Computer and Electronic Product Manufacturing

(NAICS 334)

SIGNIFICANT POINTS

- Employment is projected to decline 12 percent over the 2002-12 period, mainly due to productivity improvements.
- The industry is characterized by significant research and development activity and rapid technological change.
- Professional and related personnel account for 3 out of 10 workers.

Nature of the Industry

The computer and electronic product manufacturing industry produces computers, computer-related products such as printers, communications equipment, and home electronic equipment, as well as a wide range of goods used for both commercial and military purposes. In addition, many electronics products or components are incorporated into other industries' products, such as cars, toys, and appliances.

Products manufactured in this industry include computers and computer storage devices, such as disk drives, and computer peripheral equipment, such as printers and scanners; communications equipment, such as wireless telephones and telephone switching equipment; consumer electronics, such as televisions and audio equipment; and military electronics, such as radar, communications equipment, guidance for "smart" bombs, and electronic navigation equipment. This industry also includes the manufacture of semiconductors—silicon or computer "chips," or integrated circuits—which constitute the heart of computers and many other advanced electronic products. Two of the most significant types of computer chips are microprocessors, which make up the central processing system of computers, and memory chips, which store information. Technological innovation characterizes this industry more than most others and, in fact, drives much of the industry's production. Many new products reflect a convergence of technologies. Such products include digital cameras and hand-held devices that permit wireless Internet access.

The computer and electronic product manufacturing industry differs from other manufacturing industries in that production workers account for a much lower proportion of all workers. The unusually rapid pace of innovation and technological advancement requires a high proportion of engineers, engineering technicians, and other highly technical workers to continually develop and produce new products. Likewise, the importance of promoting and selling the products manufactured by the various segments of this industry requires knowledgeable marketing and sales workers. American companies manufacture and assemble many products abroad because of lower production costs and new trade agreements.

Companies producing intermediate components and finished goods frequently locate near each other because doing so allows easier access to recent innovations. Electronic products contain many components—and sometimes even major parts, such as integrated circuits—that often are purchased from other manufacturers. As a result of having the skilled workforce that fosters product improvement, some areas of the country have become centers of the electronics industry. The most prominent of these centers is "Silicon Valley," a concentration of integrated circuit, software, and computer firms in California's Santa Clara Valley, near San Jose; however, there are electronics manufacturing plants throughout the country.

To a large extent, electronics manufacturing has become truly global, and it is difficult to characterize many companies and their products as American or foreign. The movement of foreign companies to manufacture some goods in the United States does not change the fact that many products are being designed in one country, manufactured in another, and assembled in a third. Highly sensitive and sophisticated products such as semiconductors and computers are being designed and manufactured in the United States, for example, but it remains likely that other parts of final products, such as the keyboards and outer casings, are made somewhere else and shipped to yet another site for final assembly.

Although some of the companies in this industry are very large, most are actually small. The history of innovation in the industry explains the startup of many small firms. Some companies are involved in design or research and development (R&D), whereas others may simply manufacture components, such as computer chips, under contract for others. Often, an engineer or physicist will have an innovative idea and set up a new company to develop the product. Although electronic products can be very sophisticated, it has been possible to manufacture many electronic products or components (not necessarily finished products) with a relatively small investment. Furthermore, investors often are willing to put their money behind new companies in this industry because of the history of large paybacks from some very successful companies. Success always will depend on innovation, and, although investment costs are rising, there should continue to be opportunities to develop good ideas.

The rapid pace of innovation in electronics technology makes for a constant demand for newer and faster products and applications. This demand puts a greater emphasis on R&D than is typical in most manufacturing operations. Being the first firm to market a new or better product can mean success for both the product and the firm. Even for many relatively commonplace items, R&D continues to result in better, cheaper products with more desirable features. For example, a company that develops a new kind of computer chip to be used in many

brands of computers can earn millions of dollars in sales until a competitor is able to copy the technology or develop a better chip. Many employees, therefore, are research scientists, engineers, and technicians whose job it is to continually develop and improve products.

The product design process includes not only the initial design, but also development work, which ensures that the product functions properly and can be manufactured as inexpensively as possible. When a product is manufactured, the components are assembled, usually by soldering them to a printed circuit board. Often tedious, hand assembly requires both good eyesight and coordination, as many of the parts are very small. However, because of the cost and precision involved, assembly and packaging are becoming highly automated.

Working Conditions

In general, computer and electronics manufacturing enjoys relatively good working conditions, even for production workers. In contrast to those in many other manufacturing industries, production workers in this industry usually work in clean and relatively noise-free environments. Computer chips are manufactured in "clean rooms," in which the air is filtered and workers wear special garments to prevent any dust from getting into the air. A speck of dust will ruin a computer chip.

In 2002, the rates of work-related injuries and illness per 100 full-time workers were 1.9 in computer and office equipment, 2.1 in communications equipment, 3.1 in electronic components and accessories, 5.5 in household audio and video equipment, and 1.5 in search and navigation equipment. These rates were, with one exception, lower than the 5.3 average for the private sector. However, some jobs in this industry may have risks. For example, some workers who fabricate integrated circuits and other components may be exposed to potentially hazardous chemicals, and working with small parts may cause eyestrain.

Most employees work regular 40-hour weeks, but pressure to develop new products ahead of competitors may result in some research and development personnel working extensive overtime to meet deadlines. The competitive nature of the industry makes for an exciting, but sometimes stressful, work environment—especially for those in technical and managerial occupations.

Employment

The computer and electronic product manufacturing industry employed 1.5 million wage and salary workers in 2002 (table 1). Few workers were self-employed.

The industry comprised about 21,000 establishments in 2002, many of which were small, employing only one or a few workers. Large establishments of 250 workers or more employed the majority—63 percent—of the industry's workforce (see chart).

Under the new North American Industry Classification System (NAICS), workers in R&D establishments that are not part of a manufacturing facility are included in a separate industry—research and development in the physical, engineering, and life sciences. However, due to the importance of R&D work to the computer and electronic product manufacturing industry, computer and electronic product-related R&D is discussed in this statement even though a large proportion of the associated workers are not included in the employment data.

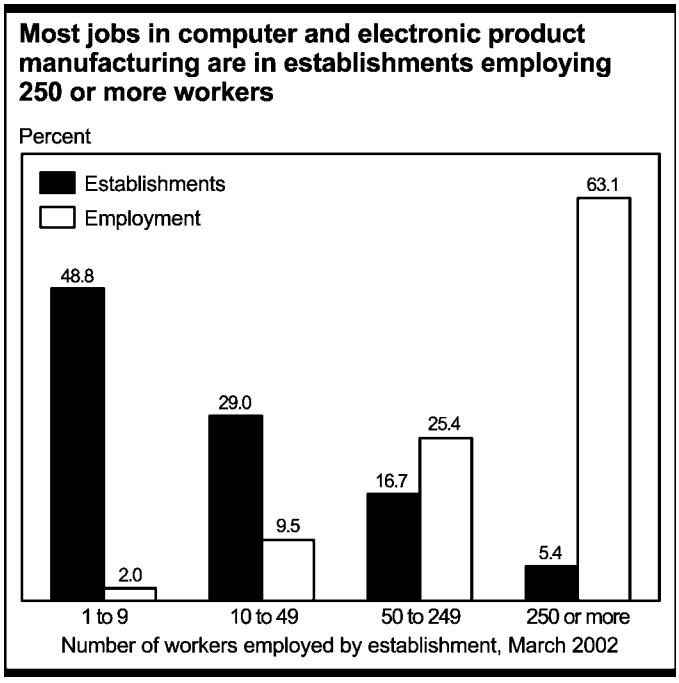
Table 1. Distribution of wage and salary employment in computer and electronic product manufacturing by industry segment, 2002
(Employment in thousands)

Industry segment	Employment	Percent
Total, computer and electronic product manufacturing	1,521.2	100.0
Semiconductor and other electronic components	531.4	34.9
Navigational, measuring, electromedical, and control instruments	450.6	29.6
Computer and peripheral equipment	249.8	16.4
Communications equipment	190.9	12.5
Manufacturing and reproducing magnetic and optical media	56.9	3.7
Audio and video equipment	41.6	2.8

Occupations in the Industry

Given the importance of R&D to the industry, it is not surprising that a large proportion—about 3 in 10—of all workers are in professional and related occupations (table 2). About 12 percent of these are engineers—predominately *electrical and electronics engineers* and *computer hardware engineer*s, but also including many *industrial* and *mechanical engineers*. These workers develop new products and devise better, more efficient production methods. Engineers may coordinate and lead teams developing new products. Others may work with customers to help them make the best use of the products. *Computer systems analysts, database administrators, and computer scientists* are employed throughout the industry as both development and production methods become more computerized. Other professionals include *mathematical* and *physical scientists*, and *technical writers*.

About 6 percent of workers are *engineering technicians*, many of whom work closely with engineers. They help develop



new products, work in production areas, and sometimes help customers install, maintain, and repair equipment. They also may test new products or processes to make sure everything works correctly.

Despite the relatively high proportion of professional and technical workers in electronics manufacturing, more than 3 out of 10 employees are production workers. Many are assemblers, who place and solder components on circuit boards, or assemble and connect the various parts of electronic devices. *Semiconductor processors* initiate and control the many automated steps in the process of manufacturing integrated circuits or computer chips. *Electrical and electronic equipment assemblers* are responsible for putting together products, such as computers and appliances, telecommunications equipment, and even missile control systems. Some assemblers are highly skilled and require significant experience and training to assemble major components. A skilled assembler may put together an entire subassembly, or even an entire product, especially when products are made in relatively small numbers. Other, less skilled assemblers often work on a production line, attaching one or a few parts and continually repeating the same operation. Increasingly, as production work becomes more automated, assemblers and other production workers monitor the machinery that actually does the assembly work. *Inspectors, testers, sorters, samplers*, and *weighers* use sophisticated testing machinery to ensure that devices operate as designed.

About 14 percent of workers in the industry are in management, business, and financial operations occupations. In this industry, top management is much more likely to have a technical background than are its counterparts in other industries. This is especially true in smaller companies, which often are founded by engineers, computer scientists, or other technical professionals.

About 14 percent of workers in this industry hold office and administrative support or sales and related jobs. Sales positions require technical knowledge and abilities and, as a result, engineers and technicians often may find opportunities in sales or sales support.

Training and Advancement

Workers with different levels of education find employment opportunities in the computer and electronic product manufacturing industry. Entry to engineering occupations generally requires at least a bachelor's degree in engineering, although those with 4-year degrees in physical science, computer science, or other technical areas can sometimes qualify as well. Some positions, however, may require a master's degree or higher, or relevant work experience. Computer systems analysts or scientists usually need a degree in computer science or a related field and, in many cases, they also must have considerable programming experience. Because companies often are founded by professionals with technical backgrounds, opportunities for advancement into executive or managerial positions may arise for experienced workers who keep up with rapid changes in technology and possess the business expertise necessary to succeed in the rapidly changing economy.

Training for engineering technicians is available from a number of sources. Although most employers prefer graduates of 2-year postsecondary training schools—usually technical in-

Table 2. Employment of wage and salary workers in computer and electronic product manufacturing by occupation, 2002 and projected change, 2002-12
(Employment in thousands)

Occupation	Employment, 2002 Number	Employment, 2002 Percent	Percent change, 2002-12
All occupations	1,521	100.0	-12.4
Management, business, and financial occupations	218	14.3	-6.6
Top executives	27	1.7	-7.2
Marketing and sales managers	20	1.3	-3.3
Industrial production managers	16	1.0	-7.1
Engineering managers	28	1.8	-8.2
Buyers and purchasing agents	21	1.4	-10.4
Financial specialists	24	1.5	-8.9
Professional and related occupations	476	31.3	-7.7
Computer programmers	15	1.0	-23.4
Computer software engineers, applications	35	2.3	-4.9
Computer software engineers, systems software	41	2.7	-0.6
Computer support specialists	18	1.2	-4.0
Computer hardware engineers	28	1.8	-16.2
Electrical engineers	37	2.4	-13.5
Electronics engineers, except computer	38	2.5	-6.5
Industrial engineers	24	1.6	-7.6
Mechanical engineers	21	1.4	-12.4
Engineering technicians, except drafters	92	6.1	-5.8
Life, physical, and social science occupations	17	1.1	-11.0
Sales and related occupations	45	2.9	-6.6
Sales representatives, wholesale and manufacturing	27	1.8	-6.9
Office and administrative support occupations	170	11.2	-16.9
Financial clerks	19	1.2	-19.3
Customer service representatives	16	1.0	-3.5
Production, planning, and expediting clerks	20	1.3	-2.2
Shipping, receiving, and traffic clerks	22	1.4	-18.0
Secretaries and administrative assistants	30	2.0	-21.3
Office clerks, general	16	1.0	-21.0
Installation, maintenance, and repair occupations	44	2.9	-7.3
Electrical and electronic equipment mechanics, installers, and repairers	15	1.0	-9.9
Industrial machinery installation, repair, and maintenance workers	20	1.3	-6.7
Production occupations	519	34.1	-18.8
First-line supervisors/managers of production and operating workers	35	2.3	-6.0
Electrical and electronic equipment assemblers	160	10.5	-27.8
Electromechanical equipment assemblers	22	1.4	-20.6
Team assemblers	72	4.7	-21.3
Machinists	16	1.0	-9.5
Inspectors, testers, sorters, samplers, and weighers	43	2.8	-15.6
Semiconductor processors	44	2.9	-12.7
Transportation and material moving occupations	35	2.3	-9.6
Laborers and material movers, hand	27	1.8	-11.4

NOTE: May not add to totals due to omission of occupations with small employment.

stitutes or junior colleges—training in the U.S. Armed Forces or through proprietary schools also may meet employer requirements. Engineering technicians should have an aptitude for math and science. Entry-level technicians may begin working with a more experienced technician or engineer. Advancement opportunities for experienced technicians may include supervisory positions or movement into other production and inspection operations.

Though assembly workers generally need only a high school diploma, assemblers in the computer and electronic product manufacturing industry may need more specialized training or experience than do workers in other manufacturing industries. Precision assembly work can be extremely sophisticated and complex, and some precision assembly jobs may even require formal technical training. A 1-year certificate in semiconductor technology is good preparation for semiconductor processor operator positions; for more highly skilled technician positions, an associate degree in electronics technology or a related field is necessary. Again, advancement opportunities depend not only on work experience, but also on the level of technical training and the ability to keep up with changing technology.

Earnings

In general, earnings in the computer and electronic product manufacturing industry are high, although this is partly because many of the lower wage production jobs have been automated or exported to other countries. Average weekly earnings of all production or nonsupervisory workers in the industry were $643, higher than the average of $506 for all industries in 2002 (table 3).

Table 3. Average earnings of nonsupervisory workers in the computer and electronic product manufacturing industry, 2002

Industry segment	Weekly	Hourly
Total, private industry	$506	$14.95
Computer and electronic products manufacturing	643	16.19
Computer and peripheral equipment	799	19.64
Search, detection, and navigation instruments	732	18.37
Electronic instruments	657	16.65
Semiconductors and electronic components	611	15.32
Communications equipment	601	15.69
Audio and video equipment	508	13.28

Earnings in selected occupations in several components of the computer and electronic product manufacturing industry in 2002 appear in table 4.

Outlook

Wage and salary employment in the computer and electronic product manufacturing industry is expected decline by 12 percent between 2002 and 2012, compared with a 16 percent projected increase in all industries. Although the output of this industry is projected to increase more rapidly than that of any other industry, employment will still decline as a result of continued rapid productivity growth—the ability of the industry to produce more and better products with fewer employees. Employment also will be adversely affected by continued increases in imports of electronic and computer products, and by a more recent trend—outsourcing of some professional functions, such as computer programming and engineering, to lower-wage countries. Despite the overall projected decrease in employment, the technological revolutions taking place in computers, semiconductors, and telecommunications, as well as the need to replace the many workers who leave the industry due to retirements or other reasons, should continue to provide many employment opportunities in this industry, especially in research and development. Products of this industry, especially powerful computer chips, will continue to enhance productivity in all areas of the economy.

Table 4. Median hourly earnings of the largest occupations in computer and electronic product manufacturing, 2002.

Occupation	Computer and electronic product manufacturing	All industries
Computer software engineers, systems software	$38.36	$35.60
Computer software engineers, applications	37.53	34.09
Electronics engineers, except computer	34.15	33.62
Electrical engineers	34.10	32.78
First-line supervisors/managers of production and operating workers	22.62	20.64
Electrical and electronic engineering technicians	19.04	20.65
Inspectors, testers, sorters, samplers, and weighers	13.55	13.01
Semiconductor processors	13.16	13.14
Electrical and electronic equipment assemblers	11.19	11.03
Team assemblers	10.77	10.90

The projected change in employment over the 2002-12 period varies by industry segment (table 5). Although demand for computers should remain relatively strong worldwide, employment is expected to decline 27 percent in computers and peripheral equipment and 15 percent in semiconductor and other electronic component manufacturing due to the introduction of new technology and automated manufacturing processes, and due to a slowdown in growth of output in these segments from previously high levels. These segments also will continue to face strong import competition. Employment in navigational, measuring, electromedical, and control instruments manufacturing also is expected to decrease 12 percent due to automation of the production of increasingly sophisticated equipment. Employment in audio and video equipment manufacturing also is expected to decrease, by 8 percent, largely due to continued import competition as well as productivity improvements. However, employment in communications equipment manufacturing is expected to increase 5 percent due to strong demand and rapid technological developments such as wireless phones. Ownership of wireless phones has grown quickly in recent years; continuing improvements in quality and services should lead to

even greater growth between 2002 and 2012. The only other segment expected to increase employment, by 11 percent, is the manufacturing and reproduction of magnetic and optical media.

Table 5. Projected employment change in computer and electronic product manufacturing by industry segment, 2002-12

Industry segment	Percent change
Total, computer and electronic product manufacturing	-12.4
Computer and peripheral equipment	-27.1
Communications equipment	5.5
Audio and video equipment	-7.7
Semiconductor and other electronic components	-14.9
Navigational, measuring, electromedical, and control instruments	-12.2
Manufacturing and reproducing magnetic and optical media	11.1

Among occupations in the computer and electronic product manufacturing industry, there should be a smaller decrease in employment among professional and related occupations than most other occupations in the industry. However, use of the Internet and other new forms of communication makes it possible for engineers and other professionals working in other countries to do much design and other work that previously was done in this country. Some of these workers are directly employed by U.S. companies and others work for contractors engaged by domestic companies. Because the earnings of professional workers in many countries are much less than earnings in this country, the trend toward hiring foreign workers undoubtedly will accelerate, especially as companies gain more experience and confidence in the use of these workers. While this trend undoubtedly will negatively affect professional worker employment, there still will be numerous jobs in this country that cannot be exported.

Employment of production occupations is expected to decline more rapidly than that of the industry as a whole, as more jobs are lost to technological innovation. However, the numbers of semiconductor processors will decline at a slower rate than that of other production occupations.

The computer and electronic product manufacturing industry is characterized by rapid technological advances and has grown faster than most other industries over the past several decades, although rising costs, imports, and the rapid pace of innovation continue to pose challenges. Certain segments of the industry and individual companies often experience problems. For example, the industry occasionally undergoes severe downturns, and individual companies can run into trouble—even those in segments of the industry doing well—because they have not kept up with the latest technological developments or because they have erred in deciding which products to manufacture. Such uncertainties can be expected to continue. In addition, the intensity of foreign competition and the future role of imports remain difficul to project. Import competition has wiped out major parts of the domestic consumer electronics industry, and future effects of import competition depend on trade policies and market forces. The industry is likely to continue to encounter strong competition from imported electronic goods and components from countries throughout Asia and Europe.

As defense expenditures are expected to increase, sales of military electronics, and important segment of the industry, will likely pick up. Furthermore, firms will continue developing new products, creating large new markets as they have in the past. Smaller, more powerful computer chips are continually being developed and incorporated into an even wider array of products, and the semiconductor content of all electronic products will continue to increase. The growth of digital technology, artificial intelligence, multimedia applications, and the expansion of the Internet and demand for global information networking will continue to create new opportunities.

Sources of Additional Information

Information on the electronics industry, including publications, salary surveys, and education and training, is available from:

- American Electronics Association, The Center for Workforce Excellence, 5201 Great America Pkwy., Suite 520, Santa Clara, CA 95054. Internet: **http://www.aeanet.org**

For information on technology and other aspects of the electronics industry, contact:

- The Electronic Industries Alliance, 2500 Wilson Blvd., Arlington, VA 22201. Internet: **http://www.eia.org**

Information on these occupations may be found in the 2004-05 *Occupational Outlook Handbook*:

- Assemblers and fabricators
- Computer hardware engineers
- Computer software engineers
- Computer systems analysts, database administrators, and computer scientists
- Electrical and electronics engineers, except computer
- Engineering and natural sciences managers
- Engineering technicians
- Semiconductor processors