, Bureau of the Census, "Computers and Office and Accounting Machines," *Current Industrial Reports*, MA-35R, Oct. 1993 and Dec. 1991.

[142] U.S. portable computer producers claim that the 63 percent duty imposed on imports of active matrix displays from Japan (see USITC, *Certain High Information Content Flat Panel Display and Display Glass therefor from Japan*) caused them to move production of portable computers that use the displays overseas. Shin Kusunoki, "Japan to the Rescue?" *Electronics*, Oct. 1991, pp. 27-30.

[143] Evelyn Richards, "Apple Takes Another Stab at Laptops With New Product Line," *Washington Business*, Oct. 21, 1991, p. 6.

[144] Apple representative, telephone interview with USITC staff, Oct. 1993.

According to industry sources, imports are increasing for several reasons. As more firms depend on outside sources for components, there is an incentive to produce in close proximity to components suppliers.[145] In addition, the trend away from vertical integration suggests that more U.S. firms are partly assembling their computer products overseas and doing final assembly in the United States.

Computer products containing U.S. parts sometimes enter the United States under HTS subheading 9802, under which duty is assessed only on the foreign content of the product. Computer products imported under HTS subheading 9802 accounted for 6 percent of total computer product imports in 1993. On average, 30 percent of the value of such imports was considered to be of U.S. origin and therefore entered duty free. Duty-free imports from Canada, which are subject to duty phase-out under the North American Free Trade Agreement were $845 million in 1993. Duty-free imports accounted for 36 percent of $2.3 billion in total computer hardware imports from Canada.

The majority of U.S. computer product imports are from Asian countries. Japan (34 percent), Singapore (18 percent), and Taiwan (13 percent) together accounted for 65 percent of total computer hardware imports during 1993 (see table 7). Singapore and Taiwan export more subassemblies than finished computer products to the United States and are significant microcomputer producers and exporters. Japan, also, exports mostly unfinished products.

Imports from several countries increased rapidly during 1989-93. Imports from Malaysia grew by an average annual rate of 87 percent, followed by a 42 percent average annual increase in imports from Ireland and a 29 percent average annual increase in imports from Thailand. In addition, imports from the Australia increased an average of 23 percent per year while imports from Taiwan increased 21 percent annually. Increased imports from these countries are partly the result of offshore manufacturing by U.S. firms. For instance, Digital's newest PCs are designed and partially assembled in its Taiwan plant for final assembly in the United States or other markets.[146] Other companies moved their portable computer production to Ireland, Japan, or Singapore, reportedly to escape the tariff on flat panel displays from Japan.[147]

[145] Thus, as firms move production near component suppliers, computers are more frequently imported from those regions.

[146] Brian O'Connell, "A Piece of the PC Action: Already the Fastest Growing PC Supplier, DEC Expects a Big Payoff with New PC Products and Services," *DEC Professional*, May 1993, p. 68 (3).

[147] Although Apple has moved production back to the United States, other companies have not followed suit.

Computer products are imported by manufacturing firms as well as distributors. To expand product lines, manufacturing firms often enter licensing agreements to resell other companies' computer products. Marketing agreements with foreign firms are increasing, resulting in higher levels of computer hardware imports for resale. For instance, under a recent agreement, Control Data will sell NEC supercomputers in the United States and Europe.

FOREIGN MARKETS

There are distinct differences in consumer preferences by areas of the world. While platform downsizing has decreased demand for mainframes and minicomputers and increased demand for PCs and workstations in the United States, European and Japanese customers have been slower to modify their preferences. The extent of platform downsizing in the United States has increased price sensitivity in the United States, while consumers in Europe and Japan still emphasize larger systems and have only begun to demand lower prices on PCs.

Japan

The Japanese market lags slightly behind the U.S. market in the shift to smaller computers. Mainframes are still standard due to limitations in Japanese office space. Desks in Japan are one-third the size of those in the United States, leaving little room for computers on desktops.[148] As a result, portable computers are estimated to account for more than 40 percent of Japanese PC sales.[149] In 1994, over 37 percent of U.S. households had computers compared to 12 percent of Japanese households.[150]

The Japanese computer hardware market reached an estimated $41 billion in 1993, and accounted for approximately 20 percent of the worldwide computer hardware market.[151] Market leaders in Japan are Fujitsu (23 percent), NEC (19 percent), and IBM Japan (16 percent).[152] In 1992, PCs and workstations accounted for only 33 percent of Japanese computer product sales.[153] Nevertheless, personal computer sales in Japan increased at an average annual rate of

[148] Paul Gillin, "Desktop Deprivation," supplement to *Computerworld*, Aug. 13, 1990, p. 19.

[149] "Outlook '92, Japan," *Asian Sources Computer Products*, Jan. 1992, p. 237.

[150] EIAJ, *Perspective on the Japanese Electronics Industry; 1994 Edition* (Tokyo: EIAJ, 1994), p. 9; and Electronic Industries Association, 1994.

[151] U.S. DOC, ITA, "World- Computers and Peripherals," *Market Research Reports*, Sept. 25, 1993.

[152] Dataquest data as presented in David E. Sanger, "IBM Losing Ground in Japan," *New York Times*, June 3, 1991, p. D1.

[153] Ministry of Technology and Industry of Japan, as presented by Nomura Research Institute (NRI), Nov. 17, 1993.

Table 7
Computer hardware products: U.S. imports for consumption, by principal sources 1989-93
(Million dollars)

Source	1989	1990	1991	1992	1993
Japan	8,519	8,578	9,377	11,099	12,857
Singapore	3,542	4,220	4,493	5,466	6,832
Taiwan	2,374	2,868	3,513	4,333	5,046
Canada	1,504	1,707	2,133	2,208	2,277
Korea	1,272	1,247	1,200	1,328	2,129
Malaysia	118	157	409	880	1,432
Thailand	421	492	534	834	1,158
United Kingdom	632	639	860	1,021	999
Mexico	740	671	655	863	968
Hong Kong	753	689	686	751	800
All other	1,481	1,659	2,126	2,781	3,408
Total	21,356	22,928	25,986	31,564	37,906

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

32 percent from $3.4 billion in 1990 to $7.8 billion in 1993.[154]

Unlike the U.S. and European markets, there is little import penetration in the Japanese market. While domestically produced computer products are estimated to account for over 90 percent of sales,[155] Japanese computer hardware firms supply approximately 70 percent of the market and U.S. firms in Japan account for most of the remainder. U.S. firms with large market shares in Japan have acquired their prominence by establishing a local presence. Notably, IBM has had offices in Japan since the 1920s. Products from the United States account for 78 percent of Japan's total computer hardware imports.[156]

IBM's long relationship with Japan has been instrumental in the competitiveness of its mainframes. The installed base of mainframes in Japan is dominated by Fujitsu (27 percent), IBM Japan (25 percent), Hitachi (24 percent), and NEC (12 percent), together accounting for 88 percent of the market in 1993.[157]

NEC has consistently led the PC market, holding 49 percent, followed by Apple (13 percent), IBM (7 percent), and Fujitsu (7 percent), together making up nearly 80 percent of the Japanese market in 1993.[158] According to industry sources, the introduction of DOS V into the Japanese computer hardware market, which facilitates the use of Japanese software on DOS based machines, coupled with the entry of Compaq in the PC market suggests that U.S. firms may increase their presence in the Japanese PC market in the future. Sales of PCs based on proprietary operating systems in Japan dropped 34.5 percent in 1993 and are estimated to decline 50 percent more in 1994.[159]

Many Japanese consumers perceive U.S. electronic products as inferior to Japanese products, and therefore prefer Japanese computer products.[160] In a Gallup survey conducted in the United States, Japan, and Germany, 80 percent of Japanese respondents said that the highest quality PCs were Japanese.[161] The perception of quality affects brand name recognition and loyalty. Service is also very important to Japanese customers, providing an incentive to buy from long-established companies located in Japan rather than from foreign companies. Thus, companies such as IBM and NCR,[162] with production facilities in Japan, are more successful than those attempting to import their products.[163]

Taiwan

Taiwan's computer hardware market is estimated to have reached $2.3 billion in 1993.[164] While domestic companies dominate the PC market, U.S. computer hardware firms are Taiwan's main suppliers of workstations, minicomputers and mainframes. U.S. firms account for over 80 percent of mainframe sales in

[154] USITC staff estimates from Domicity, *NEC: A Strategic Analysis*, ch. 7.
[155] U.S. Department of Commerce, ITA, "World - Computers and Peripherals," *Market Research Reports*, Feb. 1993.
[156] Ibid.
[157] Yano Research Institute data as presented by NRI, Sept. 1994.
[158] IDC Japan data as presented by John Boyd, " Battle of the Bytes," *Japan Scope*, Spring 1994, p. 54.
[159] Jonathan Friedland, "Mac Attack," *Far Eastern Economic Review*, May 12, 1994, p. 52.
[160] Theories on the reasons behind these attitudes are discussed in William R. Nester, p. 26.
[161] An International Survey of Consumers' Perceptions of Product and Service Quality (Milwaukee: American Society for Quality Control, 1991), pp. 120, 124.
[162] NCR, formerly National Cash Register, was acquired by AT&T in 1991 and is now called AT&T Global Information Solutions.
[163] U.S. industry representatives and industry analysts, USITC staff interviews, Japan, Singapore, Korea, Taiwan, Oct. 1992.
[164] U.S. Department of Commerce, ITA, "World-Computers and Peripherals."

Taiwan.[165] Experts anticipate the continued growth of U.S. sales in Taiwan and expect U.S. firms to supply at least half the computer products procured under 29 planned major public computerization projects.[166]

Unlike most markets, PC sales in Taiwan are not dominated by large multinational firms, but by many small local firms. Even major U.S. PC manufacturers such as Apple currently have less than 1 percent of the Taiwan PC market. Apple is attempting to increase its market share in Taiwan with a version of its Macintosh computer capable of using English and Chinese in the same program.[167]

Taiwan is almost totally dependent on imports for minicomputers and mainframes, which are supplied predominantly by the United States. U.S. firms have an advantage over Japanese firms because their equipment is respected for its dependability and performance levels.[168] In addition, their longstanding presence in the market has increased brand loyalty to their products.

Singapore

Unlike many developing countries in East Asia, computer products are prevalent throughout Singapore. Computer hardware can be found in more than 75 percent of businesses and 25 percent of all homes.[169] Over 90 percent of all foreign trade transactions are processed through a nationwide computer network, encouraging those who handles wish to engage in international trade to invest in computer products.[170]

The Singapore government's IT2000 plan to network the entire island by the year 2000, and similar government programs suggest that computer hardware sales will continue to grow. In 1994, Singapore's computer product sales are expected to increase by 15 percent.[171] Singapore, like Taiwan, produces mainly PCs, peripherals, and parts, and imports most of the workstations, minicomputers, and mainframes that are consumed domestically. U.S. companies benefit from perceptions that U.S. firms provide better services and software with their products than Japanese competitors. Consequently, U.S. firms supply over 50 percent of the minicomputers and mainframes.[172] Leading U.S. firms in the minicomputer and mainframe market include IBM, Hewlett-Packard, DEC, and NCR.

Growth in Singapore's PC market is estimated at 25 percent per year.[173] While IBM, Apple, Hewlett-Packard, and Compaq have a large portion of the personal computer market, low-cost suppliers based in Singapore and Taiwan dominate the low-end PC market. The market for portable computers in Singapore is led by Toshiba.

European Market

The markets of Germany, the United Kingdom, France, and Italy account for 69 percent of Europe's estimated $58 billion computer hardware market.[174] Five of the top ten suppliers to the European market are U.S. firms (see table 8). IBM, DEC, and ICL[175] are the current market leaders.[176]

Although the products sold are similar, the European market differs from the U.S. market in several ways. Price competition among suppliers in the European market is less than in the U.S. market.[177] Although price competition is increasing, the 1993 average selling price of PCs in Europe was 18 percent above the U.S. average.[178] The public sector market in Europe is relatively more important than that in the United States because it accounts for a large portion of domestic sales. According to an EU-commissioned report, the public sector's purchases of domestic products "have contributed to the survival of national competition."[179]

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[165] U.S. Department of Commerce, ITA, "Taiwan-Mainframes," *Market Research Reports*, Apr. 1993.

[166] Department of Commerce, ITA, "Taiwan - Upcoming Projects, Business Profile," *Market Research Reports*, Apr. 1993.

[167] Krista M. Conley, "Planting Another Apple," *Electronics*, July 1991, p. 12.

[168] Computer industry analysts, interviews with USITC staff, Taiwan, Oct. 1992.

[169] National Computer Board, Singapore (NCB), *A Vision of an Intelligent Island* (Singapore: SNP Pub., 1992), pp. 8, 10.

[170] U.S. DOC, ITA, "Singapore - Microcomputers," *Market Research Reports*, May 1991. For more information on the NCB's role in the computer industry and IT 2000, see NCB, *National Computer Board 1990/1991 Yearbook*.

[171] U.S. DOC, ITA, "World - Computers and Peripherals."

[172] Computer industry analysts, interviews with USITC staff, Singapore, Oct. 1992; and U.S. DOC, ITA, "Singapore - Minicomputers," *Market Research Reports*.

[173] "Rapid Growth for Asian Microcomputer Trade," *Asian Sources Computer Products*, August 1991, p. 25.

[174] Europe, in this case, includes the EU 12 countries and the 5 EFTA countries. USITC staff estimates based upon International Data Corp. Data as presented in EUROBIT, *European Information Technology Observatory 93*, pp. 213, 218, 219, 222, 229. The exchange rate used was .77 ECUs per U.S. dollar.

[175] In 1991 ICL bought Nokia, a Finnish computer company ranked sixth in European sales.

[176] Commission of the EC, *Panorama of EC Industries 1993* (Brussels: Office for Official Publications of the EC, 1993), p. 10-19.

[177] Industry representatives, USITC staff interviews, Taiwan, Korea, Hong Kong, and Singapore, Oct. 1992.

[178] USITC staff estimates using EUROBIT, *European Information Technology Observatory 94*, (Frankfurt: *European Information Technology Observatory*, 1994) pp. 335.

[179] Ibid., p. 10-15.

Table 8
Personal computers, workstations and computers: market shares in Western Europe by company, 1992, 1993

Product	Company	Percent
Personal computers	IBM	15.3
	Compaq	9.3
	Apple	8.7
	Other	66.7
Workstations	Sun	26.0
	Hewlett-Packard	22.0
	IBM	17.0
	Digital	13.0
	Other	22.0
Computers[1]	IBM	32.0
	Siemens-Nixdorf	9.0
	PC Compatibles	8.0
	Hewlett Packard	6.0
	Other	45.0

[1] Computers used in commerical enviroments only.

Source: Commission of the European Communities, *Panorama of PC Industries 94*, p. 10-17, and "PC market share: IBM increases worldwide PC market share for the first time in four years. Compaq nearly doubles revenue in 1993," *Edge: Work-Group Computing Report*, Dec. 27, 1993, p. 5.

Despite European Government involvement in the computer hardware industry, U.S. firms dominate the market. U.S. firms, many of which have significant European production, hold a 57 percent market share followed by European firms (40 percent), and Japanese companies (3 percent).[180] Imports from outside Europe account for over 30 percent of European consumption, and imports from the United States account for 8 percent of European consumption.[181] U.S. penetration is greatest in the European PC market. In 1992, PC market leaders in Europe were IBM (15.3 percent), Compaq (9.3 percent), Apple (8.6 percent), and Olivetti (6 percent).[182]

U.S. exports to Europe are affected by several factors in the European market. Competition from Asian producers of lower-cost PCs has put downward pressure on prices.[183] The recent economic downturn in Europe has adversely affected demand. U.S. firms have a long-established presence in Europe and are recognized for their quality products and service. However, as large-scale systems begin to play a smaller role in the industry, name recognition becomes less important to purchasers.

[180] Ibid., p. 10-17.
[181] These data include office machines and other information technology products. Estimates by USITC staff using EUROBIT, *European Information Technology Observatory 93*, pp. 24, 28, and 29.
[182] "PC market share," p. 5.
[183] Commission of the EC, *Panorama of EC Industries 1994*, p. 10-17.

U.S. Exports

The United States exported $25.4 billion in computer products in 1993, reflecting an annual growth rate of 4.4 percent since 1989 (table 9). Over 50 percent of all computer hardware exports were components, followed by finished computers and subassemblies (30 percent). Global market shares of selected U.S. firms for certain computer products are shown in table 10. Exports of computer peripherals account for less than 19 percent of total exports.

Exports to Thailand and Mexico grew at an average annual rate of 20 percent, while exports to Malaysia grew by a 17 percent average annual rate. Exports to Canada increased at an average of 11 percent per year and exports to the Netherlands increased by 10 percent. Exports to other major markets increased only slightly or decreased. Exports to Japan and Germany increased by less than a 1 percent and 3 percent average annual rate respectively, while exports to the United Kingdom averaged a 1 percent annual decline over the period. One contributing factor to sluggish export growth is the growing tendency of U.S. firms to manufacture in overseas facilities.

Although the United States previously restricted exports of certain computer products to former communist bloc countries, the U.S. is currently undergoing dramatic changes in its export policy. The previous organization that monitored exports to the communist countries, the Coordinating Committee for

Table 9
Computer hardware products: U.S. exports of domestic merchandise, by principal markets, 1989-93

(Million dollars)

Market	1989	1990	1991	1992	1993
Canada	2,328	3,099	3,354	3,558	3,588
Japan	2,856	3,248	3,260	3,243	2,937
United Kingdom	2,854	2,797	2,681	2,728	2,714
Germany	2,211	2,371	2,633	2,505	2,479
Netherlands	1,209	1,376	1,370	1,548	1,736
France	1,180	1,284	1,248	1,261	1,184
Mexico	563	706	825	981	1,175
Singapore	845	865	771	729	954
Australia	918	807	821	894	860
Hong Kong	386	322	385	500	614
All other	6,070	6,130	6,654	7,037	7,156
Total	21,422	23,005	24,001	24,985	25,397

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

Table 10
Selected computer products: global market shares of selected U.S. firms, 1992 and 1993

Market	Year	Company	Percent
Personal computers	1993	IBM	11.9
		Apple	8.6
		Compaq	6.6
		Dell	3.8
		Total	30.9
Workstations[1]	1993	Sun	33.4
		Hewlett-Packard	20.4
		Silicon Graphics	10.1
		IBM	10.1
		Digital Equipment	8.3
		Total	82.3
Mainframes and minicomputers	1992	IBM	33.9
		Hewlett-Packard	7.3
		Digital Equipment	5.6
		Unisys	4.0
		Total	50.8
Supercomputers	1992	Cray Research	35.5
		IBM	14.4
		Convex	8.9
		Intel	5.1
		Thinking Machines	4.8
		Total	68.7

[1] Workstation market shares are based on unit shipments.

Source: Data compiled by USITC staff.

Multilateral Export Controls (CoCom),[184] was disbanded in May 1994 due to the collapse of the U.S.S.R. and the communist governments in Central Europe. However, efforts are currently underway to form a new organization that would restrict exports to countries such as Iran, Iraq, Libya, and North Korea. Advanced technology, such as high-end workstations, was becoming more accessible from non-CoCom countries, such as Taiwan and India, and the U.S. Government was examining ways to reduce the level of restrictions on U.S. firms. The government began restructuring export regulations in September 1993, with a revised export licensing policy, increasing the processing speeds of computers that require export licenses. The proposal for revised regulations includes new rules that would raise the supercomputer export control definition over fivefold, from 195 million to 1 billion theoretical operations per second (MTOPs), thereby easing restrictions on many high-powered workstations.[185] The changes to U.S. export policy are ongoing and the results of such changes cannot be anticipated.

[184] CoCom was an organization of industrial countries including Australia, Japan and all NATO members except Iceland, that attempted to restrict technology transfer to certain regions of the world. Historically, CoCom controls on access to western technology were established with respect to China, the former U.S.S.R, Central Europe, and several other regions.

[185] Further information on the proposed reforms can be found in "Export Control Reform," *Statement of the Press Secretary*, Mar. 30, 1994.

U.S. TRADE BALANCE

The United States registered a deficit in computer product trade of $12.5 billion in 1993 (table 11). The U.S. trade balance has been in steady decline since a $77 million trade surplus was recorded in 1990. The escalating trade deficit is primarily due to increasing imports of disk drives (18 percent annual increase), input/output units (16 percent), and parts (12 percent) as firms source these computer components and peripherals from overseas subsidiaries or foreign firms.

The United States enjoys computer hardware trade surpluses with Canada and certain European countries such as Germany, the Netherlands, and the United Kingdom. In contrast, the United States has large trade deficits with many of the Asian countries, including Japan, Singapore, Taiwan, and South Korea. The declining trade balance with these Asian countries is not expected to change soon as price competitive parts are increasingly produced in these nations.

Table 11
Computer hardware products: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1989-93[1]

(Million dollars)

Item	1989	1990	1991	1992	1993
U.S. exports of domestic merchandise:					
Japan	2,856	3,248	3,260	3,243	2,937
Singapore	845	865	771	729	954
Canada	2,328	3,099	3,354	3,558	3,588
Taiwan	420	405	430	479	440
United Kingdom	2,854	2,797	2,681	2,728	2,714
Germany	2,211	2,371	2,633	2,505	2,479
Korea	560	591	576	456	532
Mexico	563	706	825	981	1,175
Netherlands	1,209	1,376	1,370	1,548	1,736
Malaysia	97	90	126	128	180
All other	7,479	7,457	7,975	8,630	8,663
Total	21,422	23,005	24,001	24,985	25,397
EU-12	9,557	9,867	9,847	10,001	9,751
OPEC	246	284	445	426	404
ASEAN	1,107	1,166	1,147	1,087	1,384
CBERA	110	98	110	145	163
Central Europe	15	28	70	132	154
U.S. imports for consumption:					
Japan	8,519	8,578	9,377	11,099	12,857
Singapore	3,542	4,220	4,493	5,466	6,832
Canada	1,504	1,707	2,133	2,208	2,277
Taiwan	2,374	2,868	3,513	4,333	5,046
United Kingdom	632	639	860	1,021	999
Germany	338	408	545	548	556
Korea	1,272	1,247	1,200	1,328	2,129
Mexico	740	671	655	863	968
Netherlands	81	72	75	82	112
Malaysia	118	157	409	880	1,432
All other	2,237	2,360	2,725	3,735	4,697
Total	21,356	22,928	25,986	31,564	37,906
EU-12	1,730	1,827	2,331	2,620	2,887
OPEC	3	2	4	43	31
ASEAN	4,114	4,944	5,510	7,365	9,591
CBERA	6	10	8	8	14
Central Europe	1	1	1	1	8
U.S. merchandise trade balance:					
Japan	-5,663	-5,330	-6,117	-7,856	-9,920
Singapore	-2,697	-3,355	-3,722	-4,737	-5,878
Canada	824	1,392	1,221	1,350	1,311
Taiwan	-1,954	-2,463	-3,083	-3,854	-4,606
United Kingdom	2,222	2,158	1,821	1,707	1,715
Germany	1,871	1,963	2,088	1,957	1,923
Korea	-712	-656	-624	-872	-1,597
Mexico	-177	35	170	118	207
Netherlands	1,128	1,304	1,295	1,466	1,624
Malaysia	-21	-67	-283	-752	-1,252
All other	5,244	5,097	5,250	4,895	3,966
Total	66	77	-1,985	-6,579	-12,509
EU-12	7,826	8,040	7,516	7,381	6,864
OPEC	259	296	461	406	399
ASEAN	-3,007	-3,778	-4,363	-6,278	-8,207
CBERA	104	89	106	143	153
Central Europe	34	55	93	141	108

[1] Import values are based on customs value; export values are based on f.a.s. value, U.S. port of export. U.S. trade with East Germany is included in "Germany" but not "Central Europe."

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

APPENDIX A
TARIFF AND TRADE AGREEMENT TERMS

The ***Harmonized Tariff Schedule of the United States*** (HTS) replaced the *Tariff Schedules of the United States* (TSUS) effective January 1, 1989. Chapters 1 through 97 are based upon the internationally adopted Harmonized Commodity Description and Coding System through the 6-digit level of product description, with additional U.S. product subdivisions at the 8-digit level. Chapters 98 and 99 contain special U.S. classification provisions and temporary rate provisions, respectively.

Rates of duty in the ***general*** subcolumn of HTS column 1 are most-favored-nation (MFN) rates; for the most part, they represent the final concession rate from the Tokyo Round of Multilateral Trade Negotiations. Column 1-general duty rates are applicable to imported goods from all nonembargoed countries except those enumerated in general note 3(b) to the HTS—Afghanistan, Azerbaijan, Cuba, Kampuchea, Laos, North Korea, and Vietnam—whose goods are dutiable at the rates set forth in ***column 2***. Goods from Albania, Armenia, Belarus, Bosnia, Bulgaria, the People's Republic of China, Croatia, the Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Mongolia, Poland, Romania, Russia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan are now eligible for MFN treatment. Among goods dutiable at column 1-general rates, particular products of enumerated countries may be eligible for reduced rates of duty or for duty-free entry under one or more preferential tariff programs. Such tariff treatment is set forth in the ***special*** subcolumn of HTS column 1. Where eligibility for special tariff treatment is not claimed or established, goods are dutiable at column 1-general rates.

The ***Generalized System of Preferences*** (GSP) affords nonreciprocal tariff preferences to developing countries to aid their economic development and to diversify and expand their production and exports. The U.S. GSP, enacted in title V of the Trade Act of 1974 and renewed in the Trade and Tariff Act of 1984, applies to merchandise imported on or after January 1, 1976 and before September 30, 1994. Indicated by the symbol "A" or "A*" in the special subcolumn of column 1, the GSP provides duty-free entry to eligible articles the product of and imported directly from designated beneficiary developing countries, as set forth in general note 4 to the HTS.

The ***Caribbean Basin Economic Recovery Act*** (CBERA) affords nonreciprocal tariff preferences to developing countries in the Caribbean Basin area to aid their economic development and to diversify and expand their production and exports. The CBERA, enacted in title II of Public Law 98-67, implemented by Presidential Proclamation 5133 of November 30, 1983, and amended by the Customs and Trade Act of 1990, applies to merchandise entered, or withdrawn from warehouse for consumption, on or after January 1, 1984; this tariff preference program has no expiration date. Indicated by the symbol "E" or "E*" in the special subcolumn of column 1, the CBERA provides duty-free entry to eligible articles, and reduced-duty treatment to certain other articles, which are the product of and imported directly from designated countries, as set forth in general note 7 to the HTS.

Preferential rates of duty in the special subcolumn of column 1 followed by the symbol "IL" are applicable to products of Israel under the ***United States-Israel Free Trade Area Implementation Act*** of 1985 (IFTA), as provided in general note 8 to the HTS. Where no rate of duty is provided for products of Israel in the special subcolumn for a particular provision, the rate of duty in the general subcolumn of column 1 applies.

Preferential nonreciprocal duty-free or reduced-duty treatment in the special subcolumn of column 1 followed by the symbol "J" or "J*" in parentheses is afforded to eligible articles the product of designated beneficiary countries under the ***Andean Trade Preference Act*** (ATPA), enacted in title II of Public Law 102-182 and implemented by Presidential Proclamation 6455 of July 2, 1992 (effective July 22, 1992), as set forth in general note 11 to the HTS.

Preferential rates of duty in the special subcolumn of column 1 followed by the symbol "CA" are applicable to eligible goods of Canada, and those followed by the symbol "MX" are applicable to eligible goods of Mexico, under the ***North American Free Trade Agreement***, as provided in general note 12 to the HTS, effective January 1, 1994.

Other special tariff treatment applies to particular ***products of insular possessions*** (general note 3(a)(iv)), goods covered by the ***Automotive Products Trade Act*** (APTA) (general note 5) and the ***Agreement on Trade in Civil Aircraft*** (ATCA) (general note 6), and ***articles imported from freely associated states*** (general note 10).

The ***General Agreement on Tariffs and Trade*** (GATT) (61 Stat. (pt. 5) A58; 8 UST (pt. 2) 1786) is a multilateral agreement setting forth basic principles governing international trade among its

signatories. The GATT's main obligations relate to most-favored-nation treatment, the maintenance of scheduled concession rates of duty, and national (nondiscriminatory) treatment for imported products; the GATT also provides the legal framework for customs valuation standards, "escape clause" (emergency) actions, antidumping and countervailing duties, and other measures. Results of GATT-sponsored multilateral tariff negotiations are set forth by way of separate schedules of concessions for each participating contracting party, with the U.S. schedule designated as Schedule XX.

Officially known as "The Arrangement Regarding International Trade in Textiles," the ***Multifiber Arrangement*** (MFA) provides a framework for the negotiation of bilateral agreements between importing and producing countries, or for unilateral action by importing countries in the absence of an agreement. These bilateral agreements establish quantitative limits on imports of textiles and apparel, of cotton and other vegetable fibers, wool, man-made fibers and silk blends, in order to prevent market disruption in the importing countries—restrictions that would otherwise be a departure from GATT provisions. The United States has bilateral agreements with many supplying countries, including the four largest suppliers: China, Hong Kong, the Republic of Korea, and Taiwan.

APPENDIX B
GLOSSARY OF SELECTED TECHNICAL TERMS

GLOSSARY OF SELECTED TECHNICAL TERMS

application software: Computer programs that enable activities such as word processing, spreadsheet analysis and database creation/updates. Computer firms conform to many hardware and software standards to insure that available application software are compatible with their products and operating systems.

binary digit (BIT): A zero (0) or a one (1) in the binary language of computers. It represents a physical memory cell, a magnetic spot on disk or tape, or a pulse of high or low voltage travelling through a circuit.

byte: Made up of eight bits, it is the common unit of computer storage in all computers. The memory in most computers is now measured by megabytes, or millions of bytes.

central processing unit (CPU): The part of the computer that computes information. A single microprocessor is the CPU in a PC while a CPU in a minicomputer or mainframe is contained on one or several printed circuit boards.

centralized processing: Processing performed by one or more computers at a principal location that receives and disperses information to dumb terminals. The computer industry is moving away from centralized processing toward distributive processing, where computations are performed both at a central location and at the PC or workstation on the desktop.

client-server: See distributive processing.

clone: A computer that is compatible with a particular machine and is designed to be as similar to the original as legally possible. Clones of the IBM PC revolutionized the computer industry by cultivating a mass market based on price competition.

component: Any hardware part that is contained within a computer, such as disk drives, power supplies, or printed circuit boards. Internal modems are not included in this report's definition of a component because the HTS classifies modems with telecommunication equipment.

computer: Usually an electronic digital machine capable of processing data using temporary or permanent internal instructions. The definition of a computer changes as the industry evolves and new technology emerges.

computer architecture: The basic design of a computer system based on the type of applications needed and the desired level of interoperability; it determines available memory, computing power, processing speed, and type of operating system. As users begin to demand interoperability and standardized products, computer architectures are starting to become more compatible.

computer platform: The hardware architecture on which computer systems are based, often defined by the processing power available at each terminal. Computer users are moving from mainframe-based computer platforms that process all information at a central location, to client-server platforms, which distribute processing capabilities to individual users.

disk drive: An internal or external storage device that allows users to extract and store information between computer uses on removable magnetic or optical disk cartridges, or on non-removable disk platters. Computer firms are constantly searching for smaller and faster disk drives to speed up the read/write process.

disk operating system (DOS): A single user operating system used in IBM and IBM-compatible PCs. Although several companies have developed operating systems to compete with DOS, over 50 percent of PCs now use DOS.

display: A video screen that shows a computer's output. Displays differ depending on the computer size and the required graphics capabilities.

distributive processing: A type of computer platform in which each computer handles its own workload while the server, which connects all of the computers, provides application programs, communication between computers, and limited memory; this is often referred to as a client-server network. Distributive processing is becoming a popular alternative to centralized processing and is the impetus behind the platform downsizing trend.

dumb terminal: An input/output unit that has no processing capability; it is attached to a central processor, usually a mainframe. Dumb terminals are becoming obsolete as mainframe systems begin to use PCs and workstations as their terminals to battle the platform downsizing trend.

flat panel display (FPD): A thin display screen that uses technologies other than cathode ray tubes. Flat panel displays are relatively new and are essential in the development of lightweight portable computers. See USITC *Certain High-Information Content Flat Panel Displays and Display Glass Therefor from Japan* (investigation No. 731-TA-469 (F)) and *Views on Remand* in Investigation No. 731-TA-469 (F).

floppy disk: A removable storage medium, also called a diskette; it is a single round disk of flexible, tape-like material that is housed in a square envelope or cartridge. The disk drive grabs the disk at its center and spins it inside its envelope.

hardware: The physical equipment in a computer system. Computer hardware is the focus of this study.

integrated circuit (IC): A collection of transistors, diodes, capacitors, and resistors attached to a silicon chip in a precise format to perform specific electronic functions. There are several types of integrated circuits, often called chips, including memory chips and microprocessors.

laptop computer: A portable computer that weighs between 7 and 12 pounds.

mainframe computers: Mainframe computers support a large number of users at one time and are primarily used by large organizations for general-purpose applications such as payroll, accounting, and decision support. Because users are moving away from centralized processing, mainframe producers are attempting to incorporate distributive processing in upcoming models.

memory: The working storage of a computer, memory determines the size and number of programs that can be run simultaneously as

well as the amount of data that can be processed instantly. As chip technology improves, computer memories expand.

microprocessor: A type of processor that is used in PCs and workstations as the CPU. Advances in microprocessors are often catalysts to new models of PCs.

million instructions per second (MIPS): A unit of measure for the processing speed of computers. MIPS is usually used to describe the speed of PCs and workstations.

minicomputers: Similar to mainframes, they serve as the central processor for multiple terminals, but generally have less processing power and memory and are available at a lower price. The market for minicomputers is shrinking as high-end workstations and low-end mainframes continue to encroach upon their market.

motherboard: The main printed circuit board in computers. It contains sockets to accept additional boards, a microprocessor, and other components. Motherboards are critical to the performance of a computer and many firms design the layout of their boards in order to incorporate the maximum amount of components on the board.

network: A system of interconnected computers, usually PCs attached to a server (local area network), or multiple computer systems connected through phone lines to a central server and information distributor (wide area network). Many new networks are being installed to replace aging mainframes, and they are contributing to the shift toward smaller computer systems.

notebook computer: A portable computer that weighs less than 7 pounds and usually incorporates a flat panel display. Notebooks are making up a larger portion of total PC sales as users begin to buy these small machines for home, office, and travel use.

open systems: Computer platforms that are designed to be fully compatible with other platforms so that companies may easily use the same software on various machines throughout their institutions. Users are encouraging the development of open systems, especially in workstations, which currently have a variety of proprietary architectures.

operating system: This software serves as the bridge between computer hardware and application software programs. While there are two standard operating systems for PCs, there are still several proprietary operating systems for workstations, mainframes, and supercomputers, making interoperability between different computers difficult. See disk operating system and UNIX.

peripheral: Any hardware device connected to a computer, such as a monitor, keyboard, or printer. Peripherals are needed in order to input information and receive feedback from computers. External modems are not included in this report's definition of a peripheral because the HTS classifies them as telecommunication equipment.

personal computer (PC): The least powerful of all computers, PCs are also called microcomputers. PCs, which include desktop computers, laptop computers, and notebook computers can run applications software such as word processing, financial analysis, and computer programming software. The popularity

	of PCs, especially attached to networks, is a major reason for the current platform downsizing trend.
platform downsizing:	The replacement of mainframes, minicomputers, or supercomputers with smaller, often less powerful machines, that are attached to a server through a network. The platform downsizing trend has caused a shift in demand from mainframes and minicomputers to PCs and workstations.
portable computer:	PCs that weigh less than 12 pounds and usually incorporate flat panel displays so that users can carry their computers wherever they go.
printed circuit board (PCB):	Flat boards that contain chips and other electronic components that necessary for computers. PCB design is essential to manufacturers because the number and size of PCBs in a computer determine the size of the computer.
semiconductor:	A solid state substance that can be electrically altered; silicon is the semiconductor used in the computer industry. Semiconductors are the building blocks used in computer design and are part of the PCBs that make up a computer.
server:	One of the central computers in a network that distributes information to and from hundreds of users, many times acting as a "traffic cop" by directing information from one user to another. Any computer can act as a server as long as it has the required processing and memory capabilities to fill the needs of its network.
software:	The instructions that tell a computer what to do. See applications software and operating system.
standard:	A widely accepted architecture, hardware, or software that facilitates interoperability between different brands of computers. As an unregulated industry, most standards are "de facto" standards that have evolved from consumer preferences and market conditions. Companies attempt to influence new de facto standards for emerging products.
supercomputers:	Large-scale computers that are distinguished from mainframe computers by their faster execution, larger memory, and generally higher prices. Historically, they have been used for scientific research and in applications requiring the processing of massive amounts of data, such as weather forecasting.
terminal:	An input/output device for a computer that usually has a keyboard for input and a video screen or printer for output. Terminals are usually attached to mainframes.
Unix:	An operating system used mainly in workstations and supercomputers that allows multi-tasking. There are several versions of Unix, and different consortia of workstation producers are attempting to establish an industry standard based on one, non-proprietary version of Unix.
workstations:	Similar in appearance to PCs and often attached to networks, these computers have greater technical analysis and computing capabilities. Although workstations were first developed for use in the engineering profession, they are now used in all industries. Workstations are also used as servers in networks as well as in attempts at parallel processing.