The software and engineering industries: threatened by technological change?

Since 1990, job growth has slowed in the engineering and software industries; many factors contributed to the slowdown, including reduced defense spending and more automated processes achieved through highly sophisticated software

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The computer services industry, which includes the makers of computer software, and the engineering industry, which designs a vast range of physical products, are similar in that both partake of the important role of originating and changing technology. Therefore, jobs in the two industries depend, to a great extent, on technological progress. Ironically, technology also may *reduce* the number of careers in these industries, as advanced computer tools decrease the amount of labor required to design a product, be it largely intellectual (as in the case of a software application) or physical (as in the case of a new weapon, a household appliance, or an office product). A variety of advanced computer tools are already widely used in the two industries and in some cases drastically reduce the requirements for labor. Jobs in the two industries, then, depend on technological progress for their existence, yet are vulnerable to technologically enhanced efficiency.[1]

At least one additional consequence of technological progress is highly relevant to job growth or loss in the two industries: advances in communications technologies, including links between computers, now make it much more practical to have programming or engineering performed overseas; as a result, both foreign competition for the business of U.S. clients and sales of U.S. services abroad have increased.

Certain social and political changes also have a considerable impact on the number of jobs in the two industries. For example, during the cold war, the development of advanced weapons contributed strongly to increasing demand for engineering and computer services.[2] With the end of the war, advanced weaponry became less of an influence on demand. Recently, corporate downsizing has been a major influence on the number of jobs in the two industries,[3] but not in the way one might think initially, as a later section will explain.

Since 1972, the combined number of jobs in the engineering and computer services industries has increased by more than 300 percent, to about 1.9 million. Jobs in engineering and architectural services (primarily engineering) increased by about 140 percent, to a level of 800,000. Jobs in computer services increased to about 10 times their number in 1972, reaching 1.0 million in 1995. But trends during the period of more than two decades have not been steady, with a severe slowdown in growth occurring in recent years.

This article describes the nature of the two industries in some detail, explains the major developments that affect employment in the industries, and examines the impact of those developments on the number of jobs in engineering and computer service firms.

What the industries produce

Engineering services exhibit great variety. Engineering firms may design ships, boats, machines of any kind (including machine tools used in factories to produce other products), advanced weapons, public works such as bridges or public utilities, petroleum extraction systems, airplanes, or any of the components of such products.[4] The engineering industry derives income, employment, and growth from a broad range of services for a broad range of clients.[5] Table 1 indicates the distribution of the industry's sales among the various types of clients.

Variety also characterizes the *computer services* industry, which includes custom computer programming for specific clients, typically from the corporate or government sector. The industry also includes prepackaged software companies, which develop and mass-produce software sold in stores or installed in computers prior to sale, for business or individual use. Widely sold, mass-produced software ranges from amusements for children and adolescents to high-powered business applications. Computer integrated systems design, which entails both selecting hardware and developing software to make a custom system, is included as well, as are information retrieval systems for quickly disseminating news or specialized information (for example, the Dow-Jones News Retrieval Service and companies such as CompuServe, which provide public access to the Internet). Computer-related consulting, custom data-processing services, and other services are also provided by the industry.[6]

Technically as well as economically, the engineering and computer services industries have much in common. When advanced products such as military aircraft or space vehicles are engineered, a great deal of software is generated in the process, so that much of the activity in engineering resembles that of custom software design. In fact, some of the same types of highly sophisticated computer software are usable in both industries.

Table 1. Demand for computer services and engineering services, by purchaser's industry, 1993

[In billions of dollars]

Purchasing industry group	Purchases of— Computer services	Purchases of— Engineering services
Mining	$0.4	$0.8
Construction	.0	37.9
Manufacturing	6.0	5.8
Transportation, communications, and utilities	9.0	2.2
Wholesale trade	.8	.4
Retail trade	5.2	.2
Finance, insurance, and real estate	34.3	1.4
Services	45.6	5.9
Defense[1]	3.2	6.1
Government enterprise[2]	.5	3.5
State and local government[1]	9.1	([3])
Personal consumption[1]	2.1	([4])

[1] Final demand, as opposed to use in making a product or service.
[2] Includes only those government entities, such as the Postal Service, which sell a product or service.
[3] Not available.
[4] Approximately zero.
SOURCE: Derived from tables provided by the Office of Employment Projections, Bureau of Labor Statistics.

Causes of change in employment

Computer services and engineering have been far from static in recent years, in terms of both technology and economics. Perhaps the most obvious economic development in the two industries is their enormous, if decelerating, growth. From 1972 to 1995, employment in computer services increased by 913 percent, and employment in engineering and architectural firms increased by 140 percent. (Employment in all nonagricultural jobs increased by 59 percent during that time.) Growth in computer and engineering services has been driven especially by increased demand from various service-producing industries and government entitities, including defense and government enterprises (those government organizations, such as the Postal Service, which sell a product or service). In recent years, many service-producing industries have undergone major technological changes that have increased the industries' need for computer and engineering services. The enormous growth of automatic teller machines is one familiar example. (Information on some of the many technological changes in service industries can be found in other articles in this issue of the *Review*.)

While there is virtually no direct demand from consumers for engineering services, demand from consumers for computer services, which include individuals' purchases of software and household subscriptions to Internet servers, increased from virtually none in 1977 to $2 billion in 1993. Still, consumers' purchases of computer services remained less than 2 percent of the industry's output through 1993.[7]

As previously mentioned, employment in both industries largely depends on technological progress, yet is vulnerable to technologically enhanced efficiency. *Advanced computer tools* already in widespread use include computer-aided design (CAD), computer-aided software engineering (CASE), and artificial intelligence (AI). But measuring their impact on employment in the two industries is not simple, as we will see.

Aside from the double-edged influence of advancing computer technology, *other consequences of technological progress* affect the number of jobs in the industries. Because of progress in communications technologies, such as FAX and improved telephone links, it is now more practical than ever to have engineering or computer systems design performed far from the site at which the product will be used, even overseas.[8] Advances in communications, therefore, imply both a greater threat of low-priced foreign competition for projects in the United States and a larger potential market for U.S. services. For example, as stated in an article in from EIU Viewswire:

> In the past few years India has gained a reputation as a useful offshore base for software development. Firms such as Texas Instruments, IBM, Motorola, Bull and Deutsche Bank all have operations in Bangalore, the country's Silicon Valley. Foreign companies have recently been looking to India as a base for engineering and R&D support services as well. The main draw is the ready availability of extremely cheap and well-educated engineering talent.[9]

The U.S. media have expressed much fear of foreign competition; but as we will see, the relationship between imports and exports of these services has more complex implications than some have been led to believe.

Political and social changes have strong effects on the trends of employment in engineering and computer services. Reductions in U.S. defense spending in the area of advanced weapons are relevant to the overall amount and types of demand for engineering and computer services. Toward the end of the cold war, in 1987, defense spending—especially the development of advanced weapons—was responsible for 11 percent of the sales of engineering services and 5 percent of the sales of computer services. The development of high-tech weapons then declined substantially.

The reductions in U.S. defense spending resulting from the end of the cold war may translate into greater progress in civilian technology as technological resources become more available for nondefense purposes. Indeed, certain Government-initiated programs that stimulate the development of nonmilitary technology have already begun. For example, the Department of Commerce's Advanced Technology Program and the Pentagon's Technology Reinvestment Project, the latter of which is designed to stimulate technologies with both military and civilian applications, fund numerous technological research projects conducted by a large number of companies and universities. Still, one authority comments, "These levels of [Government] funding are not insignificant, but compared to the military R&D pipeline in recent years, they are a mere trickle; at best, they are seeds that will take time to grow."[10]

Corporate downsizing is another factor relevant to employment in the computer services and engineering industries.[11] As manufacturing companies cut back, laying off engineers as well as other workers, engineering firms may be needed more often to perform engineering projects that otherwise would go to manufacturers' own engineers. Engineers laid off from manufacturing corporations may respond by starting their own small engineering businesses, thus moving from the goods-producing sector to the service-producing sector and, if they hire employees, adding to employment in engineering services.

Aside from the downsizing issue, the broader question of *the extent to which companies in general hire their own engineers or computer professionals, as opposed to using the services of firms specializing in these fields,* is crucial to employment in the computer services and engineering industries. Temporary help supply services and employee-leasing firms that provide engineers or computer experts also, in effect, compete for work with engineering or computer services firms. An entirely different form of competition that, according to some sources,[12] has already thrown vast numbers of engineers out of work, will be discussed next.

Computer tools

As more and more sophisticated hardware and software ease the requirements for labor in other industries, computers are developing impressive capabilities for use in both engineering and software development itself. At least as early as 1984, workstations and associated software were recognized as valuable in engineering for improving productivity.[13] Software for computer-aided design/computer-aided manufacturing (CAD/CAM) has proven particularly significant in this regard. By 1987, CAD was "fulfilling its design potential by linking the geometric shapes on a workstation screen to the rules of engineering and physics that determine whether a part will survive testing as a prototype."[14] According to one authority, "Civil engineers tell us that the development of CAD/CAM systems means that one skilled senior professional can accomplish the same amount of work that used to require teams of six to twelve degreed professionals."[15]

Computer-aided software engineering, or CASE, is usable both in the development of software for a specific engineering project and in the development of software applications for sale to the public. Like "CAD/CAM," "CASE" is a generic term rather than the name of a specific software package. CASE software is used to automate parts of the process of making software.[16] While CASE has not been able to generate perfect code without human assistance, it does have certain limited uses. CASE reportedly was introduced in 1987,[17] and in 1989 it was estimated that "thousands of medium and large enterprises . . . [were] using CASE products as part of their system building process."[18] "Upper" CASE products are used in the overall design of a software package, while "lower" CASE products are used to test and debug specific pieces of code.[19]

The use of CASE has ranged from disappointing to clearly beneficial. Studies have provided empirical evidence that CASE does improve the productivity of software developers if it is used well. The consistency with which CASE tools are used among members of teams and the degree of integration between CASE and other software used in a project are reportedly key to the effective use of CASE.[20]

More recently, various forms of artificial intelligence (AI) have become prominent in software design and engineering. Like all other types of computer systems, AI depends initially on exact, explicit instructions to the computer; but at least some types of AI can generate their own rules for drawing conclusions and can improve their performance with experience. According to *Business Week*, "AI is alive and well in thousands of applications in commerce, industry, and the professions. More than 70% of America's top 500 companies are using it."[21] AI has been used in engineering problems, as well as in the software industry.[22]

Greater automation, of course, should result in increased labor productivity, which in turn should reduce the need for workers to produce a certain level of output. But the study of productivity in service-sector industries involves difficult questions.

The productivity issue

Quantifying labor productivity changes, arising from computerization or any other factor, is difficult at best in many service-producing industries. The issue of whether there has been an improvement in the quality of the product or service, and if so, how to measure the dollar value of the improvement is perhaps the most serious problem. If productivity measures are to be comparable over time, dollar output figures used to estimate production should be adjusted for both changes in prevailing prices of the product and any improvements in the quality of the product. But the dollar value of some improvements is difficult or impossible to determine. The user-friendliness of software applications is a good example of a clearly improving quality that can be difficult to quantify in dollars. In regard to engineering, the value of plans produced by engineering firms increases with the quality of the products produced from those plans to the extent that improvements in those products result from better engineering. Price adjustments for engineering services, then, should reflect such increasing value whenever it exists. Unfortunately, however, improvements in products include qualities that are hard to quantify in economic terms, such as the improved sound of a modern stereo system. Because of this quantification problem, the BLS Office of Productivity and Technology does not publish any labor productivity rates for either the software industry or the engineering industry.[23]

Despite the absence of quantitative proof, it is believed that vast increases have occurred in the quality of software and engineering. The improvements are believed to have resulted in large gains in the value of software and engineering products and, consequently, greater productivity among software producers and engineers. Perhaps the most striking improvement in software in recent years has been its increased user-friendliness. Aside from making the use of software more pleasurable (a result whose dollar value is especially difficult to determine), user-friendliness, by reducing the time spent learning to use an application and by moderating the need for assistance from experts, results in greater efficiency on the part of workers in industries buying the software. Similarly, improvements in engineering result in superior manufactured products. For example, the tremendous increases in the efficiency and capability of today's desktop computers, as opposed to those of 5 or 10 years ago, reflect improved hardware design.

Although the trends in productivity in the two industries probably would be highly favorable if improvements in quality were reflected in some economic measure, certain problems that have caused inefficiencies in the workplaces of the industries have been identified; and some of these problems are increasing. CASE tools are not used by all software developers. Says one authority, "The case against CASE simply may be that we haven't given it a decent chance or time frame to succeed."[24] Undocumented or poorly documented code takes time to be understood when software is being replaced. "Simply figuring out what existing code, often poorly documented, is supposed to do"[25] can take up as much as 40 percent of a programmer's time "in the CASE model for software development and maintenance."[26] A lack of compatibility among increasingly numerous software products and programmers' expenditures of time in learning to use them are perhaps the most serious problems affecting labor productivity in software. These problems tend to increase as more and more software tools are produced.

Because engineering projects often entail software development, the same problems are likely to affect projects in the engineering industry. Furthermore, the transition from weapons development to peacetime technology entails some reorientation among engineers and may cause a temporary reduction in their efficiency.

International trade

U.S. media have shown a great deal of concern about foreign competition threatening our sophisticated service industries, including engineering and software.[27] As previously noted, modern communications technologies facilitate engineering or programming being performed continents away from the site of installation. So far, import and export data show that the United States has had a rapidly growing trade surplus in computer services. Trends in engineering and related services also are, in general, highly favorable.

International trade is divided into two types of transactions: cross-border sales and sales by affiliates. Cross-border transactions are sales between a buyer residing in one country and a seller in another country. For example, a U.S. manufacturer whose business is located entirely in the United States might have computer programming performed by an Indian company in India.

Sales by affiliates occur when a company of one country establishes a plant or other work site in another country—for example, when a Toyota factory in the United States sells cars to Americans or when Exxon extracts oil in foreign waters. Because sales by affiliates typically involve the use of local labor and materials, their economic impact on the two countries affected is not the same as in cross-border transactions, assuming that all other factors are unchanged. For example, when a Japanese make of automobile is assembled in the United States, its sale here is more advantageous to the U.S. economy than when the product is assembled in Japan, all other factors being equal.

Although imports of computer services have grown rapidly, exports have increased far more. Trends in trade balances in both cross-border transactions and affiliated sales of computer services have been highly favorable. (See table 2.) The U.S. trade surplus in cross-border transactions of computer services increased by $1.2 billion from 1986 to 1994, and the Nation's surplus in affiliated sales increased by $6.1 billion from 1987 to 1993.

In cross-border transactions of industrial engineering, the U.S. surplus increased by about $100 million from 1986 to 1994 as a result of fairly flat imports and growing exports. Trends in cross-border trade of construction, nonindustrial engineering, architectural, and mining services, taken together, also show flat imports and growing exports. (Figures for nonindustrial engineering alone are not available.) The U.S. trade surplus in nonindustrial engineering and related services increased by about $2 billion from 1986 to 1994. The trade surplus in affiliated sales of engineering, however, was reduced by approximately $220 million from 1987 to 1993, to a balance of $2.1 billion, as sales by affiliates of foreign companies to U.S. parties increased more than sales by affiliates of U.S. companies to foreign parties. (See table 3.)

But future trends in U.S. trade balances may not resemble the trends of the recent past. The latest data are still too early to reflect much effect of the two major trade agreements of late 1994: the North American Free Trade Agreement (NAFTA) and changes to the General Agreement on Tariffs and Trade (GATT). Both agreements reduce barriers to international trade and may well change the trends in imports, exports, or both. The net effects on U.S. trade balances in the software and engineering industries are unknown at this time.

Table 2. U.S. international trade in computer services and U.S. computer services industry output, 1986–94

[In millions of dollars]

Year	International trade in computer services				U.S. computer services industry output
	Cross-border transactions		Affiliated sales		
	Imports	Exports	To U.S. persons by affiliates of foreign companies	To foreign persons by affiliates of U.S. companies	
1986	$32	$965	—	$3,847	$49,864
1987	74	649	736	5,028	56,144
1988	107	1,198	1,004	5,912	67,878
1989	46	978	1,589	5,613	77,419
1990	44	1,031	1,907	7,741	86,045
1991	116	1,738	1,720	9,782	91,483
1992	141	1,902	2,224	12,091	100,901
1993	304	2,306	2,431	12,867	105,826
1994	386	2,546	—	—	114,893

NOTE: Dash indicates data not available.
SOURCE: Bureau of Economic Analysis, U.S. Department of Commerce.

Reduced defense spending

Cuts in U.S. defense spending in recognition of the end of the cold war began in 1987. Since then, defense-related industries (manufacturing industries that derived at least half of their business from defense contracts in 1987) have lost vast numbers of jobs. The cutbacks also have affected defense-related purchases of engineering and computer services: from 1987 to 1993, as defense industries trimmed employment, their purchases of computer services decelerated greatly, to less than one-tenth the previous rate of growth, and purchases of engineering declined slightly, in contrast to the previous strong upward trend.[28] Similarly, direct purchases of computer and engineering services by the Pentagon declined slightly from 1987 to 1993, after showing tremendous growth from the mid-seventies to the mid-eighties.

Interindustry shifts in personnel

Aside from the issue of overall demand for programming and engineering, the question of just where and by whom the work is performed is crucial to the number of jobs in software and engineering firms. Severe deceleration occurred in the computer services industry partly because companies outside of computer services hired many more computer professionals as their own employees. As a result, by 1993, businesses had less need for contractual computer services than they would otherwise have had. While the number of computer engineers, computer scientists, and systems analysts in the computer services industry increased by 13 percent from 1990 to 1993, members of those occupations working in all industries increased by 35 percent, so that the computer services industry's share of experts was reduced.

In addition, increasing computer expertise among workers in general may soften the need for outside computer help. In 1984, 23 percent of U.S. jobholders used computers at work; in 1993, 43 percent did.[29] The development of more user-friendly software may have contributed much toward this change.

Unlike the case of interindustry shifts among employees with computer expertise, the occupational redistribution of engineers does not explain the deceleration of the engineering industry. In fact, the industry distribution of engineers follows the opposite pattern: engineers have become more concentrated in engineering firms, as opposed to other industries. From 1990 to 1993, as engineering companies gained 7,200 engineers, all industries lost a net 122,000. Businesses outside the engineering services industry evidently now contract out a greater portion of their engineering, to the benefit of engineering firms. Manufacturing lost 79,000 engineering positions, more than half the total loss, largely because of reduced defense spending and corporate downsizing for purposes of reducing costs.

Both computer services and engineering services are subject to competition from help supply companies, such as "temp" agencies. Help supply companies pay and perform administrative services for employees who are sent to work at client companies. The growth of help suppliers, arguably at the expense of permanent jobs, has been a persistent issue in the media. The number of engineers and computer scientists on the payrolls of help supply firms increased from 1989 to 1994. But even in 1994, the number of professionals supplied by these firms who competed with engineers and computer scientists in engineering and computer service companies was relatively slight. In 1994, computer professionals provided by help-supply agencies amounted to less than one-half of 1 percent of the employment of the computer services industry. Similarly, that same year, engineers provided by help-supply firms represented less than one-half of 1 percent of the employment of the engineering industry.[30]

CHANGES IN EMPLOYMENT in computer and engineering services are the net result of all the influences that have been discussed in this article, plus general economic conditions. Although growth in the number of jobs has continued in both industries, it has slowed considerably since about 1990. (See chart 1 and table 4.) The latest recession partially explains the deceleration, but the recession cannot explain all of the reduction in growth in the most recent years. Even in 1993 and 1994, well after the recession, both industries grew at a rate considerably below that of earlier years. The slowdown prevailed despite the fact that growth in all nonfarm jobs has been fairly strong in the last few years. The following tabulation, which shows the annual percent growth in employment in all nonfarm jobs and in computer and engineering services, makes the point:[31]

Table 3. U.S. international trade in engineering and associated industries, 1986–94

[In millions of dollars]

Year	Sales: Cross-border transactions: Industrial engineering: Imports	Exports	Construction, nonindustrial engineering, architectural, and mining services: Imports	Exports	Affiliated sales of engineering and architectural services: To U.S. persons by affiliates of foreign companies	To foreign persons by affiliates of U.S. companies	Total output of U.S. engineering and architectural establishments
1986	$75	$96	$301	$759	—	$2,414	$53,283
1987	103	304	163	668	(1)	2,369	58,340
1988	133	278	307	790	1,279	2,923	62,582
1989	53	219	443	939	1,918	3,456	71,544
1990	74	473	170	867	2,447	4,651	75,222
1991	30	363	315	1,478	2,665	5,470	75,386
1992	112	212	261	1,935	3,567	5,561	78,220
1993	142	286	336	2,358	3,681	5,827	82,529
1994	103	235	296	2,704	—	—	—

1 Less than $500,000.
NOTE: Dash indicates data not available.
SOURCE: Bureau of Economic Analysis, U.S. Department of Commerce.

	All nonfarm jobs	Computer services	Engineering and architectural services
1979–84	1.0	11.9	4.0
1984–89	2.7	9.2	4.3
1989–94	1.1	5.4	.2
1992–93	2.0	6.9	2.0
1993–94	3.1	7.4	2.8

Still, in 1994, the computer services industry grew in employment at more than twice the rate of the nonfarm sector as a whole.

Many of the factors discussed in this article cannot in fact explain the slowing of employment growth in the computer services and engineering industries, because those particular factors either influence employment in the direction of acceleration or have effects that cannot readily be determined. In the last few years, the U.S. trade surplus in computer serv-ices has expanded greatly, following a slight drop in the late eighties, so that international trade in computer services has been an influence in the direction of acceleration in U.S. employment. Affiliated transactions in engineering and architecture also have shifted in the Nation's favor in the last few years, after a trade surplus in this category dropped from 1987 to 1989. In cross-border transactions of construction, nonindustrial engineering, architectural, and mining services, the U.S. trade surplus quadrupled from 1989 to 1993, after increasing only minimally from 1986 to 1989.

Greater efficiency of labor through the use of constantly improving computer tools may explain much of the slowdown in hiring in the two industries, but the lack of good measures of productivity in the industries means that there is currently no way to quantify the effects of increasingly sophisticated automation on the need for workers. The factors that remain as clearly having contributed to the slowdown include the recession, which explains some of the deceleration in 1990 and 1991 only; greater in-house computer expertise in businesses in general, lessening the demand for outside computer services; more user-friendly computer applications that reduce the need for outside expertise; a deterioration in the U.S. trade surplus in cross-border transactions of industrial engineering (see table 3); and reduced defense spending.

Estimates of employment in 1995 show renewed strength in both industries. Because other, related data for 1995 generally are not currently available, these most recent employment trends cannot yet be analyzed in the same way as earlier employment changes. In 1995, jobs in computer services increased by 12.7 percent from 1994, a sharp upward break from the trend of the preceding years. Jobs in engineering

Chart 1. Employment change in engineering and computer services, 1979–94

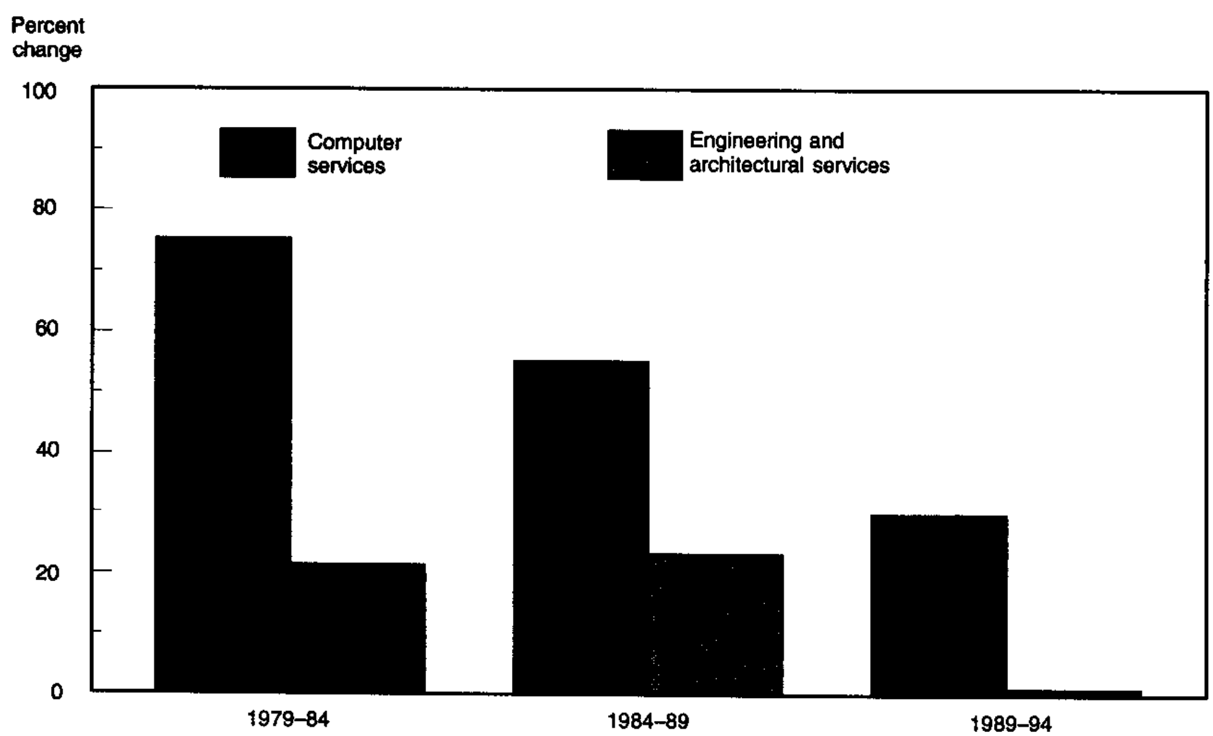

Table 4. **Employment in computer services (SIC 737) and in engineering and architectural services (SIC 871)**

[In thousands]

Year	Employment: Computer services	Employment: Engineering and architectural services
1972	106.7	339.3
1973	119.5	372.3
1974	134.6	394.7
1975	143.0	382.3
1976	159.4	386.9
1977	186.6	424.0
1978	223.8	472.6
1979	270.8	515.0
1980	304.3	544.9
1981	336.6	571.9
1982	364.6	572.2
1983	415.6	575.6
1984	474.4	625.0
1985	541.5	656.4
1986	588.1	681.4
1987	628.6	705.7
1988	673.3	730.4
1989	736.3	770.3
1990	771.9	786.3
1991	797.0	750.1
1992	835.5	742.4
1993	892.8	757.1
1994	958.6	778.3
1995	1,080.4	814.1

Source: Current Employment Statistics Program, Bureau of Labor Statistics.

and architectural services gained 4.6 percent from 1994 to 1995, increasing much faster than in any earlier year of the nineties and slightly faster than during the eighties. In early 1996, however, each industry returned to a slower rate of annual growth, 10.3 percent for computer services and 3.7 percent for engineering.

Without more up-to-date related data, trying to explain the latest rates of growth in the same terms as for earlier years would be speculative. It is well known, however, that the introduction of Windows®95, the extremely popular Microsoft operating system, in mid-1995 involved not only the completion of the package itself, but also an abundance of modifications to applications, in order to make them compatible with the new operating system or to make them more efficient when used with it. In the first three quarters of 1995, software applications sales in North America accelerated greatly, increasing 23 percent over the first three quarters of 1994; in earlier years of the nineties, annual increases ranged from 6 percent to 14 percent. From the first three quarters of 1994 to the first three quarters of 1995, Windows applications increased in sales by 47 percent as sales of DOS applications and Macintosh software dropped. In terms of the function of applications, as opposed to the operating system under which they operate, entertainment (up 73 percent) and personal information management (electronic personal appointment schedules, address books, and the like, up 75 percent) were the strongest categories.[32] Considering the equally dramatic *decline* in software sales in the fourth quarter of 1995—down 9 percent from the fourth quarter of 1994 and a factor in the relatively small 12-percent increase from 1994 as a whole to 1995—it is uncertain that rising software sales will continue to accelerate hiring. □

Footnotes

[1] R. A. Ellis, *At the Crossroads: Crisis and Opportunity for American Engineers in the 1990's*, special edition of the *Engineering Workforce Bulletin* (Washington, DC, American Association of Engineering Societies, Inc.), January 1994.

[2] *Ibid.*

[3] *Ibid.*, p. 3.

[4] *Standard Industrial Classification Manual* (Washington, DC, Executive Office of the President, Office of Management and Budget, 1987), p. 401.

[5] Engineering services (Standard Industrial Classification (SIC 8711) is the largest component of the broader industry classification called engineering and architectural services (SIC 871), which also includes architectural services (SIC 8712) and surveying services (SIC 8713). Engineering firms (SIC 8711) have 78 percent of the employment in engineering and architectural services (SIC 871). From 1988 to 1994, engineering firms contributed all of the change in employment in engineering and architectural services. These facts are important because far more quantitative information exists for engineering and architectural services than for engineering services alone. Because engineering services contains most of the employment and about all of the volatility of engineering and architectural services, it is likely that data pertaining to the latter primarily reflect developments in engineering serv-ices alone. In later sections, data for engineering and architectural services will often be cited, because more specific data pertaining solely to engineering services are not available.

[6] *Standard Industrial Classification Manual*, pp. 365–67. The computer services industry is classified as SIC 737.

[7] Information on industry sales to other industries, government, and consumers is from input-output tables of the Office of Employment Projections, Bureau of Labor Statistics.

[8] Ellis, *At the Crossroads*, p. 13.

[9] "India Industry: Educated, Cheap Labour Draws Western Software, R&D," EIU Viewswire, May 1, 1995.

[10] Ellis, *At the Crossroads*, p. 9.

[11] *Ibid.*, p. 10.

[12] *Ibid.*, pp. 10–11.

[13] "Multifunction workstations boost engineering productivity," *Machine Design*, Oct. 25, 1984, p. 12.

[14] David Stamps, "CASE: Cranking out productivity," *Datamation*, July 1, 1987, p. 55.

[15] *At the Crossroads*, p. 10.

[16] Stamps, "CASE: Cranking out productivity," pp. 55ff.

[17] *Ibid.* p. 55.

[18] Ronald J. Norman and Jay F. Nanamaker, Jr., "CASE productivity perceptions of software engineering professionals," *Communications of the ACM*, September 1989, p. 1102ff.

[19] Howard Mozeico, " CASE integration boosts engineering productivity," *Computer Design*, Jan. 1, 1990, p. 82.

[20] John Pallato, "Study relates success of CASE tools," *PC Week*, Jan. 9, 1989, pp. 43ff. See also Norman and Nanamaker, "CASE productivity perceptions," pp. 1102ff.

[21] Otis Port, "Computers that Think Are Almost Here," *Business Week*, July 17, 1995, pp. 68ff.

[22] *Ibid.*

[23] The Bureau is, however, developing a Producer Price Index for engineering services (SIC 8711).

[24] Merle P. Martin, "The case against CASE," *Journal of Systems Management*, January 1995, p. 54.

[25] Tom Williams, "CASE tools prove worth in boosting productivity," *Computer Design*, January 1992, pp. 51ff.

[26] *Ibid.*; see also Michael J. Major, "The unresolved case: CASE promises great productivity, but users still are awaiting the evidence," *MIDRANGE Systems*, Apr. 28, 1992, pp. 25ff.

[27] For example, see Pete Engardio, Rob Hof, Elisabeth Malkin, Neil Gross, and Karen Lowry Miller, "High-tech jobs all over the map," *Business Week Special 1994 Bonus Issue: 21st Century Capitalism*, Nov. 18, 1994, pp. 112–19.

[28] The values of purchases by the defense-related industries and by the Department of Defense are from BLS input-output tables from the Office of Employment Projections. The defense-related industries are those which, at the peak of the cold war (1987), sold at least half their output to the Department of Defense. These industries include ordnance and ammunition (SIC 348), aerospace manufacturing (SICs 372 and 376), ship and boat building and repairing (SIC 373), and search and navigation equipment (SIC 381).

[29] Robert Kominski, *Computer Use in the United States: 1984* (Bureau of the Census, 1988), p. 5. See also the unpublished Bureau of the Census PPL–22 table 7, "Uses of computer at work, by sex and intermediate industry," for 1993.

[30] *Industry Wage Survey: Help Supply Services* (Bureau of Labor Statistics, October 1989), p. 8. See also *Occupational Compensation Survey: Temporary Help Supply Services, United States and Selected Metropolitan Areas* (November 1994), p. 2.

[31] Employment estimates in this article are from the BLS Current Employment Statistics (CES) survey of establishments, unless otherwise noted. The CES program produces estimates of employees on all nonfarm payrolls, except in private households, based on a monthly survey of about 390,000 work sites. Data from the survey appear in the Bureau's monthly periodical, *Employment and Earnings*.

[32] Figures are from press releases of the Software Publishers Association, Washington, DC, and are for the United States and Canada combined; data on U.S. sales alone are not provided.