Digital Economy 2000

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I am pleased to release *Digital Economy 2000*, the Commerce Department's third annual report on the information-technology revolution and its impact on our economy. Understanding sweeping economic changes as they are happening is a formidable challenge. In government agencies and research institutions around the world, analysts are trying to meet this challenge. *Digital Economy 2000* is an important contribution to this effort and a measure of its progress.

In the twelve months since our previous digital economy report, confidence has increased among both experts and the American public that the new, proliferating forms of e-business and the extraordinary dynamism of the industries that produce information-technology products and services are harbingers of a new economic era. For most economists, the key measure of our new condition is the exceptional increase in productivity of the last five years, which has helped drive a welcome combination of falling inflation and very strong growth. For many people, however, the clearest evidence lies in the extraordinary increase in the electronic connectedness among individuals and businesses through the Internet. Three hundred million people now use the Internet, compared to three million in 1994. They can access more than one billion web pages, with an estimated three million new pages added every day.

These numbers do not tell the full story. We are witnessing an explosive increase in innovation. Using open standards, people around the world are creating new products and services that are instantly displayed to a global audience. We are witnessing myriad new forms of business activity, such as electronic marketplaces linking buyers and sellers in seamless global bazaars, and changes in business processes from customer service to product design that harness the new technologies to make businesses more efficient and responsive.

Nor are our numbers complete. Surveys by the Census Bureau, for example, now measure business to consumer e-commerce or "e-tailing" and have begun to measure business-to-business e-commerce. Hard questions of definition and measurement will still have to be resolved, however, before we can understand the full impact of these changes on our economy.

What we can see clearly are expanding opportunities. To meet these opportunities, we will have to ensure a stable and conducive economic and legal environment for continuing innovation in information technologies and e-commerce. We need to encourage the building of a broadband infrastructure that allows all Americans to have access to the advanced services that support the Internet, and take the steps necessary with respect to privacy, consumer protection, security, reliability and intellectual property rights that will inspire confidence in the Internet. To realize the full potential of this digital economy, every person and every business must be able to participate fully and make their own unique contribution to its development.

William M. Daley

EXECUTIVE SUMMARY

The U.S. economic expansion is now in its tenth year, showing no signs of slowing down. The rate of labor productivity growth has doubled in recent years, instead of falling as the expansion matured as in previous postwar expansions. Moreover, core inflation remains low despite record employment and the lowest jobless rates in a generation. Our sustained economic strength with low inflation suggests that the U.S. economy may well have crossed into a new era of greater economic prosperity and possibility, much as it did after the development and spread of the electric dynamo and the internal combustion engine.

The advent of this new era has coincided with dramatic cost reductions in computers, computer components, and communications equipment. Declines in computer prices, which were already rapid—roughly 12 percent per year on average between 1987 and 1994—accelerated to 26 percent per year during 1995-1999. Between 1994 and 1998 (the last four years for which data are available), the price of telecommunications equipment declined by 2 percent a year.

Declining IT prices and years of sustained economic growth have spurred massive investments not only in computer and communications equipment, but in new software that harnesses and enhances the productive capacity of that equipment. Real business investment in IT equipment and software more than doubled between 1995 and 1999, from $243 billion to $510 billion. The software component of these totals increased over the period from $82 billion to $149 billion.

The new economy is being shaped not only by the development and diffusion of computer hardware and software, but also by much cheaper and rapidly increasing electronic connectivity. The Internet in particular is helping to level the playing field among large and small firms in business-to-business e-commerce. In the past, larger companies had increasingly used private networks to carry out electronic commerce, but high costs kept the resulting efficiencies out of reach for most small businesses. The Internet has altered this equation by making it easier and cheaper for all businesses to transact business and exchange information.

There is growing evidence that firms are moving their supply networks and sales channels online, and participating in new online marketplaces. Firms are also expanding their use of networked systems to improve internal business processes—to coordinate product design, manage inventory, improve customer service, and reduce administrative and managerial costs. Nonetheless, the evolution of digital business is still in an early stage. A recent survey by the National Association of Manufacturers, for example, found that more than two-thirds of American manufacturers still do not conduct business electronically.

Advances in information technologies and the spread of the Internet are also providing significant benefits to individuals. In 2000, the number of people with Internet access will reach an estimated 304 million people world-wide, up almost 80 percent from 1999; and, for the first time, the United States and Canada account for less than 50 percent of the global online population. Further, according to Inktomi and the NEC Research Institute, the amount of information available online has increased ten-fold over the last three years, to more than a billion discrete pages.

As more people have moved online, so have many everyday activities. In March 2000, the Census Bureau released the first official measure of an important subset of business-to-consumer e-commerce, "e-retail." Census found that in the fourth quarter of 1999, online sales by retail establishments totaled $5.3 billion, or 0.64 percent of all retail sales. People increasingly use the Internet not only to make purchases, but also to arrange financing, take delivery of digital products, and get follow-up service.

The vitality of the digital economy is grounded in IT-producing industries—the firms that supply the goods and services that support IT-enabled business processes, the Internet and e-commerce. Analysis of growth and investment patterns shows that the economic importance of these industries has increased sharply since the mid-1990s. Although IT industries still account for a relatively small share of the economy's total output—an estimated 8.3 percent in 2000—they contributed nearly a third of real U.S. economic growth between 1995 and 1999.

In addition, the falling prices of IT goods and services have reduced overall U.S. inflation—for the years 1994 to 1998, by an average of 0.5 percentage points a year, or from 2.3 percent to 1.8 percent. The rates of decline in IT prices accelerated through the 1990s—from about 1 percent in 1994, to nearly 5 percent in 1995, and an average of 8 percent for the years 1996 to 1998.

IT industries have also been a major source of new R&D investment. Between 1994 and 1999, U.S. R&D investment increased at an average annual (inflation adjusted) rate of about 6 percent—up from roughly 0.3 percent during the previous five-year period. The lion's share of this growth—37 percent between 1995 and 1998—occurred in IT industries. In 1998, IT industries invested $44.8 billion in R&D, or nearly one-third of all company-funded R&D.

New investments in IT are helping to generate higher rates of U.S. labor productivity growth. Six major economic studies have recently concluded that the production and use of IT contributed half or more of the acceleration in U.S. productivity growth in the second half of the 1990s. This has occurred despite the fact that IT capital accounts for only 6 percent of private business income. Such remarkable leverage reflects in part the fact that businesses must earn immediate rates of return on investments in IT hardware high enough to compensate for the rapid obsolescence (*i.e.*, depreciation) and falling market value of these assets. In short, IT investments must be extraordinarily productive during their short lives. Recent firm-level evidence indicates that IT investments are most effective when coupled with complementary investments in organizational change, and not very effective in the absence of such investments.

Although the official data show declining productivity for a number of major service industries that invest heavily in IT (*e.g.*, health, business services), this probably reflects the inadequacy of official output measures for those industries. Until these measures are improved, the full effect of IT on service industry productivity will remain clouded.

In 1998, the number of workers in IT-producing industries, together with workers in IT occupations in other industries, totaled 7.4 million or 6.1 percent of all American workers. Growth in the IT workforce accelerated in the mid-1990s, with the most rapid increases coming in industries and job categories associated with the development and use of IT applications. Employment in the software and computer services industries nearly doubled, from 850,000 in 1992 to 1.6 million in 1998. Over the same period, employment in those IT job categories that require the most education and offer the highest compensation, such as computer scientists, computer engineers, systems analysts and computer programmers, increased by nearly 1 million positions or almost 80 percent.

At the same time, the rapid pace of technological change and increased competition have added an element of uncertainty to IT employment. The number of jobs has declined in some IT industries, such as computers and household audio and video equipment. Moreover, while IT-producing industries as a whole paid higher-than-average wages in 1998, some IT jobs remain low-skilled and low-paid.

Paradoxically, although America's IT-producing companies are clearly world-class, the United States regularly runs large trade deficits in IT goods—an estimated $66 billion in 1999. One reason is that American IT firms more often service foreign customers with sales from their overseas affiliates than by exports from their U.S. operations. In 1997, foreign sales by overseas affiliates of American IT companies totaled $196 billion, compared to U.S. exports by firms in comparable industries of $121 billion. In the same year, American affiliates of foreign-owned IT companies operating in the United States reported sales here of $110 billion. Therefore, while the U.S. balance of trade in IT products was negative, the "balance of sales" favored American companies by $86 billion.

IT has not only propelled faster growth during this expansion, but it will have a tendency to dampen the next business cycle downturn. Because IT investment is driven by competitive pressures to innovate and cut costs more than to expand capacity, it will be less affected by a slowdown in demand. In addition, by creating supply chain efficiencies that reduce inventories, IT should dampen the inventory effect that has worsened past recessions.

The strong performance of the U.S. economy since 1995 contrasts both with U.S. performance from 1973 to 1995 and with the rest of the industrial world in recent years. Historically, there have been long lags between fundamental technological breakthroughs, such as electricity and electric motors, and large economic effects from them. Although IT is generally available in world markets, the U.S. economy to date has achieved greater gains from IT than other countries at least partly because of favorable monetary and fiscal policies, a pro-competitive regime of regulation, and a financial system and business culture prepared to take risks.

Even in this country, however, the diffusion of IT has been uneven. Although the number of homes with computers and Internet connections has been rising rapidly, the majority of Americans do not have online connections at home. Those on the wrong side of the digital divide—disproportionately people with lower incomes, less education, and members of minority groups—are missing out on increasingly valuable opportunities for education, job search, and communication with their families and communities.

In conclusion, a growing body of evidence suggests that the U.S. economy has crossed into a new period of higher, sustainable economic growth and higher, sustainable productivity gains. These conditions are driven in part by a powerful combination of rapid technological innovation, sharply falling IT prices, and booming investment in IT goods and services across virtually all American industries. Analysis of the computer and communications industries in particular suggests that the pace of technological innovation and rapidly falling prices should continue well into the future. Moreover, businesses outside the IT sector almost daily announce IT-based organizational and operating changes that reflect their solid confidence in the benefit of further substantial investments in IT goods and services. The largest and clearest recent examples come from the automobile, aircraft, energy and retail industries, which all have announced new Internet-based forms of market integration that should generate large continuing investments in IT infrastructure. These examples mark only the beginning of the digital economy.

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INTRODUCTION

Robert J. Shapiro
Under Secretary of Commerce for Economic Affairs

This is the third annual report from the Commerce Department on the digital economy. The first two reports were titled, *The Emerging Digital Economy*. This third edition has a new title, because the digital economy and digital society are no longer "emerging." They are here. Americans have definitively crossed into a new era of economic and social experience bound up in digitally-based technological changes that are producing new ways of working, new means and manners of communicating, new goods and services, and new forms of community.

This report, like its two predecessors, measures the economic performance of information technology (IT) industries and their substantial impact on growth and inflation, and sketches the emerging dimensions of e-commerce. For the first time, it can be reasonably claimed that the extraordinary dynamism of the IT sector and the new, proliferating forms of e-business and e-commerce are part of an enduring and broad economic pattern. The rapid pace and proliferation of innovation associated with IT, and the substantial increases in U.S. productivity and growth associated with IT-related innovation, now appear to be persistent.

At the core of the proposition that the digital economy can produce higher long-term productivity gains and national growth than we knew in the 1970s and 1980s are certain singular qualities associated with information technologies. Most obviously, these technologies provide new ways of managing and using a resource that is common to every sector and aspect of economic life; namely information. Compared, for example, to the introduction of refrigeration or jet propulsion, IT innovations can be applied across the economy and throughout the economic process. As a result, economic gains directly associated with improving the capacity to obtain, process and transmit information mount up.

Further, many IT markets exhibit what economists call "network effects": The more the technology is deployed, the greater its value. Compare certain information technologies to automobiles. When you own a car, its value to you is basically the same whether 5,000 or 1 million other people own the same brand of automobile. When you buy a computer operating system or graphics program, its value to you increases as more people buy it, because their purchases of the same program increase your ability to digitally communicate and interact. As these forms of innovation spread, the productivity benefits may increase at a faster rate than simply arithmetically.

The spread of IT innovations in the digital economy affect growth in other ways. For example, IT innovations appear to raise business investment in equipment. The last seven years have seen the fastest growth of business investment in equipment on record, and IT investments have accounted for almost two-thirds of that growth. The digital economy also can stimulate improvements in workers' skills, since many firms have to train their employees to use information technologies. This may be one reason why Americans across the work force are making real wage gains for the first time in two decades. Further, IT markets with the network effects described above tend to be dominated by a handful of products and companies, and this tendency creates the possibility of beneficial economies of scale.

Perhaps most important of all, a dynamic of cascading or continuous innovation has characterized the development and deployment of information technologies in this period. Productivity gains come not just from deploying innovative technologies that enable workers to process information faster. In addition, firms intent on taking advantage of innovative new technologies often have to rethink the way they operate and reorganize their operations, which can produce a round of organizational innovation. Many firms also have discovered that the new technologies can be used to develop and produce new goods or services for themselves, producing yet another round of innovation. Furthermore, as these areas of potential are widely recognized and the process spreads from firm to firm, this generates demand for faster information processing. This can lead to another round of innovation in IT itself— part of the basis for the doubling of chip capacity every 18 months, articulated as Moore's Law— and the cascade can begin again. A leading example of this dynamic is the Internet itself. Regular and large increases in chip power provided a technological foundation for the Internet, which in turn generated myriad innovations first in software and then in how businesses organize themselves and operate, which in turn has led to more myriad innovations in the goods and services available to businesses and individuals.

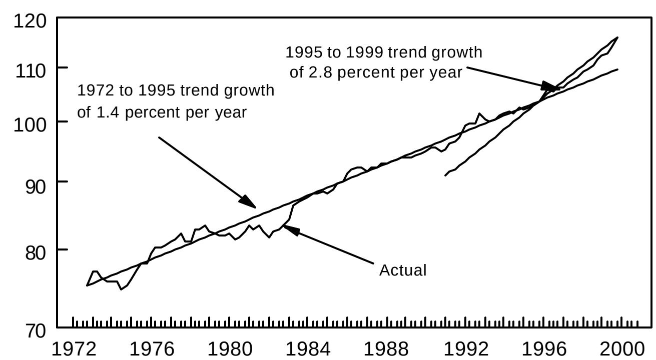
The complex of hardware and software innovations that encompass the IT sector have made information the most important basis for creating value in the economy. The process of creating value from information, throughout and across the economy, is the ultimate basis for the digital economy. This digital economy is just beginning today, and this report will provide a sketch of its current bounds.

CHAPTER I

INFORMATION TECHNOLOGY AND THE NEW ECONOMY

Two remarkable developments occurred in the second half of the 1990s. After quietly improving in speed, power, and convenience since 1969, the Internet burst onto the economic scene and began to change business strategy and investment. At the same time, the U.S. economy has enjoyed a remarkable resurgence. Productivity growth, one of the most important indicators of economic health, doubled its pace from a sluggish 1.4-percent average rate between 1973 and 1995, to a 2.8-percent rate from 1995 to 1999 (Figure 1.1).[1]

Figure 1.1
The Trend Rate of Nonfarm Productivity Growth Accelerated After 1995
(Index 1992=100, log scale)



Source: U.S. Department of Labor, Bureau of Labor Statistics

Evidence is increasing that these two phenomena are not coincidental but derive substantially from the same phenomenon: the synergistic convergence of dramatic increases in computer power, an explosion in connectivity, and increasingly powerful new software. These advances in technology have produced sharp declines in the prices of computer processing, data storage and retrieval, and communications, that are in turn driving both the surge in Internet activity and the increases in business investment in IT hardware and software. Such investment has been a major source of recent U.S. economic strength.

[1] If productivity growth had remained at 1.4 percent for the last four years, nonfarm output would have been $300 billion lower in 1999, the equivalent of about $1,100 in lost output for every person in the country.

The advances in computer power overwhelm imagination. Since the 1960s, the number of transistors per microprocessor chip has been doubling roughly every 18 to 24 months, resulting in a massive increase in processing capability and sharply declining costs.[2] (Figure 1.2)

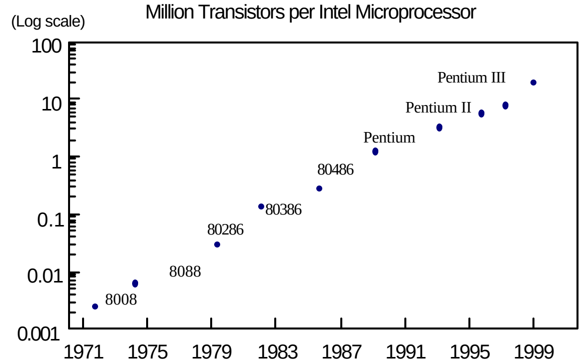
Technologies associated with computer use, such as data storage technologies, have also shown dramatic improvements in performance and even more dramatic cost reductions. The capacity of today's hard-disk drives is doubling every nine months and the average price per megabyte for hard-disk drives has declined from $11.54 in 1988 to an estimated $.02 in 1999.[3] As a consequence of technological advances in microprocessors, storage, and other components, already steep annual declines in computer costs from 1987 to 1994 accelerated sharply beginning in 1995 (Figure 1.3).

Similar improvements have occurred in communications technologies. In recent years, for example, wavelength division multiplexing, digital subscriber lines, and cable modems have produced exponential increases in the speed of data communication and the carrying capacity of the communications infrastructure. The carrying capacity of fiber is currently

Figure 1.2

Moore's Law

Million Transistors per Intel Microprocessor

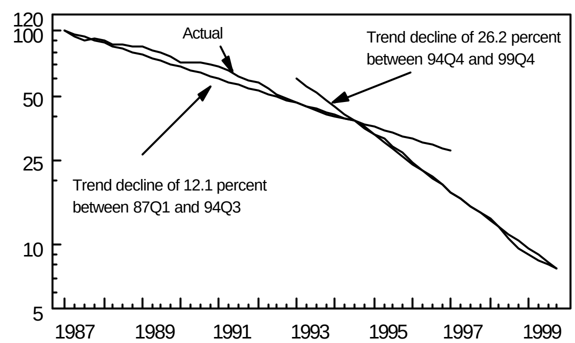


SOURCE: http://www.intel.com/intel/museum/25anniv/hof/tspecs.htm

Figure 1.3

Price Declines in Computers Have Accelerated Since 1995

(log scale; index 1987 Q1=100)



Source: U.S. Bureau of Economic Analysis

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[2] Doubling every 18 months is closely equivalent to increasing by a factor of 10 every 5 years and by a factor of 100 every 10 years. This phenomenon is know as "Moore's Law" and was first noted by Gordon Moore, co-founder of Intel, in 1965. Intel. "What is Moore's Law" Intel Museum Home Page. (http://intel.com/intel/museum/ 25anniv/hof/moore.htm)

[3] Jon William Toigo, "Avoiding a Data Crunch." *Scientific American*. May 2000. (http://www.scientificamerican.com/ 2000/0500issue/0500toig.html)

doubling every 12 months.[4] Between 1994 and 1998 (the last four years for which data are available), the price of telecommunications equipment declined by 2 percent per year.

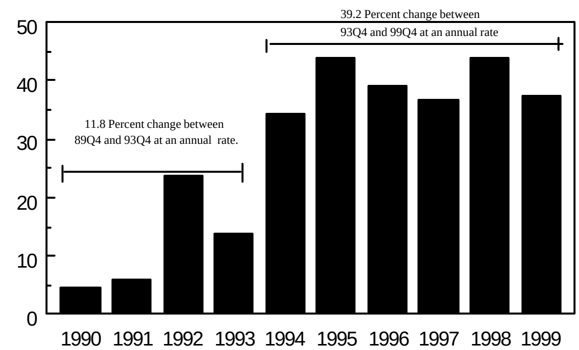
Price declines for computers and peripheral equipment and for communications equipment have spurred major increases in business IT investment and extraordinary growth in U.S. production of computers, communications equipment and semiconductors. (Figure 1.4) Output growth in these industries has jumped from about 12 percent a year in the early 1990s to roughly 40 percent in the past six years.

In addition, the declining costs of computing and communications are helping to drive complementary investment in new software that harnesses and further enhances the productive capacity of IT hardware and infrastructure. Overall, U.S. businesses have increased their investments in new software from about $28 billion in 1987 to $149 billion in 1999. (Figure 1.5)[5]

Figure 1.4

Output Growth in Computers, Communications Equip. & Semiconductors Surged in the 1990s

Percent Change, fourth quarter-to-fourth quarter

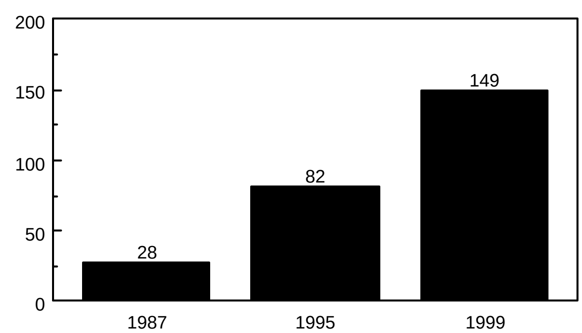


Source: Board of Governors of the Federal Reserve

Figure 1.5

Real Business Investment in Software

(billions of 1996 dollars)



Source: U.S. Bureau of Economic Analysis

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[4] David Clark, senior research scientist at MIT's Laboratory for Computer Science, cited in Jeff Hecht, "Wavelength Division Multiplexing." *MIT's Technology Review*. March/April 1999. (http://www.techreview.com/articles/ma99/hecht.htm)

[5] Skeptics argue that software upgrades do not represent increases in performance, but only the addition of bells and whistles that offset improvements in processing speed. However, that view ignores the directions taken in the business uses of their software investments. Businesses are deploying software to combine cheaper computer power with more reliable communications to create extraordinary efficiencies and improve decision making within their own operations and supply networks. For example, over a three-year period, Wal-Mart achieved a 47 percent increase in sales on only

The new economy is being shaped by developments not only in computer hardware and software, but also in electronic connectivity. Larger businesses have been increasing efficiencies through standardizing and automating routine transactions electronically for some time. Until recently, however, most small and medium sized businesses found that the costs of necessary hardware, software, and communications service for these systems exceeded the benefits.

The advent of the Internet as an instrument of commerce fundamentally altered this equation by cutting the costs of software and communications services needed to conduct electronic transactions. Beginning in the mid-1990s, as a result of the convergence toward digital formats and the development of *de facto* standards for digital networks, such as the Internet's technical specifications, the expansion and commercialization of the Internet made connecting computers and communications devices easier and cheaper. Commercial opportunities on the Internet and the falling costs of computer and communications hardware created an extraordinarily fertile environment for innovations that are creating new value and new efficiencies for businesses of all sizes.

The Internet is both an effect and a cause of the new economy. It is, in part, a product of the powerful technological and economic changes that are shaping a new epoch of economic experience. However, as this report shows, the Internet and related networking technologies are also increasingly the new economy's medium.

Networks, like telephone networks or the Internet, are subject to a phenomenon called "network effects" or "network externalities." Establishing a network involves large, up-front fixed costs (*e.g.*, for purchasing equipment, laying new cable, or developing new software), but adding an additional user to an existing network costs very little. Conversely, the value of a network to participants is low when the number of participants on the network is low, but rises rapidly as network participation expands. For example, a network of a single telephone is of no use. Adding another telephone increases the value of the network because now calls can be made between the two phones. As phones are added, the number of possible connections rises almost as fast as the number of phones squared.[6] Any person with a phone can reach more people, so the network's value to them increases.

Similarly, as the number of people online has grown, so has the value of being online to each Internet user. Moreover, as the Internet gains popularity, its technological specifications have become a default standard, encouraging new hardware and software innovations that use Internet technology as a platform.

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a 7 percent increase in inventories by using a relational database system running on massively parallel computers. The system allows vendors to access almost realtime information on sales and customer transactions and handles 120,000 queries each week from 7,000 suppliers. Businesses are also investing in software to integrate information and reduce staffing in other activities, such as production operations, human resource management, payroll, and sales force activities. "High-tech Complements Human Touch." *Discount Store News.* October 1999.

[6] The number of possible connections is technically n(n-1). This contrast between the change in cost and value of a network as it grows is sometimes labeled "Metcalfe's Law." Shapiro, Carl and Varian, Hal. *Information Rules: A Strategic Guide to the Network Economy,* Boston: Harvard Business School Press. 1998. p. 184.

Fundamental engineering breakthroughs alone do not have important economic effects until their costs and applications become favorable. For example, by the mid-1970s, Xerox PARC had already made several breakthroughs underpinning today's IT revolution: a microcomputer with a mouse, graphical user interface, and Ethernet communications capabilities. But there was no mass market for their machine, which at the time cost about $25,000 each to produce,[7] especially given its slower processing speed and the absence of applications software that drives computer use today. In contrast, technological advances in recent years have brought IT costs down to a far more commercially attractive range, and new software applications for networked systems have been developed.

Nothing approaching the activities now conducted over the Internet was possible a few years ago. Push back the technology or cost declines in any one of the four elements—computer processing, data storage, software, or communications—just a few years and the Internet activities we now view as commonplace would be too frustrating or too costly for a mass market. Likewise, roll back any one of those elements and business would have found IT investment to be far less productive. As applications software is developed to exploit the continuing plunge in hardware prices in coming years, businesses and consumers will find new ways to create value and increase efficiency.

[7] Robert X. Cringely, *Accidental Empires,* New York: Harper Business. 1992. P. 83.

Chapter II

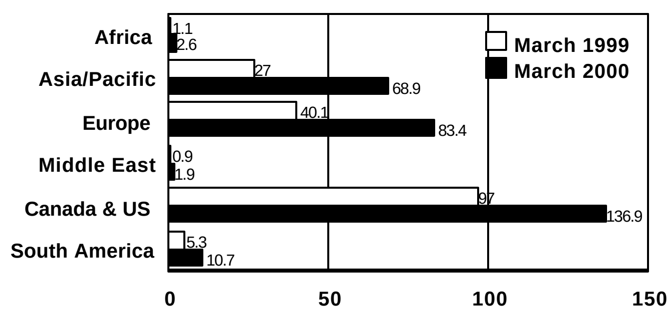
ELECTRONIC COMMERCE: THE LEADING EDGE OF THE DIGITAL ECONOMY*

The resurgence of the U.S. economy coincides with the growing use of the Internet, including the rapid growth of electronic commerce (e-commerce). In ever greater numbers, people are shopping, looking for jobs, and researching medical problems online. Businesses are moving their supply networks online, participating in and developing online marketplaces, and expanding their use of networked systems to improve a host of business processes. And new products and services are being created and integrated into the networked world. This chapter explores activities at the leading edge of the digital economy.

We live in an increasingly wired world. The remarkable growth of the Internet in recent years shows no signs of abating. According to *Nua Internet Surveys*, during the past year Internet access has grown significantly in all regions of the world, rising from 171 million people in March 1999 to 304 million in March 2000, an increase of 78 percent (Figure 2.1).[1]

Figure 2.1

Internet Access Grew To 304 Million in 2000 From 171 Million in 1999



Source: Nua Internet Surveys (http://www.nua.ie)

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* This chapter was written by Patricia Buckley, Senior Policy Advisor, and Sabrina Montes, Economist, in the Office of Policy Development.

1 Specific estimates from private sources and company-specific examples are included in this report to be illustrative of developing trends and their inclusion does not signify Department of Commerce validation or approval. Disparities among private estimates can result from differences in definitions, methods, data, model and sampling error, and product coverage. Variations also reflect the research needs of customers. While data used for estimates and forecasts are based on a combination of surveys and interviews, the survey questions and answers are not made public, sample sizes vary considerably across surveys, and little information is available on the respondents.

The United States and Canada still account for a large proportion of worldwide online users; but for the first time, they now account for less than 50 percent of the total (Table 2.1). Over the past year, Internet access in the United States and Canada grew by more than 40 percent; over the same period, Internet access in all other parts of the world more than doubled.

Table 2.1
Number of People Online
(in Millions)

	Mar-99	Mar-00	level increase	percent increase
Africa	1.1	2.6	1.5	136
Asia/Pacific	27.0	68.9	41.9	155
Europe	40.1	83.4	43.3	108
Middle East	0.9	1.9	1.0	111
Canada & US	97.0	136.9	39.9	41
South America	5.3	10.7	5.4	102

Source: Nua Internet Surveys

The amount of information available online to people with Internet access has also grown very rapidly. A recent study by Inktomi and the NEC Research Institute, Inc., for example, indicates that in January 2000 the World Wide Web contained more than one billion unique pages,[2] compared to 100 million in October 1997.[3]

CONSUMERS IN THE NEW ECONOMY

Consumers today—wherever they are in the world—go online to shop, learn about different products and providers, search for jobs, manage their finances, obtain health information and scan their hometown newspapers. While many of these activities are not captured by official output and productivity measures, a growing body of anecdotal evidence suggests that the digital revolution is improving many people's lives.

[2] Inktomi, "Inktomi WebMap," Press Release, January 2000 (http:/www.inktomi.com/webmap). Although over one billion unique pages exist, it should be noted that even the most sophisticated search engines cover only a relatively small proportion of the total number of existing Web sites.

[3] David Peterschmidt, President of Inktomi, quoted by Yahoo, "Internet Volume is Doubling Every 90 Days," October 3, 1997 (http://www.nua.ie).

Business-to-Consumer Electronic Commerce

Individuals with Internet access increasingly approach the Web as a market space.[4] People online do research before they buy, make purchase commitments, arrange financing, take delivery of digital products, and obtain followup service. The "commerce" in e-commerce encompasses all of these activities. However, when measuring business-to-consumer (B2C) e-commerce in particular, it is the commitment to purchase—the transactional component—that both buyers and sellers can easily identify and quantify. This transactional component is the focus of most current e-commerce measurements.

In March 2000, the U.S. Bureau of the Census released the first official measure of e-retail, an important subset of business-to-consumer e-commerce. Census found that during the fourth quarter of 1999, online sales by retail establishments totaled $5.3 billion, or 0.64 percent of all retail sales.[5]

By contrast, private estimates for consumer e-commerce in the fourth quarter of 1999 ranged from approximately $4 billion to $14 billion. However, many private estimates of B2C e-commerce include the value of a wide range of consumer online purchases such as airline tickets, hotel rooms, and shares of stocks that are not captured in The Census Bureau's survey of retail establishments. When these private estimates are adjusted to cover only those purchases included in the retail measure, the Census Bureau estimate of $5.3 billion appears to fall in the midrange. For example, Forrester Research estimated fourth-quarter online sales at $9 billion, but when travel and event tickets are subtracted—both categories that are not part of the official definition of retail sales—the Forrester estimate falls to a comparable $5.5 billion.[6]

Prior to the 1999 holiday shopping season, some analysts expressed concern that if online retailers experienced the problems filling orders that had plagued many of them in the 1998 online holiday season, consumers might turn away from online shopping. Private surveys conducted shortly after the holiday

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[4] This analysis follows the draft definition of electronic commerce developed by the U.S. Bureau of the Census. According to this definition, electronic commerce is a specific type of e-business processes—one that involves a transaction, the transfer of ownership. See Thomas L. Mesenbourg, "Measuring Electronic Business: Definitions, Underlying Concepts, and Measurement Plans," U.S. Bureau of the Census, 1999 (http://www.census.gov/epcd/www/ebusines.htm).

[5] The Census retail e-commerce estimate was obtained by surveying goods retailers. The survey panel included not only the traditional bricks and mortar retailers, but also Internet "pure plays," online versions of traditional retailers, and manufacturers that have set up a retail establishments (real or virtual) to sell directly to the public. The Census retail e-commerce estimate does not include business-to-consumer sales of services, such as travel, entertainment, or stock transactions. Ongoing Census surveys will provide information on 1998 and 1999 transactions in other areas of the business-to-consumer e-commerce market space (including services and food service and accommodations businesses).

[6] Forrester Research, Forrester Findings (http://www.forrester.com/ER/Press/0,1772,0,FF.html).

season indicated that such problems were minimal and that online customer satisfaction was high.[7] Nonetheless, some analysts believe that delivering goods ordered by consumers from e-retailers will prove to be more costly and complex than currently appreciated.[8] The ultimate size of online consumer sales will depend on resolving these fulfillment issues, along with other important matters such as taxation, consumer protection, privacy, intellectual property rights, security, and network reliability.

Online Pricing

In the consumer realm, the most significant impact of e-commerce may be on the pricing of goods and services. Potential buyers can check the price and availability of products from a variety of sites in far less time than it would take to conduct store-to-store comparisons in the world of bricks and mortar. Furthermore, online digital shopping spaces can be perused for consumers by software specialized to operate as digital shoppers. Such digital agents, known as "bots," cruise through numbers of Internet sites almost instantaneously, searching for the most favorable price and feature combinations.

One would expect that this ability to easily and cheaply gather information on prices and product characteristics would force Internet retailers to charge the same low price—one that would approach their cost—on the same or comparable products. One might also expect these online prices to influence prices charged in physical stores. Thus far, however, the data on these matters are mixed. For example, a study of 20 book titles and 20 CD titles sold by 41 Internet and conventional retail outlets between February 1998 and May 1999 found that Internet prices were between 9 and 16 percent lower than prices in conventional outlets, depending on whether taxes, shipping, and shopping costs were included in the price.[9] However, another study of book prices covering 107 titles sold by 13 online and two physical bookstores during the week of April 19, 1999, found that prices online and in physical bookstores were the same. This suggests that certain Web sites have sufficiently differentiated themselves through factors other than price (e.g., convenience, product reviews) that they can attract sales even when they are not the lowest-price seller.[10]

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[7] See for example, Jupiter Communications, "Online Holiday Sales Hit $7 Billion, Consumer Satisfaction Rising," Press Release, January 13, 2000 (http://www.jup.com) and PC Data Online, "Web Retailers Score High In Customer Satisfaction Study," Press Release, January 11, 2000 (http://www.pcdataonline.com).

[8] Jonathan Weber, "The Last Mile," *The Industry Standard*, March 27, 2000 (www.thestandard.com).

[9] Erik Brynjolfsson and Michael D. Smith, "Frictionless Commerce? A Comparison of Internet and Conventional Retailers," *Management Science*, April 2000 (http://ecommerce.mit.edu/papers/friction).

[10] Karen Clay, Ramayya Krishnan, Eric Wolff, and Danny Fernandes, "Retail Strategies on the Web: Price and Non-price Competition in the Online Book Industry," Working Paper, December 1, 1999. Differentiating factors include site brand name awareness, ease of navigation while on the site, and a reputation for reliability. (http://dnet.heinz.cmu.edu/dcsrg/books/papers/paper1.pdf). In addition, a recent Activmedia Research report found that competing on price alone is not enough for an e-commerce site to sustain competitive advantage. See *Nua Internet Surveys*, "Activmedia: Competitive Advantage is Not About Price," March 2, 2000 (http://www.nua.ie. Another survey,

Even if the jury is out on the price sensitivity of online shoppers, online commerce has fostered a variety of pricing schemes. One of these is online auctions. Live auctions have existed for a long time, but their practical uses have been limited by the expense and difficulty of getting prospective buyers to a single location at the same time. Sealed bid auctions are less expensive, but they often do not produce the highest possible return to the seller. By contrast, the Internet provides a relatively low-cost and convenient way of bringing buyers and sellers together, and the use of auction sites such as eBay has grown rapidly. Variations on the standard auctions are also gaining popularity. In the reverse auction format of PriceLine.com, the consumer names the price and the seller decides whether or not to accept it. In the Mercata.com format, price is determined by the number of people that want to buy a product—the greater the number of buyers, the lower the price.

A "single price" model holds for most offline goods and services since most offline sellers do not have sufficient information to vary their prices from customer-to-customer and because changing the price of individually tagged items may involve considerable cost. Where providers do have sufficient customer information and price adjustments are relatively easy to make, however, variable pricing can produce benefits to both seller and consumer. For example, airlines have long set lower fares for tickets issued 21 days in advance that include a Saturday night stay (that is, tickets sold to more price-sensitive and time-flexible travelers who can plan ahead) and much higher fares for next-day tickets (tickets sold to less price- and more time-sensitive business travelers). More recently, airlines have developed an e-mail strategy to attract "spur of the moment" travelers with last minute travel deals. As a result, while vacation travelers obtain fares at a lower cost than if the airline charged a single price for all seats on the plane, business travelers can be confident that they can secure seats with little advanced notice, and airlines operate with a higher proportion of their seats filled.

The Internet opens up this airline-type variable pricing to many other types of goods and services, creating the potential for greater specificity in variable pricing. By gauging the price sensitivity of particular consumers relative to the marginal cost of the good and its availability, online sellers can fine tune prices for individual customers to maximize profits. The study of 20 book titles and 20 CD titles cited above (Brynjolfsson and Smith) found that Internet retailers regularly make price adjustments that are smaller than the smallest price changes observed in conventional stores.

Electronic Information

Product and Service Information. Regardless of where people are, those with Internet access have at their finger tips a repository of information on product and service prices, quality, and availability that would have been unimaginable before the Web. Manufacturers, retailers, and online magazines now offer detailed product, warranty, and repair information, along with comparisons of competitive products. Rather than

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this one by Cyber Dialogue, found that price was a decisive factor in online purchases. See *Nua Internet Surveys*, "Cyber Dialogue: Price Still Drives Choice of Shopping Site," March 1, 2000 (http://www.nua.ie).

comparison shopping at brick-and-mortar stores, consumers can now get reliable information conveniently on the Web.

Consider the information about automobiles now available online, from dealer costs and expert reviews to the availability of options and detailed product specifications. Consumers cannot test drive an automobile on the Web, so auto buyers still want to visit car dealerships. (Consumers are also constrained by laws in most states that restrict the sale of new cars to licensed auto dealers who cannot also be car manufacturers.) However, consumers who do their homework online can approach dealers with a wealth of information that can strengthen their bargaining position and reduce some of the stress of car buying. According to J.D. Powers and Associates, while only 2.7 percent of the people who purchased a new vehicle during the first quarter of 1999 purchased their car through an online buying service, the percentage of new-vehicle shoppers using the Internet to help them shop increased from 25 percent in 1998 to 40 percent in the first quarter of 1999, and it is projected to reach more than 65 percent by the end of 2000.[11] After purchasing a car, consumers can find other valuable information online, including authorized repair locations, warranty information, recalls, and information to troubleshoot problems.

Health Care. The Internet increases the ability of patients to participate more actively in matters related to their own health. A recent study by the California HealthCare Foundation cites estimates that the Internet offers at least 17,000 different health care sites and that some 24.8 million U.S. adults have searched for health information. This number is projected to grow to over 30 million during 2000.[12] Jupiter Communications has estimated that 45 percent of online consumers access the Internet for health information.[13] Today, some patients arrive at their doctors' offices carrying possible diagnoses downloaded from sites such as Healtheon/WebMD or America Online Health Channel. In addition, people with Internet access can obtain information about their healthcare plans, find doctors, and in some cases submit claims for fee reimbursement. Doctors, too, are increasing their use of the Internet as a source of information on the latest news in medical research. Other aspects of health care delivery, including laboratory results reporting, prescriptions, office visit scheduling, and records transmittal may move online once issues such as privacy and authentication are resolved.

Employment. Many private companies now post job openings on their company's Web site, and in some cases these sites can accept online applications. In their 2000 survey, recruitsoft.com and iLogos Research found that 79 percent of the Global 500 used their Web sites for recruitment compared with 29 percent in 1998. Approximately one-half (46 percent) of the Global 500 both posted openings and

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[11] J.D. Powers and Associates, "More Than Five Million New-Vehicle Shoppers Nationwide Use the Internet to Shop for New Vehicles," Press Release, August 23, 1999 (http://www.jdpower.com).

[12] Janlori Goldman, Zoe Hudson, and Richard Smith, "Privacy: Report on the Privacy Policies and Practices of Health Web Sites," sponsored by California HealthCare Foundation, January 2000. Executive Summary, pp. 4-5 (http://ehealth.chcf.org).

[13] Jupiter Communications, "Internet Health Commerce to Soar to $10 Billion, But Current Offerings Don't Deliver on Consumer Convenience," Press Release, January 26, 2000 (http://www.jup.com).

accepted applications online, while one-third listed openings online, but encouraged application by mail or fax. Web site recruiting among the North American-based Global 500 was even more prevalent, with over 90 percent of such firms participating and 71 percent accepting applications online.[14]

In addition to firm-specific online recruiting, a growing number of Web sites offer online employment classifieds, grouping together requests from multiple employers. Some of these sites are maintained by newspaper companies, traditional providers of employment classifieds. Others have been established to specialize in specific employment areas. For example, the U.S. Government maintains www.usajobs.opm.gov, a site containing a listing of current Federal job openings, as well as general employment information.

Some observers believe that effective online recruiting faces substantial barriers. A recent Forrester Research study, for example, noted that "[t]o reach a critical mass of Web users, recruiters must manage multiple job postings, multiple site relationships, and a flood of resumes. Meanwhile, job seekers must explore listings from both companies and recruitment agencies and submit multiple resumes."[15] As a result, Forrester and other analysts believe that these job-classified sites will be superceded by consolidated online career networks that aggregate training, assessment, and placement services.

Research. The Internet's original purpose was to disseminate research and information, and this use continues to be important today. Educational research and technical materials are available online to students, researchers, scientists, and engineers anywhere in the world. Many universities make their research papers available on the Internet, and most academic and professional journals are available online (though often on a cost basis). In addition, previously unpublished information is increasingly available on the Internet. For example, students can download lectures at their convenience, and live classroom presentations are broadcast on the Internet with students submitting questions via e-mail.

The Internet also provides access to research of a more general or recreational nature. News with frequent updates is available from local, national, and foreign sources, as are weather and traffic information. Numerous online services also provide information covering everything from the floor plans of museums and restaurant reviews, to local television and radio listings. During several recent foreign conflicts and natural disasters, the Internet played a role in providing news and information when traditional media outlets were closed. For example, in 1999 the independent Belgrade radio station, B-92, continued to broadcast over the Internet even after its radio broadcasts had been shut-down.

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[14] Recruitsoft.com and iLogos Research, *Global 500 Web Site Recruiting 2000 Survey, An Internet Intelligence Report* (http://www.recruitsoft.com/iLogosSurvey/doc.html). The Global 500 is a list of the largest companies in the world, by gross revenue, according to *Fortune Magazine*.

[15] Forrester Research, "Forrester Predicts Career Networks Will Capture Majority of Online Recruitment Market in 2005," Press Release, February 14, 2000 (http://www.forrester.com).

Digital Government. Federal, state and local governments also are rapidly developing new ways of using the Internet to communicate with clients and to provide public services to businesses and individuals. Activities at the Federal level include:

- The Patent and Trademark Office X-Search system, available at www.uspto.gov, enables anyone to use an Internet browser to search and retrieve more than 2.6 million pending, registered, abandoned, cancelled or expired trademark records. This is the same database and search system used by PTO's examining attorneys.

- The National Institutes of Health offers an online service, www.ClinicalTrials.gov, that provides information about the latest clinical research into cancer, heart disease, and other life-threatening illnesses.

- At the Internal Revenue Service site, www.irs.gov, taxpayers can download any tax forms and instructions they need.

Many state and local governments are also moving services online. Interested individuals and businesses can find information on a wide variety of topics such as registration (voter, business, property, pets), parks, and trash removal. In addition, people can pay their local property taxes and parking tickets on commercial sites such as www.govworks.com or www.ezgov.com.[16]

Online Communities

The spread of Internet access is being accompanied by a proliferation of new community spaces online. Some of these are commercial spaces such as online auctions that allow consumers to sell or trade goods and services. Others are meeting spaces where individuals interact around a particular interest or topic—from chat rooms for hobbyists, and online current events discussions, to support groups for people facing similar challenges. In the process of providing places for individuals to interact, these online spaces create virtual communities.

- We Media, Inc, a multimedia company providing services for people with disabilities, includes on their www.wemedia.com site a WeHomePlace for members to meet and interact with people of similar interests and backgrounds.

- A community center in Arlington, Virginia provides Internet access to immigrants from many parts of the world—including South and Central America, Morocco, Bangladesh, and Albania—so they can

[16] Glenn R. Simpson, "The Web's Final Frontier: City Hall—Two Internet Start-Ups Find Bureaucrats a Harder Sell Than Venture Capitalists," *The Wall Street Journal*, May 17, 2000, p. B1.

e-mail friends abroad, use chat rooms where discussion is conducted in their native language, and read online versions of newspapers from their home countries.[17]

- At www.geneticalliance.org individuals can search for support groups and resource information for almost any genetic condition.

The Internet has also become a popular sharing tool for people to research their family trees, organize family reunions, and share news and photographs—all without long-distance charges.

THE RISE OF THE DIGITAL BUSINESS

While business-to-consumer e-commerce is the most visible aspect of e-commerce, it is only a small part of what is now possible due to recent technological advances. Increasingly, business-to-business (B2B) e-commerce is emerging as an area of critical importance for businesses faced with rapidly changing markets and opportunities. Transactions between businesses account for the lion's share of commercial activity, and e-commerce technologies appear to have an enormous potential to make these transactions more efficient. Companies are also using these technologies to increase the efficiency of their internal operations.

Business-to-Business E-Commerce

Estimates of the dollar value of B2B e-commerce transactions vary widely.[18] According to a summary prepared by *The Industry Standard*, forecasts for 2003 of the dollar value of transactions between U.S. businesses that are conducted electronically range from $634 billion to $2.8 trillion. This wide disparity is due to a combination of methodological and definitional differences.[19] One important difference is the degree to which non-Internet network transactions, such as those conducted over electronic data interchange (EDI) systems, are included in the estimates of B2B e-commerce. Irrespective of the dollar amounts, the market researchers all expect strong growth as companies seek to cut costs and increase efficiency by streamlining their purchasing, sales, and other business processes.

At present, many firms are at the beginning stages of implementing e-commerce technologies in their business processes. A recent National Association of Manufacturers survey found that 68 percent of

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[17] Emily Wax, "Immigrants Use Internet As a Link With Past," *The Washington Post*, February 3, 2000.

[18] Although The Census Bureau has developed a measurement program to capture B2B e-commerce and the broader category of activities generally termed e-business processes, no government estimates are currently available. For a discussion of the surveys currently scheduled see http://www.census.gov/epcd/www/ebusines.htm.

[19] Stacy Lawrence, "Behind the Numbers: The Mystery of B2B Forecasts Revealed," *The Industry Standard*, February 21, 2000 (http://www.thestandard.com).

manufacturers are not yet using electronic commerce to conduct business transactions. While 80 percent of the surveyed firms reported having a Web site, far fewer firms reported using the Internet for business processes such as requests for proposals, purchasing, etc.[20] In contrast, a recent *Purchasing Magazine* survey shows that 38 percent of buyers currently use the Web to conduct at least some of their company's transactions. The survey also finds that of those who do not currently conduct transactions over the Internet, approximately 35 percent say they will begin to conduct transactions electronically within the next year and 54 percent say they will do so within the next three years. Only 11 percent of those not currently online have no expectation of using the Internet for procurement.[21]

Transforming the Market Place

The potential of e-commerce technologies to transform business practices is evident in the new marketplaces that are developing online. These important intermediaries have emerged rapidly in virtually all industries, providing new places for buyers and sellers to meet, allowing a variety of pricing schemes to flourish, altering the roles of traditional intermediaries, enabling complex transactions, and, by making vast amounts of information available at very low costs, shifting the balance of power among market participants. The expanded reach of these online market spaces enables buyers to solicit bids from a broader range of suppliers and, in turn, allows suppliers to develop relationships with additional buyers.

According to a recent estimate by the *Economist*, over 750 networked marketplaces have been developed worldwide.[22] Some of these cover a wide variety of products and a diffuse group of buyers and sellers. E-Bay, for example, which started out providing a marketplace for consumers selling to other consumers (C2C) in online auctions, has expanded to include B2C and B2B transactions.

Some sites offer broader functions for more targeted client groups. Onvia, for example, is one of the many sites seeking to be the small business portal for goods and services. Other sites leverage existing relationships within specific industries on a global basis. One prominent example is the new online marketplace under development in the automotive industry. In November 1999, both General Motors Corporation and Ford Motor Company independently announced plans to move their purchasing operations online. Then, in late February 2000, these two companies announced that together with DaimlerChrysler AG, they would work to form the world's largest online marketplace.[23] According to

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[20] National Association of Manufacturers, "New NAM Poll Shows that Despite Tech Advances, Most Manufactures Still Not Using E-commerce." Press Release. February 22, 2000 (http://www.nam.org/News/Releases/Feb00/ pr0222.htm).

[21] Mark A. Brunelli, "What Buyers Want From Web Sites," *Purchasing Online, Special Internet Report*, December 16, 1999 (http://www.manufacturing.net/magazine/purchasing).

[22] "Seller Beware," *The Economist*, March 4, 2000, p. 61-2.

[23] General Motors Corporation, Ford Motor Company, and DaimlerChrysler, "Ford, General Motors and DaimlerChrysler Create World's Largest Internet-Based Virtual Market Place," Press Releases, February 25, 2000.

press reports, if completed, this exchange is expected to handle the nearly $250 billion worth of parts and other items that these companies purchase each year. Auto executives estimate that they will be able to reduce purchasing costs by up to 10 percent over several years with the new system. These savings are expected to arise from increased competition, as the number of bidders for each contract increases, and by eliminating many of the meetings now required before a parts order is placed. "Since half of the cost of a $20,000 car lies in purchased parts, the new system could reduce the cost of producing a typical automobile by $1,000."[24]

Similarly, Sears, Roebuck and Company, the second largest U.S. retailer, is joining with Carrefour SA, a Paris-based retailer, to create GlobalNetXchange, an online marketplace for the retail industry. These two companies buy a combined $80 billion in goods and services a year from 50,000 suppliers, and they are seeking other retailers to join with them.[25] While Sears's current EDI system costs the company approximately $150 per hour; their new Internet-based exchange could reduce these costs to $1 per hour.[26] In addition, on March 28, 2000, Boeing, Lockheed Martin, BAE Systems, and Raytheon Company unveiled plans to develop an Internet trading exchange for the global aerospace and defense industry. Together these companies have procurement outlays of $71 billion.[27]

While the large buyers organizing these online marketplaces hope to achieve significant cost savings, it is difficult to gauge *a priori* the impact these new arrangements may have on their supply communities. Some suppliers and potential suppliers that had been unable to justify the cost of EDI connections may be much more willing to use the Internet to bid on work that they would otherwise have missed. Concerns have been raised, however, about the potential for these large players to use these markets to reduce competition. The overall impact will depend on the extent to which actual efficiencies can be achieved as opposed to squeezing supplier margins. One probable side effect of moving these supply networks to the Internet will be to increase the level of investment in Internet technologies.

E-commerce technologies also appear to be driving changes among traditional intermediaries—i.e., firms such as wholesalers, travel agents, or shippers, that add value between the production of a good or service and its sale to the final consumer. Early predictions were that the Internet and e-commerce would create efficiencies by eliminating the need for intermediaries. Manufacturers and service providers would begin selling directly to the customer and "middlemen" would disappear. However, the early speculation failed to appreciate the important role that intermediaries play or the resourcefulness some intermediaries would exhibit in finding new ways to add value in an online world.

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[24] Keith Bradsher, "Carmakers to Buy Parts on Internet," *The New York Times*, February 25, 2000, p.1.

[25] Oracle, "Sears, Carrefour, Oracle to Form Retail's First Worldwide Online Marketplace," Press Release, February 28, 2000 (http://www.globalnetxchange.com).

[26] Sandra Guy, "Sears, French Giant in Online Venture," *Chicago Sun-Times*. February 29, 2000.

[27] Boeing, "Boeing, Lockheed Martin, BAE Systems and Raytheon to Create B2B Exchange for the Aerospace and Defense Industry," Press Release, March 28, 2000 (http://www.boeing.com).

Instead of vanishing, traditional intermediaries are adapting to exploit new possibilities as providers of logistical, financial, and information services. Take the case of ChemConnect, an online suppliers directory that has evolved into a global Internet exchange. ChemConnect brings suppliers and buyers of chemicals and plastics into negotiations where the providers of intermediary functions offer their services for bid. As buyer and seller work to reach agreement on a purchase, intermediaries provide estimates of costs, including carriers (ocean, inland marine, and truck), documentation (customs clearing, regulatory/tax, insurance, cargo surveying), and warehousing (terminal operations, consolidation).

Internet-based market spaces also broaden market participation by decreasing the costs of participating in B2B markets. For decades, large companies have used EDI to automate routine paperwork surrounding business transactions, to manage arrangements such as automatic inventory replenishment, and to make purchases according to pre-established terms. Until recently, the use of this e-business activity was limited to large volume supplier/customer relationships because EDI required a fairly sizable investment in dedicated hardware and proprietary software and use of expensive leased telecommunications lines. As costs of computing power, memory, and storage declined throughout the 1990s, the size threshold at which EDI became cost-effective also declined, but still remained too high for many trading applications. Now, however, the Internet with its open nonproprietary protocols and global reach has emerged as a platform for spreading the efficiencies achievable through the automation of business processes to firms of all sizes.

The bulk of B2B e-commerce remains EDI-based, although analysts are predicting that most of the future growth of B2B e-commerce will be Internet-based. The National Association of Manufacturers estimates that among businesses that currently use the Web for business, 17 percent are using it in place of EDI.[28] The Boston Consulting Group estimates that 86 percent of the $671 billion in B2B e-commerce in 1998 was EDI conducted over private networks. However, they estimate that the EDI component will fall to 28 percent by 2003.[29]

In addition, businesses and even governments have discovered the potential of the Internet as an auction space. Businesses are using auctions to sell off surplus goods, dispose of used equipment, and post requests for purchase. More than 10,000 companies have posted, sold, or bought goods on the Tradeout.com site, which focuses solely on auctioning surplus goods.[30] Dovebid, an established used-capital asset disposition auctioneer, has set up an online auction site with more that 200,000 items and is reaching out to a global market.[31]

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[28] National Association of Manufacturers, “New NAM Poll Shows that Despite Tech Advances, Most Manufactures Still Not Using E-commerce,” Press Release, February 22, 2000 (http://www.nam.org/News/Releases/Feb00/ pr0222.htm).

[29] Boston Consulting Group, “New BCG Study Re-Evaluates Size, Growth and Importance of Business-to-Business E-Commerce,” Press Release, December 21, 1999 (http://www.bcg.com/media_center/media_press_release_ archive2.asp).

[30] Clinton Wilder, "Unload your Surplus on the Web," *Informationweek*, August 30, 1999.

[31] *Ibid.*

Business purchasers are also using online auctions to request bids. Owens Corning used an online reverse auction run by Freemarkets, an online auction company, to put bids out for corrugated packaging materials for its 21 U.S. plants. At the end of the day the company had 17 two-year contracts with corrugated packaging material suppliers and had saved an estimated 10 percent.[32]

E-Business Processes

E-commerce transactions represent only one way in which innovations in computers and communications can add value and make business processes more productive. All business processes have some information component. Specifications for a design must be shared between architects and engineers. The latest maintenance information must be delivered to the mechanic working on the airplane. The manufacturer of auto interiors needs to know how many blue interiors must be delivered for a manufacturing run at the auto plant. All of these processes benefit when information flows faster, more accurately, and in greater detail to the people who need it.

Many companies are experimenting with processes that enable them to share information over a network or the Internet. For example, BOC Gases replaced a slower, more costly certification procedure with a process that sends product certification results over the Internet for customers that need specialized gas products.[33] Similarly, John Deere Construction Equipment Company uses the Internet to improve customer service by creating a portal providing component life cycle data to enable customers to manage component replacement before failure.[34]

Businesses are also using networking technologies to improve processes, such as design and engineering, reducing development time, simplifying manufacturing processes, and integrating design processes. Examples include:

- *Using Internet technologies to coordinate product design*. Conexant, a semiconductor producer, has created Web-enabled tools for its new product development process. The company's 2,000 engineers use a standard Web browser to access the company's portfolio of projects and obtain information on phase of development, team composition, deliverables, and time frame.[35]

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32 Pat Reynolds, "Corrugated Comes Over the Internet," *Packaging World Interactive*. April 2000.

33 BOC Gases, "Electronic Commerce as BOC Gases in the United States," Web site viewed February 23, 2000 (http://www.boc.com/ecom/success.html).

34 John Deere, "Deere Announces Internet-Based Customer Support Program," News Release, December 9, 1999 (http://www.deere.com).

35 David Kleinbard, "Web Puts a Charge into Electronics," *InformationWeek*, September 27, 1999.

- *Using communications networks to improve human resource functions*. Shaw Industries, a manufacturer of floor coverings, uses an internal network to support compensation planning and retention initiatives for the company's 36,000 worldwide employees.[36]

- *Using wireless networks to manage inventory more efficiently*. Cablevision, a telecommunications and entertainment company, uses wireless mobile computer appliances over a local area network to process inventory transactions in real time, at the point of activity. Previously, Cablevision workers made inventory transactions, such as transferring inventory between warehouses or scanning new shipments, by filling out forms by hand for later entry into a central computer. The new system eliminates the daylong wait to update the main database, so that inventory, such as cable boxes, can be located instantly. When the installation is complete, the project will cover 43 warehouses across four states.[37]

- *Using extranets to provide training*. Service Experts, a company specializing in the installation and maintenance of heating and cooling systems with 150 locations in 34 states, established an extranet to serve as an online resource library that includes "3-D diagrams with training manuals and step-by-step instructions for solving problems."[38]

- *Using the Internet to provide customer services and answer frequently asked questions.* Many companies are using their company Web site to offer customer services and product information. Ford offers product information and links to dealers, and their "Owner Connection" Web page provides Ford car owners with maintenance information, safety tips, service reminders, do-it-yourself pointers, and online manuals.[39]

- *Using the Internet to reduce project administration and management costs.* Over the year-long process of building a hotel in San Francisco, contractor Swinerton & Walberg estimates that by using an Internet-based project management system they will squeeze about $110,000 out of the project's $11 million budget.[40]

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[36] "Shaw Industries Optimizes Employee Compensation and Retention using Hyperion's Analytic Application Software," *Business Wire*, Feb 23, 2000.

[37] "Symbol Partners With BPA Systems To Provide Cablevision With Wireless ERP Warehouse Solution," *Business Wire*, February 23, 2000.

[38] Richard W. Oliver, "Killer Keiretsu," *Management Review*, September 1999, p.11.

[39] Ford Motor Company Web site, Viewed on May 9, 2000 (http://www.ford.com).

[40] Edward Cone, "Building a Stronger Economy," *Zdnet*, January 24, 2000 (http://www.zdnet.com/intweek/stories/news/0,4164,2425874-1,00.html).

AN INCREASINGLY WIRED WORLD

Not only are individuals, businesses, and other organizations going online in increasing numbers, but the products and services used in everyday life are becoming increasingly integrated into the networked economy. Certain goods and services can now be delivered directly to the buyer over the Internet. And Internet connectivity is no longer tied to the desktop computer.

The Internet provides a new way to have goods and services delivered. Music, legal advice, software, opera tickets, news reports, books, photographs, movies, and product designs—can all be downloaded directly into a computer. According to Forrester Research, while only 3 percent of all current online B2C sales consist of digitally-downloaded products, this level could reach 22 percent of all online sales by 2004. The most dramatic growth in direct, digital download sales will probably be in the music sector, where such sales could rise from 0.1 percent of online sales in 1999 to 25 percent in 2004, followed by software (rising from 7 percent of online sales in 1999 to 40 percent in 2004) and books (rising from 1 percent of book sales online in 1999 to 13 percent in 2004).[41]

Digitalization is also changing the design of products, so these products can be networked. For example, home-electronics producers have joined together to develop Home Audio Video Interoperability (HAVi), an open, consumer-electronics-industry standard that will allow digital audio and video devices from different vendors to work together when connected to a network in the consumer's home.[42] Appliances that can be networked are beginning to emerge in other areas as well.

New home electronics and appliances will not only be networkable, many of them also will be "network appliances"—that is, appliances that can access the Internet. The television has long been viewed as a potential portal for Internet access. More recently, simple, low cost dedicated Internet access devices have been introduced. In addition, connectivity is increasingly being viewed as an important feature to add to existing products. At recent trade shows, for example, home appliance manufacturers have unveiled prototype Internet-enabled refrigerators and ovens that offer features such as e-mail, calendar management, automated grocery ordering, and tracking of the service requirements of the appliance.

We are only in the early stages of designing and developing new products that take advantage of open networks. This development is still limited by slow connection and transmission speeds and the lack of standards to facilitate individual appliances communicating with one another. As these limitations are addressed, however, the developmental pace of digital products is likely to increase. New technologies that exploit the potential of wireless connections are already creating new ways of communicating and

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[41] Forrester Research, "Spectacular Growth for Digital Delivery," February 7, 2000 reported by *Nua Internet Surveys*, (http://www.nua.ie). The ability to download material raises concerns about intellectual property protection. For example, Napster, creator of a software program that allows users to swap music stored in the MP3 format, is facing multiple lawsuits, charging that it facilitates the pirating of digitized music.

[42] See (http://www.havi.org).

conducting business, reconfiguring many traditional industry and product definitions. As Internet access migrates from the desktop computer to a range of products, the lines that now separate the transmission of voice, data, and pictures will disappear. New devices under development today will combine cellular telephone, geopositioning, and Internet access in a handheld or automobile device. The major automakers, for example, have already announced plans to equip some of their automobiles with voice activated Internet access and handheld and automobile Internet access is already available in Japan.[43]

The technologies that make the digital economy possible are still evolving, as is the environment in which these technologies are being used. Many businesses and individuals remain hesitant about e-commerce because the business environment online does not yet have the same predictability and reliability as it does offline. And the medium itself offers new challenges. For example, our ability to deliver digital goods electronically has, in many ways, outpaced the resolution of difficult legal and policy questions associated with it, such as how to protect intellectual property rights in an environment where it is easy and inexpensive to make virtually perfect copies of digital originals. Efforts are underway, within the U.S. Government, in multilateral organizations, and within the private sector, to resolve thorny issues related to privacy, safeguards for children, consumer protection, information security, authentication, intellectual property rights, jurisdiction, taxes, and tariffs. Full realization of the economic promise of information technology depends on the development of the same safeguards and predictable legal environment that individuals and businesses have come to expect in the offline world.

[43] Emily Thornton, "Digital Wheels", *BusinessWeek Online* (International Edition), April 10, 2000 (http://www.businessweek.com/2000/00_15/b3676012.htm). For example, Toyota equips some high-end models with its Monet system that offers a online navigational system as well as audio e-mail, weather, news, and real-time video pictures of traffic at major intersections.

CHAPTER III

INFORMATION TECHNOLOGY INDUSTRIES*

The prodigious vitality of the digital economy is grounded in Information Technology (IT) producing industries—the firms that supply the goods and services that support IT-enabled business practices across the economy, as well as the Internet and e-commerce. (See Table 3.1, below). Over the past decade, and especially since the mid-1990s, these industries have been a powerful factor in the economy's rapid and sustained growth, a significant restraint on inflation, and a focal point of prolific technological innovation. This chapter examines the performance of IT-producing industries and analyzes their contribution to the new economy.

Table 3.1
Information Technology Producing Industries

Hardware Industries	Software/Services Industries
Computers and equipment	Computer programming services
Wholesale trade of computers and equipment	Prepackaged software
Retail trade of computers and equipment	Wholesale trade of software
Calculating and office machines	Retail trade of software
Magnetic and optical recording media	Computer-integrated system design
Electron tubes	Computer processing, data preparation
Printed circuit boards	Information retrieval services
Semiconductors	Computer services management
Passive electronic components	Computer rental and leasing
Industrial instruments for measurement	Computer maintenance and repair
Instruments for measuring electricity	Computer related services, nec.
Laboratory analytical instruments	
Communications Equipment Industries	**Communications Services Industries**
Household audio and video equipment	Telephone and telegraph communications
Telephone and telegraph equipment	Radio and TV broadcasting
Radio and TV communications equipment	Cable and other pay TV services

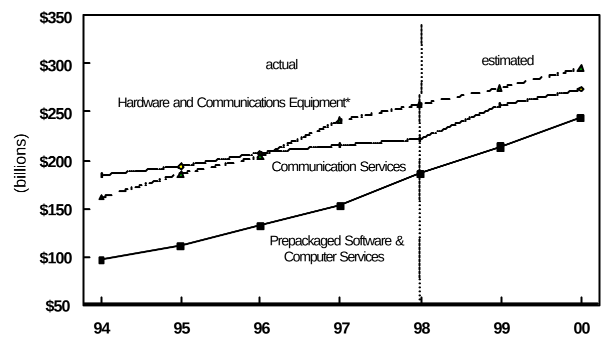
Note: Industries represented and measured here are defined in a manner consistent with the 1987 Standard Industrial Classification (SIC) categories, rather than the newly implemented North American Industry Classification System. This was done both to provide a consistent GPO time series prior to 1997 and because Census revenue data for computer services and communication services through 1998 continued to be released according to their SIC categories.

* This chapter was written by David Henry, Senior Industry Analyst, and Donald Dalton, Economist, in the Office of Business and Industrial Analysis. See the Appendix for data sources and the methodologies underlying the findings.

IT-PRODUCING INDUSTRIES—GROWTH ACCELERATES COMPOSITION SHIFTS TOWARD SOFTWARE AND COMPUTER SERVICES

Since the mid-1990s, IT-producing industries have shown extraordinary dynamism. Prepackaged software and computer services had the highest growth rate, increasing their output (gross product originating or GPO) from 1995 to 2000 at a remarkable average annual rate of 17 percent (nominal dollars).[1] (Figure 3.1) Over the same period, the computer hardware and communications equipment industries increased their output at a 9 percent annual rate, and output in the communications services sector rose at a 7 percent annual pace.

Figure 3.1
IT-Producing Industries by Sector: Gross Product Originating

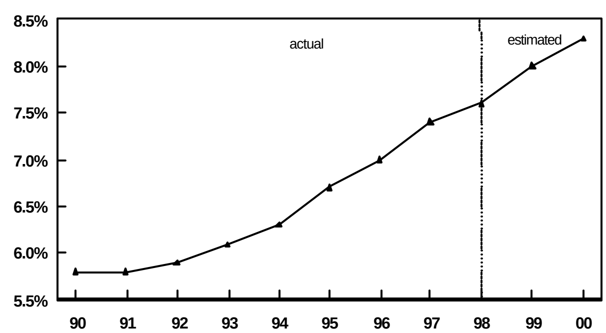


Source: ESA estimates from BEA and Census data through 1997. ESA estimates for 1998-2000 based on projections from ITA.

*Hardware includes computers, electronic components, and instruments

This dynamic growth increased IT industries' share of total output from 6.3 percent in 1994 to an estimated 8.3 percent this year. (Figure 3.2) By contrast, between 1990 and 1994, these same industries' share of the economy grew much more slowly—by only

Figure 3.2
IT Producing Industries' Share of the Economy



Source: ESA estimates based on BEA and Census data through 1997. ESA estimates for 1998-2000 based on some data for 1998 and projections from ITA.

[1] Estimates of GPO in this analysis are derived from BEA measures prior to the October 1999 benchmark revisions, but include the conceptual change made at that time in the treatment of prepackaged software and software services in the National Income and Product Accounts. Prior to this change, software purchases were treated as an intermediate input with no lasting effect. Such purchases are now classified as fixed investments for both business and government sectors.

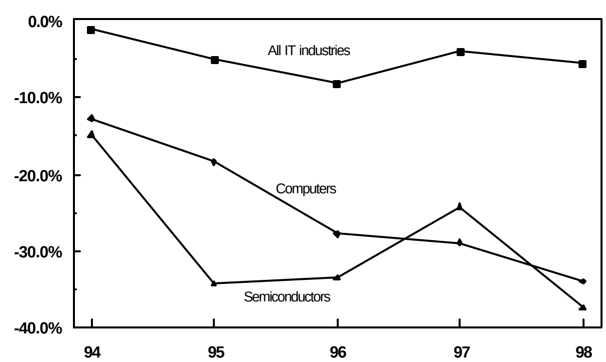
about 0.5 percentage points overall.[2] The rapid increase in these industries' share of the economy after 1994 is particularly impressive in view of both the rapid growth of the economy as a whole and the accelerated decline in IT prices over the period.

The recent swift growth of IT industries has also coincided with sharply declining prices of IT goods and the rapid expansion of both the Internet and network-related business processes. A modest share of IT growth also reflected spending related to addressing Y2K-related computer problems. ESA analysts have estimated that Y2K-related spending accounted for roughly 7 percent of the output of IT-producing industries in 1998 and 1999.[3]

FALLING IT PRICES HAVE REDUCED OVERALL U.S. INFLATION

The declining prices of IT goods and services have worked, directly and indirectly, to reduce overall inflation in the U.S. economy. Since the mid-1990s, the price decline for IT products has accelerated—from about 1 percent in 1994, to nearly 5 percent in 1995, and an average 8 percent for the years 1996, 1997, and 1998. (Figure 3.3 and Table 3.2) The steepest price declines occurred in the computer and semiconductor industries, where prices fell at average annual rates of 24 percent and 29 percent respectively, for the years 1995 to 1998.

Figure 3.3
Price Changes--IT-Producing Industries



Source: ESA estimates based on BEA data.

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[2] IT-producing industries' share of the economy is calculated from its Gross Product Originating (GPO) as a percent of the economy, as measured by Gross Domestic Income (GDI). Theoretically, the nominal dollar value of GDI, the income associated with the output of all industries, should equal that of Gross Domestic Product (GDP); i.e., final demand or the market value of the goods and services produced by labor and property in the United States. In practice, growth in GDI and GDP have differed by half a percent in recent years.

[3] Estimate of percent of output based on industry spending estimates in the *The Economics of Y2K and the Impact on the United States,* Economics and Statistics Administration, U.S. Department of Commerce, November 17, 1999.

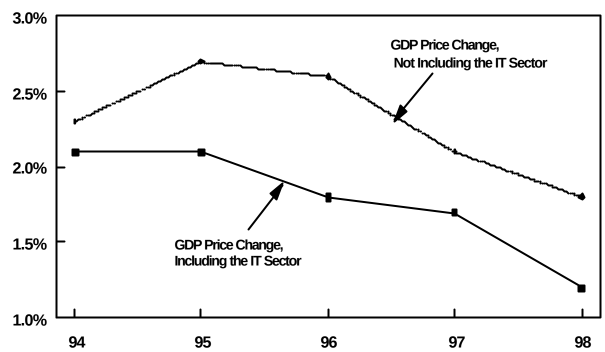
Table 3.2
Price Changes:
IT-Producing and All Other Industries

	94	95	96	97	98
			(Percent)		
IT-Producing Industries	-1.4	-4.5	-8.1	-7.1	-8.0
GDP, not including IT industries	2.3	2.5	2.5	2.3	1.8
GDP, including IT industries	2.1	2.1	1.8	1.9	1.2

Source: ESA estimates based on BEA and Census data.

Over the same period, lower prices in the IT sector reduced overall U.S. inflation directly, on average, by about 0.5 percentage points a year—from 2.3 percent to 1.8 percent. In 1998, falling IT prices helped hold overall inflation to just over 1 percent—the smallest increase in the GDP chain-type price index since 1963. (Figure 3.4 and Table 3.2)

Figure 3.4
IT-Producing Industries:
Effect on Price Change



Source: BEA data for GDP and ESA estimates for GDP, not including the IT sector.

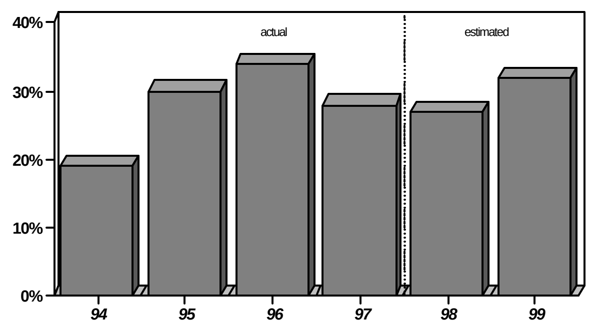
Moreover, because these estimates focus only on the direct effects and ignore the indirect effects of lower prices, they almost certainly understate IT's full importance in keeping inflation low. A more complete estimate of IT's role would cover not only the direct effects on inflation of price reductions in 8 percent of the U.S. economy that produces IT goods and services, but also the price effects of the increased competition and efficiency induced by IT deployment in the 92 percent of the economy outside the IT-producing sector. We have no way to disaggregate and measure these effects on their own. But their embedded influence is reflected in the upper line in Figure 3.4, which shows declining inflation in non-IT producing industries between 1996 and 1998.

IT-PRODUCING INDUSTRIES ACCOUNT FOR NEARLY ONE-THIRD OF REAL GDP GROWTH BETWEEN 1995 AND 1999

IT industries produce less than 10 percent of total U.S. output. Nevertheless, between 1995 and 1999, because of IT industries' extraordinary growth and falling prices, they accounted for an average 30 percent of total real U.S. economic growth.[4] (Figure 3.5 and Table 3.3)

Figure 3.5

IT-Producing Industries: Contribution To Real Economic Growth



Source: ESA estimates derived from BEA and Census data for 1994-97. ESA estimates for 1998-99 derived from projections from ITA.

Table 3.3

IT-Producing Industries: Contribution to Real Economic Growth

	94	95	96	97	98 est.	99 est.
(1) Changes in Real			(Percent)			
Gross Domestic Income*	4.2	3.3	3.5	4.7	4.8	5.0
		(Percentage Points)				
(2) IT Contribution	0.8	1.0	1.2	1.3	1.3	1.6
(3) All Other Industries	3.4	2.3	2.3	3.4	3.5	3.4
(4) IT Portion		(Percentage Share)				
Of GDI Change (2)÷(1)	19	30	34	28	27	32

*GDI is equal to the income that originates in the production of goods and services attributable to labor and property located in the U.S.

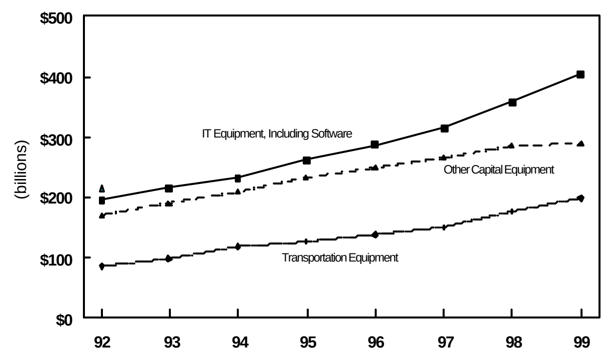
4 These estimates are based on inflation adjusted "income side" data; *i.e.*, income attributable to IT industries compared to growth in Gross Domestic Income (GDI). Income side data were used here because "product side" data—the data used to estimate GDP—are not sufficiently disaggregated to describe the economic performance of all IT-producing industries. However, for a large segment of IT output—*i.e.*, computers, software, and telecommunications—product side data can be used to test the robustness of income side estimates. In fact, for this segment of output, estimates of IT industries' contribution to economic growth based on product side data coincide quite closely with growth estimates based on income side data. Since 1995, based on product-side data, computers and software and communications services have contributed about 23 percent to economic growth; the comparable estimate using income-side data is about 22 percent.

USE OF IT EQUIPMENT INCLUDING SOFTWARE

A critical factor in IT's predominant role in recent U.S. growth is the increasingly dominant part that IT equipment, including software, plays in business investment activity. In current dollars, industry spending on IT equipment and software rose from $198 billion in 1992, or 44 percent of all equipment spending, to $407 billion in 1999, or 46 percent.[5] (Figure 3.6) Over the same period, "other capital equipment," including industrial equipment, fell from 38 percent of total equipment and software investment spending to 32 percent, and transportation equipment ranged between 18 percent and 21 percent.

Figure 3.6

Industry Spending on Capital Equipment Continues to Shift Towards IT Equipment, Including Software

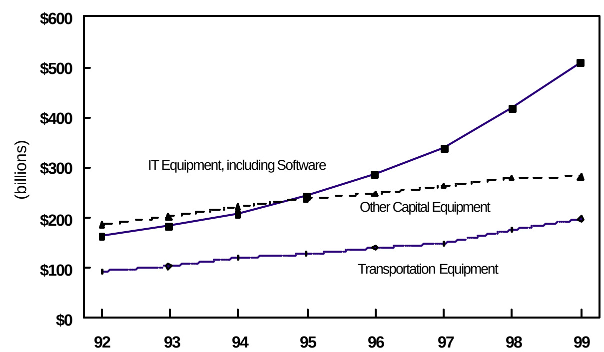


Source: BEA

Because prices for IT equipment and software have been falling, investment spending shifts are even more pronounced when expressed in real dollars, rather than nominal amounts. (Figure 3.7) Since 1995, prices of IT capital equipment and software have dropped by an average 6.7 percent per year, while prices for transportation capital equipment have increased at a 0.6-percent average annual rate and prices for other types of capital equipment have increased at a 1.5-percent rate.

Figure 3.7

Industry Spending on Capital Equipment Inflation Adjusted Dollars



Source: BEA

As a result, real business investment spending on IT equipment and software more than doubled between 1995 and 1999, from $243 billion to $510 billion (1996 dollars), while real spending on transportation equipment increased by about half and real spending on other capital equipment increased slightly.

Over the decade of the 1990s, growing industry spending on IT equipment and software was a significant factor in the high rate of growth of U.S. spending on all categories of equipment to 9-to-10 percent per

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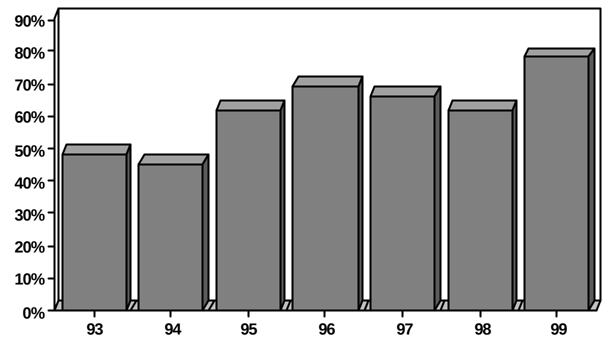
[5] Prior to the inclusion of software as an investment good, industry spending on IT equipment consistently accounted for about one-third of all capital equipment spending in the 1990s.

year, compared to 5-to-6 percent a year in the 1980s.[6] In 1999, business spending for IT equipment and software represented more than *three-fourths* of the 12 percent real growth in total equipment and software spending that year, compared to 65 percent of the real growth in equipment spending for 1995-1998 and less than 50 percent for 1993-1994. (Figure 3.8 and Table 3.4)

Figure 3.8
Contribution of IT Investment To Growth In Overall Equipment Investment



Source: ESA estimates based on BEA data.

Table 3.4
Contribution of IT Equipment* To Growth in Capital Equipment and Software

	93	94	95	96	97	98	99
			(Percent)				
(1) Change in real spending for capital equipment	11.4	11.8	11.9	11.0	11.5	15.8	12.1
			(Percentage Points)				
(2) Contribution of real spending for IT equipment	5.4	5.3	7.4	7.5	7.5	9.8	9.4
(3) Contribution for all other types of capital equipment	6.0	6.5	4.5	3.5	4.0	6.0	2.7
			(Percent)				
(4) IT's contribution to change in real capital equipment spending	47	45	62	69	66	62	78

* Defined by BEA as information processing and related equipment

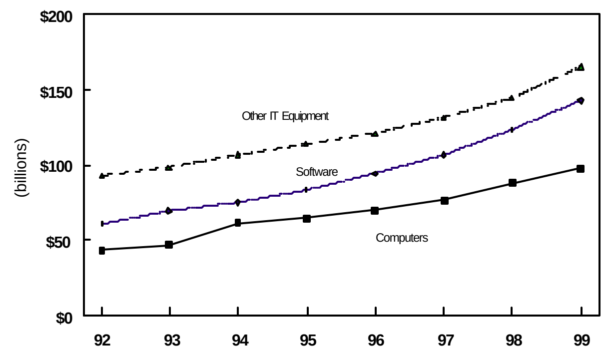
Source: ESA estimates derived from BEA data

[6] Over the 20 year period since 1980, spending on IT equipment has grown at a steady annual rate of 10-11 percent. In contrast, growth in spending in other categories of capital equipment, including industrial equipment, averaged about 5-6 percent over the same period. Spending for transportation equipment grew by an average 5 percent per year in the 1980s, but accelerated to 11 percent in the 1990s.

In nominal dollars, investment patterns within IT industries also show a substantial shift to software. As a share of total IT equipment investment, spending for software increased from just over 30 percent in 1992-1995 to 35 percent in 1999. (Figure 3.9) Despite the rapid decline in computer prices (Figure 3.3, above), computers' share of IT equipment investment in nominal dollars remained relatively constant over the 1992-1999 period. Other IT equipment, including spending on communications equipment, remained the largest category of IT equipment purchases, although its share declined from 47 percent in 1992 to 41 percent in 1999.

Figure 3.9

IT Equipment Investment: Spending for Software Accelerates after 1995

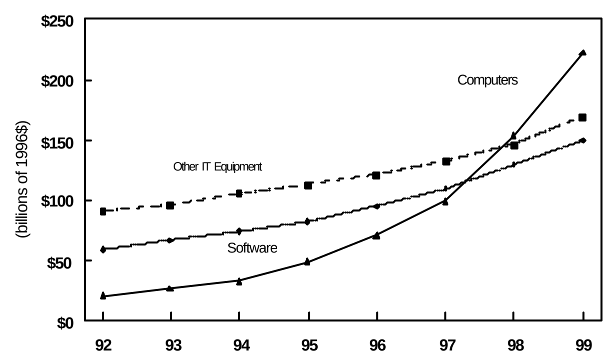


Source: BEA

Analysis of the composition of IT investment in real rather than nominal dollars yields a somewhat different picture because prices have declined far more rapidly for computer than for other kinds of IT equipment and software. Measured in real dollars, beginning in 1994, investment in computers accelerated more rapidly than investment in the two other IT categories, surpassing investment in these categories by 1998. (Figure 3.10) In 1999, price- adjusted spending for computers totaled $222 billion, compared with $149 billion for software and $170 billion for other IT equipment.

Figure 3.10

Investment Spending for Computers in Real Dollars Outpaces Software and Other IT Equipment After 1997



Source: BEA

R&D INVESTMENT IN IT INDUSTRIES

The surge in IT investment since 1994 has been accompanied by sharp increases in R&D investment in the economy as a whole and in IT-producing industries in particular. Between 1994 and 1999, total U.S. R&D investment grew at an average annual (inflation adjusted) rate of 6 percent. In contrast, between 1989 and 1994, R&D investment grew at an average annual rate of roughly 0.3 percent.

All of the growth in R&D investment in the 1990s came from the private sector.[7] Between 1995 and 1998, IT industry investment accounted for 37 percent of this growth.[8] In 1998, IT industries invested $45.7 billion on R&D, nearly half as much again as total R&D investment by the motor vehicle, pharmaceutical and aerospace industries—industries that traditionally invest large amounts on R&D. (Table 3.5)

Table 3.5

Company-funded R&D Investment by Sector, 1998

	$billions	Percent
All Industries	45.0	100.0
IT-Producing*	45.7	31.5
Computers	8.9	6.1
Communication equip.	10.2	7.1
Electronic components	9.8	6.8
Communication services	1.7	1.2
Software & computer services	14.3	9.9
Motor Vehicles	13.5	9.3
Pharmaceuticals	12.6	8.7
Aerospace	5.1	3.5
All Other Industries	68.1	47.0

*R&D data for IT industries from the Instrument sector are not available for 1998.

Source: National Science Foundation

[7] Total R&D spending includes industry, federal government, universities and nonprofit institutions.

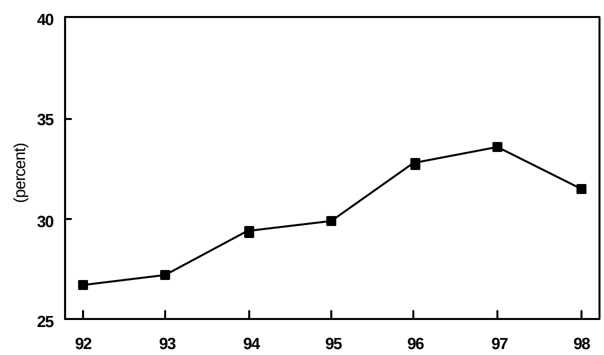
[8] R&D data are available for most, but not all, of the IT-producing industries identified in Table 3.1. Analysis in this section is based on data for the following 3-digit SIC categories: computers and office equipment, communications equipment, electronic components, communications services, and computer services and software.

Between 1992 and 1994, IT-industries' share of all company-funded R&D grew moderately, from 27 percent to 29 percent. Beginning in 1995, however, IT-industries' share of company funded R&D increased to about one-third, spurred by increases in R&D for computer services and software. (Figure 3.11)

Growth in IT industries' share of private R&D is largely the result of increased R&D investment by manufacturers of electronic components and software. (Figure 3.12) In the computer industry, annual R&D investment dropped from an average $11 billion during 1990-92, to $5 billion during 1993-95, then rose to $10 billion during 1996-98.[9] One reason for this lack of overall growth may be that as computer demand has shifted toward micro-computers, more computer-related R&D has shifted to component manufacturers and software firms.

Figure 3.11

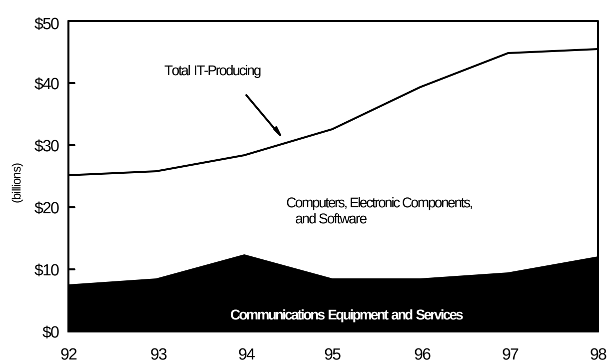
IT Share of Total Company Funded R&D



Source: National Science Foundation

Figure 3.12

R&D for Computers, Electronic Components, and Software and Communications Equipment and Services



Source: National Science Foundation

CONCLUSION

Analysis of IT industry growth and investment patterns demonstrates not only that IT industries are now a major force in the U.S. economy, but also that their economic importance began to grow dramatically in the middle of the last decade. Although many factors contributing to the digital revolution were in place well before the mid-1990s, it was then that their combined effect and potential first became evident and the new economy began to take shape.

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9 See the Appendix for the National Science Foundation data on R&D spending.

CHAPTER IV

CONTRIBUTION OF INFORMATION TECHNOLOGY TO U.S. PRODUCTIVITY GROWTH*

This chapter examines recent studies of the impact of information technology (IT) on labor productivity in the United States. Our analysis of these studies concludes that, based on macroeconomic and firm-level evidence, IT does contribute significantly to productivity growth. However, studies at the industry level continue to produce mixed results.

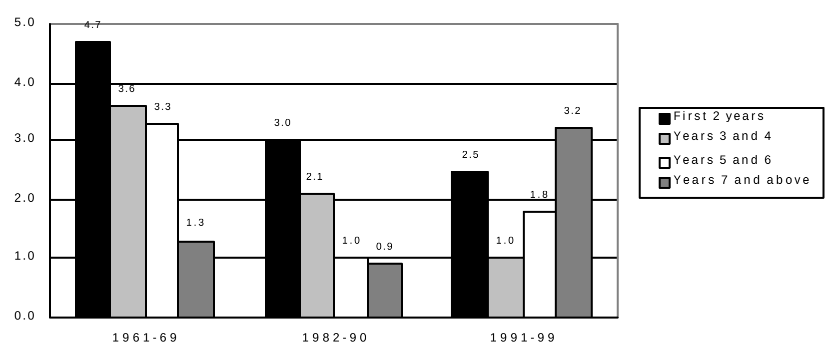
MACROECONOMIC ASSESSMENTS

The current U.S. productivity pattern, in which productivity gains have strengthened as the expansion has matured, is unprecedented for the postwar period. In previous postwar expansions, productivity growth has slowed as the expansion enters its mature phase. (Figure 4.1)

Figure 4.1

Growth in Nonfarm Business Sector Output per Hour During Expansions

(Average Annual Percent Change Over Period)



Note: For each period illustrated above, we calculated the growth in annual rates of quarterly output per hour indexes starting in the quarter when the trough of the business cycle occurred. The start for 1961-69 was in the first quarter because the trough happened in February 1961. For 1982-90, the starting quarter was the fourth, the trough having occurred in November 1982. Finally, for 1991-99, the start was in the first quarter because the trough happened in March 1991. The final column shows growth from 1997 through the fourth quarter of 1999. (Figure 4.1 updates Chart 1-9 in the Economic Report of the President (February 2000), p. 35.)

Source: Department of Labor, Bureau of Labor Statistics.

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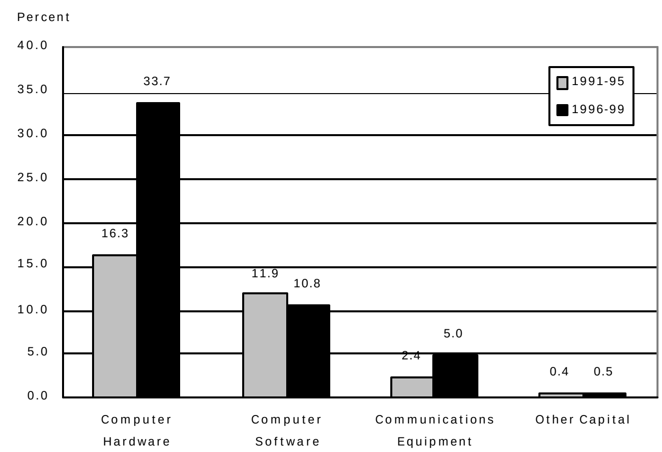
* This chapter was written by Gurmukh Gill, Director of the Office of Business and Industrial Analysis (OBIA), Jesus Dumagan, Economist, OBIA and Susan LaPorte, Economist, OBIA.

One reason for the extraordinary pattern of productivity in the current expansion appears to be the rapid growth in the real net stock of IT capital per labor hour, especially computer hardware (including peripheral equipment). This rapid growth of real net IT capital created significant IT "capital deepening," beginning in 1991 and accelerating sharply after 1995.[1] The ratio of the capital stock of computer hardware to hours worked increased, on average, by 16.3 percent per year over the period 1991-95, and 33.7 percent per year during 1996-99. (Figure 4.2) Capital deepening in computer software also grew at double-digit rates during both periods, while the growth rate in communications equipment increased from 2.4 to 5.0 percent. By contrast, over the 1990s, the rate of capital deepening for all other forms of capital—covering over 95 percent of the total U.S. capital stock—averaged only about one-half of one percent per year.[2]

Figure 4.2
Average Annual Rates of Capital Deepening by Type of Capital in U.S. Nonfarm Business Sector



Source: Oliner and Sichel (May 2000), Tables 1 and 2, pp. 24-25.

A major factor behind IT capital deepening has been the falling prices of IT, especially computer hardware, reflecting rapid and continuous improvements in quality.[3] The quality-adjusted price deflator for computer

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[1] "Capital deepening" occurs when the amount of capital rises relative to the amount of labor hours.

[2] The rates of capital deepening in Figure 4.2 are obtained for each period by subtracting the labor hours growth rate from the growth rates of each type of capital, where the labor hours growth rate is equal to the growth rate of output minus the growth rate of labor productivity. All growth rates used in the figure can be obtained from Stephen D. Oliner and Daniel E. Sichel, "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?," Washington, DC: Federal Reserve Board, May 2000, Tables 1 and 2, pp. 24-25.

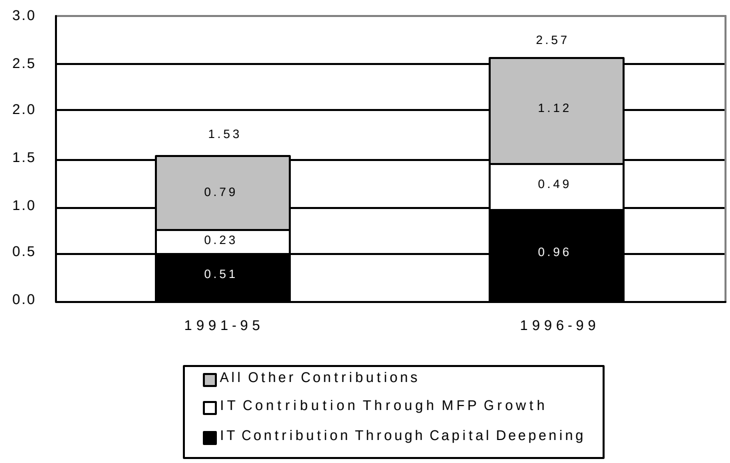
[3] Computing speed has been doubling every 18 months. This phenomenon is commonly called "Moore's Law." A number that doubles every 18 months grows exponentially 46.2 percent per year. Thus, by Moore's Law, computer

hardware fell 14 percent per year during the first half of the 1990s and 29 percent per year during 1996-98.[4] (See also Figure 1.3, Chapter I.)

Figure 4.3, comparing the 1991-95 and 1996-99 periods, shows that IT capital deepening accounts for a large and increasing share of the economy's rising productivity gains. The figure also shows that the acceleration of labor productivity growth has been accompanied by an acceleration in "multifactor productivity" (MFP) growth within the IT-producing sector itself. Multifactor productivity growth reflects the impact of factors in addition to quality-adjusted capital and labor inputs—for example, technical changes not directly incorporated in capital and labor (such as new production processes), organizational improvements, and economies of scale. As discussed below, growth in multifactor productivity has been especially strong in the computer and semiconductor industries.

Figure 4.3

Average Annual Percentage Point Contributions of IT to Rising Labor Productivity Growth



Source: Oliner and Sichel (May 2000), Table 2, p. 25 and Table 4, p. 27.

All categories of IT capital contribute disproportionately to labor productivity growth, compared to their shares of the total private nonfarm business sector and their shares of the total net capital stock. However, the contribution of computer hardware to productivity growth has been extraordinarily large. Recent research indicates that during the years 1996-99, computer hardware deepening accounted for 24 percent

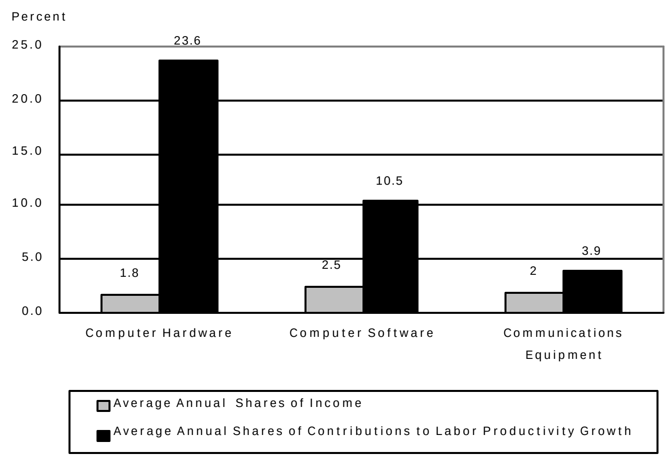
speed increases roughly ten-fold every 5 years.

[4] Daniel E. Sichel, "Computers and Aggregate Economic Growth: An Update," *Business Economics*, April 1999, pp. 18-24, Table 1, p. 19.

of all labor productivity growth.[5] (Figure 4.4) The size of this contribution is especially remarkable because computers constitute just 1.8 percent of the private nonfarm business sector and less than 1 percent of overall capital stock (1998).

Figure 4.4

Shares in Income and in Labor Productivity Growth by Type of IT Capital in the U.S. Nonfarm Business Sector, 1996-99



Source: Oliner and Sichel (May 2000), Tables 1 and 2, pp. 24-25.

The reason that IT, with such a small share of the economy and of the total capital stock, has contributed so powerfully to productivity growth is that the rapidly growing IT investments have been unusually productive. Market conditions dictate that business investments in computer hardware must earn very high rates of return. For one thing, the rapid and continuous improvements in IT quality mean that existing computer hardware becomes obsolete and hence depreciates very quickly. In addition, sharply falling hardware prices mean that businesses investing in IT equipment face rapid capital losses as purchased equipment quickly loses market value. Oliner and Sichel estimate that investment in computer hardware must produce gross rates of return of about 68 percent in order to cover an estimated depreciation rate of 30 percent and capital loss of 34 percent per year, and a competitive net rate of return of 4 percent per year. By their estimates, the payback period for computer hardware investments is less than two years.

[5] The contribution of capital deepening to labor productivity growth for each type of capital equals the rate of growth of the ratio of the capital type to labor hours multiplied by the income share of the same type of capital. For example, Oliner and Sichel, *op. cit.*, Tables 1 and 2, pp. 24-25, estimated that the rate of growth of computer hardware/labor-hour was 33.65 percent during 1996-99 and the corresponding income share of computer hardware was 1.8 percent. Thus, they estimated that the contribution of capital deepening in computer hardware to labor productivity growth was (33.65) x (0.018) = 0.606 percentage points when average labor productivity growth was 2.57 percent, yielding a contribution of 0.606/2.57 or 23.6 percent.

The Emerging Consensus on Resolving the "Computer Productivity Paradox"

Economists who held until recently that the impact of computers on U.S. productivity could be a transitory effect of unusually favorable economic circumstances have begun to credit IT for dramatic increases in the trend growth rates of U.S. output and productivity since 1995. One reason for this change in view has been the increasing attention paid by researchers to the productivity effects of software and communications equipment, in addition to computer hardware. This shift in attention follows the 1998 and 1999 editions of this report that introduced a broader definition of IT[6] and the reclassification by the Bureau of Economic Analysis (BEA) of software spending from current expenditures to investments.

Thus, Oliner and Sichel conclude that surging use of IT (including computer hardware, software, and communications equipment) in the second half of the 1990s, together with advances in the production of computers and semiconductors, contributed about two-thirds of an estimated 1.06-percentage point acceleration in productivity growth between the first and second halves of the decade.

Consistent with Oliner and Sichel's findings, the Congressional Budget Office, the *Economic Report of the President*, Jorgenson and Stiroh, Whelan, and Macroeconomic Advisers, LLC find strong evidence that the mid-1990s acceleration in productivity growth was due largely to IT capital deepening among IT users and also to technical advances and innovations made by IT producers. These analysts' recent estimates of IT's contribution both in computer use (capital deepening) and computer and semiconductor production (technical advance) are summarized in Table 4.1.[7]

When one takes into account the differences in the periods studied and in the coverage of economic activity, idiosyncratic adjustments for limitations in the available data, and other factors, these estimates appear to be remarkably consistent.

Recent studies also suggest that robust productivity growth is likely to continue. For example, Macroeconomic Advisers found that: "Given the large gap between discovery and application in the computer industry, it is reasonable to conclude that real computer prices, which on average have declined

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[6] U.S. Department of Commerce, *The Emerging Digital Economy,* April 1998 and *The Emerging Digital Economy II*, June 1999.

[7] Oliner and Sichel, *op. cit*., Table 5, p. 28; Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2001-2010*, January 2000, Appendix A; *Economic Report of the President*, February 2000, Table 2-3, p. 83; Dale W. Jorgenson and Kevin J. Stiroh, "Raising the Speed Limit: U. S. Economic Growth in the Information Age," May 1, 2000, available from kevin.stiroh@ny.frb.org; Karl Whelan, "Computers, Obsolescence, and Productivity," February 2000, Table 4, p. 34, available from kwhelan@frb.org; and Macroeconomic Advisers, LLC, "Productivity and Potential GDP in the 'New' US Economy," September 1999, pp. 2-3. Table 4.1 excludes, however, results from Macroeconomic Advisers, LLC because they pertain to acceleration in *potential productivity* defined as the "level of productivity consistent with sustainable utilization rates of capital and labor," which is different from measured or actual productivity in the other studies.

20 percent per year since 1996, will continue falling rapidly. As long as they do, the special contribution to productivity growth coming from the technology sector will persist.'[8]

Table 4.1
Contribution of IT Capital to the Acceleration of Labor Productivity Growth in the U.S. Private Nonfarm Business Sector

Studies*	Capital Deepening (Percentage Point)		Technical Advance (Percentage Point)		Total IT Contributio (Percentage Point)	Productivity Acceleratio (Percentage Point)	IT Share of Acceleratio (Percent)
	IT	Other	IT	Other	(a)	(b)	(a/b)x100
Oliner and Sichel 1996-99 over 1991-95	0.45	0.03	0.26	0.41	0.71	1.04	68.3
Congressional Budget Office 1996-99 over 1974-99	0.40	-	0.20	-	0.60	1.10	54.5
Economic Report of the President 1995-99 over 1973-95	0.47	-	0.23	0.70	0.70	1.47	47.6
Jorgenson and Stiroh 1995-98 over 1990-95	0.31	0.18	0.19	0.44	0.50	1.00	50.0
Whelan 1996-98 over 1974-95	0.46	-	0.27	-	0.73	0.99	73.7

*The studies summarized are not strictly comparable because they use different definitions of IT capital and examine different time periods. Oliner and Sichel define IT capital to include "computer hardware, software, and communication equipment." The Congressional Budget Office talks about "computers," distinguishing between computer "use" (capital deepening) and computer "production" (technical advance), while the Economic Report of the President refers to "computers and software." Jorgenson and Stiroh include in IT "capital services" those from computer, software, and communications capital. Finally, Whelan's "computing equipment" includes mainframes, terminals, storage devices, printers, and personal computers.

In the above table, "IT capital deepening" means increase in IT capital per labor hour and "other capital deepening" means increase in other types of capital per labor hour. "Technical advance" covers capital quality improvements and multifactor productivity growth from IT and other sources. Finally, there are factors contributing to labor productivity growth acceleration other than capital deepening and technical advance that are not identified in the table (e.g., improvements in labor quality). These other factors are omitted since the table is intended to highlight IT's contribution to the acceleration of labor productivity growth.

SECTORAL AND INDUSTRY-LEVEL ASSESSMENTS

Since IT investments improve productivity, those industries making the most intensive use of IT should show higher productivity growth than industries that use IT less intensively (all other factors held constant).

[8] Macroeconomic Advisers, *op. cit.*, p. 6.

Evidence of such a pattern at the industry level, however, remains mixed. IT-producing industries have recorded astonishingly high productivity gains and have been a dominant force in aggregate U.S. productivity growth.[9] Furthermore, outside the IT-producing sector itself, goods-producing industries that are IT intensive have achieved higher productivity gains than their counterparts that have not invested heavily in IT. However, official output measures for IT-intensive service industries do not indicate significant productivity gains. Indeed, between 1990 and 1997, despite heavy investments in IT and a three-decade buildup of the real net IT capital stock, IT-using service industries as a group recorded *declining* productivity.

The following sections review analyses that show significant multifactor productivity growth in IT-producing industries, improved labor productivity growth in both IT-producing and IT-using goods industries, and alternative views of IT's effect on productivity in service industries.

Computer Production

A study conducted by Kevin Stiroh examined the relationship between computers and economic growth, at both the aggregate and sectoral levels, over the period 1947 to 1991. This study found strong labor productivity, as well as multifactor productivity gains in the computer-producing sector, implying that this sector positively contributes to overall productivity growth.[10] Estimates by the Bureau of Labor Statistics (BLS) confirm Stiroh's finding that IT-producing industries make an outstanding contribution to multifactor productivity growth.[11] The BLS estimates show that industrial machinery and equipment (SIC 35) and electronic and electric equipment (SIC 36)—the categories that include the computer and semiconductor industries—ranked highest in multifactor productivity growth among all manufacturing industries between 1990 and 1996. Similarly, a May 2000 analysis by Dale Jorgenson and Stiroh concluded that IT production is a major force behind the current resurgence in multifactor productivity growth.[12]

Computer Use

Analyses of computer-using industries outside the IT sector, however, continue to show mixed results. For the period prior to 1991, Stiroh found that in computer-using sectors, rapidly falling computer prices led firms to substitute capital for labor and other inputs. The result was that remaining workers had more

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[9] *Emerging Digital Economy II*, Table 3.2, p. 29.

[10] Kevin Stiroh, "Computers, Productivity, and Input Substitution," *Economic Inquiry*, 1998, v. 36, pp. 175-191.

[11] This finding was reported originally in *The Emerging Digital Economy II*, p. 35. More recent BLS data also support the finding.

[12] See Jorgenson and Stiroh, *op. cit*.

capital to work with, and labor productivity rose. However, Stiroh found little evidence that investments in computers affected multifactor productivity growth in these sectors. These findings have been broadly confirmed by Jorgenson and Stiroh himself in studies in 1999 and 2000. Both researchers note that price declines in IT have led to capital deepening in IT-using industries, but they still see "no corresponding eruption of industry-level [multifactor] productivity growth in these sectors."[13]

By contrast, evidence of multifactor productivity growth in some IT-using industries has been documented in a study by Jack Triplett and Barry Bosworth. They estimate that from 1987 to 1997, multifactor productivity grew 9.0 percent per year among security and commodity brokers, 2.1 percent a year among insurance carriers, and 2.2 percent among holding and investment offices.[14] These estimates of productivity growth for the period 1987 to 1997 significantly exceeded productivity gains for the same industries in the years 1960 to 1973.

ESA's own industry-level analysis covering the 1990-97 period supports Stiroh's conclusion.[15] We found that gross product originating per worker (GPO/W), an approximate measure of labor productivity, was stronger in IT-using goods industries than in non-IT-intensive goods industries—2.4 percent per year compared to 1.3 percent. No similar pattern emerged, however, among service industries. IT-using service industries actually showed a negative growth rate of 0.3 percent a year, compared to 1.3 percent annual productivity gains by non-IT intensive service industries. These results largely reflect the difficult problems in conceptualizing and measuring output in many service industries.

In view of these measurement problems, we compared growth in GPO/W of IT-using service industries with that of the non-IT intensive service industries, but excluding 10 hard-to-measure service industries.[16] We found that when the hard-to-measure industries are excluded, IT-using service industries show slightly greater GPO/W growth than non-IT intensive service industries, and the overall annual average GPO/W growth for 1990-97 rises from 1.38 percent to 2.34 percent. (Figure 4.5) Because hard-to-measure service industries together account for 44 percent of the total GPO by IT-using service industries, the effect of IT on service industry productivity will remain clouded until development of better output measures.

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[13] *Ibid.*, pp. 43-44.

[14] See Jack E. Triplett and Barry P. Bosworth, "Productivity in the Services Sector," Washington, DC: Brookings Institution, January 2000, paper prepared for the American Economic Association Meetings, Boston, MA, January 7-9, 2000, Table 3, p. 24.

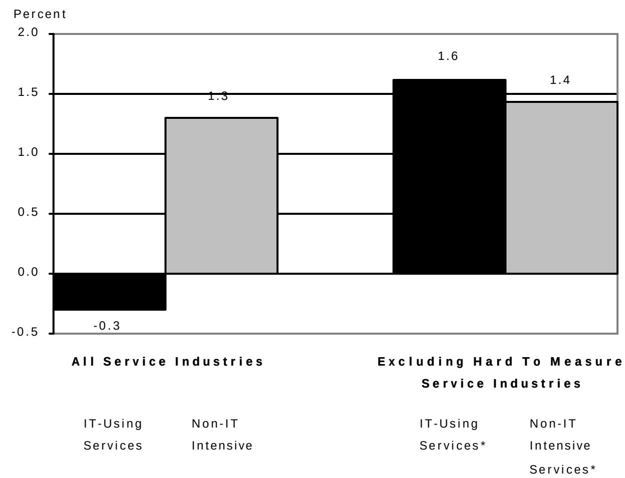
[15] See citation in footnote 8.

[16] In Figure 4.5, the ten excluded industries are water transportation, transportation services, depository institutions, nondepository institutions, holding and investment offices, business services, insurance agents, legal services, motion pictures, and health services. Based on the classification established in *Emerging Digital Economy II*, the first two are non-IT intensive and the remaining eight are IT-using. BEA estimates the real GPO of the first five industries by "extrapolation" based on "BEA persons engaged in production" and the GPO of the sixth industry based on "BLS employment weighted by Census Bureau receipts." BEA uses separate deflators for outputs and inputs ("double deflation") for the remaining four industries. See Robert E. Yuskavage, "Improved Estimates of Gross Product by Industry, 1959-94," *Survey of Current Business*, August 1996, p. 145.

BEA, BLS, and other statistical agencies are currently grappling with the challenge of improving output measurements for service industries. BEA plans to release new GPO-by-industry data this summer. We expect that, based on this new data, estimates for some hard-to-measure service industries will show productivity gains.[17]

Figure 4.5

Average Annual Growth Rates of Gross Product Originating Per Worker in Selected Service Industries, 1990-97



*See footnote for excluded service industries.
Source: OBIA calculations based on BEA GPO and BLS employment data.

FIRM-LEVEL EVIDENCE

Like the macroeconomic studies, recent firm-level analyses show that IT contributes substantially to productivity growth. This contribution is especially strong where businesses undertake organizational and other changes that complement the adoption of IT.

In one study, Erik Brynjolfsson and Lorin Hitt analyzed firms in four groups based on their levels of IT investment and degree of decentralization. While they found that average productivity was highest among firms that were high in both IT investment and decentralized organization, they also found that productivity was lowest among those firms that were high in IT investment but low in decentralization. In fact, the

[17] However, there will still be many industries awaiting similar improvements in the future. A comprehensive review of the problems and prospects for their resolution is available in Triplett and Bosworth, *op. cit.*

productivity of firms that invested heavily in IT but remained highly centralized declined relative to firms which were low on both measures.[18]

Another study by the same researchers similarly concluded that while computers make a positive contribution to productivity growth at the firm level, "the greatest benefit of computers appears to be realized when computer investment is coupled with other complementary investments; new strategies, new business processes, and new organizations all appear to be important."[19]

Another analysis, by Brynjolfsson and Shinkyu Yang, found that a one-dollar increase in computer capital is associated with a $10 increase in the valuation of the firm by the stock market, based on eight years of data for 820 non-financial U.S. firms.[20] This finding does not imply that the market values a dollar of computers at $10, but rather that "the firm that has a dollar of computers typically has another $9 of related intangibles."[21] In order to make effective use of computers, firms have to make expensive investments in software, training, and organizational changes, which together create intangible assets. The researchers estimate that when the costs of these intangible assets and other adjustment costs are added to the direct expenditures on computers, the firms had normal returns on investment. No other category of capital investment shows such high valuations relative to tangible investments.

In conclusion, based on both macroeconomic and firm-level analyses, IT makes a substantial contribution to overall productivity growth. The firm-level studies show that firms that have made the organizational and other changes necessary to effectively use IT become more productive over time than those that have not. However, analyses of the impact of IT on productivity at the industry level have produced mixed results, largely reflecting the limitations of measuring the output of many service industries. Until these measures are improved, the full effect of IT on service industry productivity will remain clouded.

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[18] Erik Brynjolfsson and Lorin M. Hitt, "Beyond the Productivity Paradox: Computers are the Catalyst for Bigger Changes," *Communications of the ACM*, August 1998.

[19] Erik Brynjolfsson and Lorin M. Hitt, "Computing Productivity: Are Computers Pulling Their Weight?," MIT Sloan School of Management, January 2000.

[20] Erik Brynjolfsson and Shinkyu Yang, "The Intangible Costs and Benefits of Computer Investments: Evidence from the Financial Markets," MIT Sloan School of Management (December 1999 revised draft). See also Erik Brynjolfsson, Lorin M. Hitt, and Shinkyu Yang, "Intangible Assets: How the Interaction of Computers and Organizational Structure Affects Stock Market Valuations," (http://ccs.mit.edu/erik). A related study by Timothy F. Bresnahan, Erik Brynjolfsson and Lorin M. Hitt, "Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-level Evidence," January 2000 draft, finds that "IT use is complementary to a new workplace organization which includes broader job responsibilities for line workers, more decentralized decision-making, and more self-managing teams. In turn, both IT and that new organization are complements with worker skill, measured in a variety of ways. ...Taken together, the results highlight the roles of both IT and IT-enabled organizational change as important components of the skill-biased technical change."

[21] As interpreted by Robert E. Hall, "The Stock Market and Capital Accumulation," NBER Working Paper 7180, Cambridge, MA: National Bureau of Economic Research, June 1999, p. 28 (http://www.nber.org/papers/w7180).

CHAPTER V

THE INFORMATION TECHNOLOGY WORKFORCE*

Information technology workers not only produce and maintain the Nation's computing and communications infrastructure, they also generate the knowledge, ideas and information critical to the development of the digital economy.

Demand for IT workers has increased with the spread of networked computers, the Internet, e-commerce, and the associated growing demand for high-quality digitized products and services. Moreover, the demand for IT workers is increasingly focused on more highly-skilled and highly paid people, as the rapid pace of innovation rewards high skills and technology reduces the number of less-skilled and lower paid IT jobs.

In 1998, the IT workforce—covering workers in IT-producing industries and workers in IT occupations in other industries— totaled roughly 7.4 million workers, or 6.1 percent of all workers. While IT employment has grown faster than overall employment for many years, the growth in both IT-producing industries and IT occupations accelerated in the mid-1990s. IT industry employment grew almost 28 percent from 1994 to 1998, and employment in IT occupations increased by 22 percent over the same period. By contrast, over those same years, total U.S. nonfarm employment rose by about 11 percent.

This chapter examines past and recent employment trends, wage trends and skill requirements in IT-producing industries and IT occupations. (See Table 5.1 for a list of IT occupations and Appendix Table

Table 5.1

IT-Related Occupations

Engineering, science, and computer systems managers	Electrical and electronics engineers
Database administrators	Computer engineers
Systems analysts	Computer support specialists
Computer programmers	All other computer scientists
Broadcast technicians	Electrical and electronics technicians
Computer equipment operators	Duplicating, mail and other office machine operators
Data processing equipment repairers	Billing, posting and calculating machine operators
Communications equipment operators	Data entry keyers
Electrical powerline installers and repairers	Electronics repairers, commercial and industrial equip.
Telephone and cable TV installers and repairers	Electrical and electronic equip. assemblers, precision
Central office and PBX installers and repairers	Electromechanical equipment assemblers, precision
	Electronic semiconductor processors

* This chapter was written by Sandra D. Cooke, Economist, in the Office of Business and Industrial Analysis.

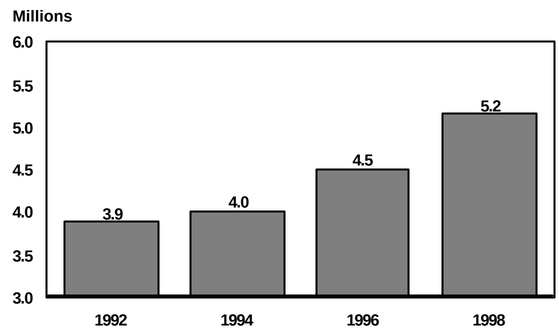
5.4 for descriptions of duties.)[1] We also analyze the factors affecting the supply of IT workers and how the public and private sectors are responding to the growing demand for IT workers.

IT-PRODUCING INDUSTRIES

Employment in IT-Producing Industries Accelerates After 1994

Jobs in IT-producing firms, after growing more slowly than overall employment in 1993 and 1994, increased dramatically in 1995 and thereafter, growing at an average annual rate of 6.5 percent. (Figure 5.1) The number of workers in IT-producing firms grew from 3.9 million in 1992 to 5.2 million workers in 1998. Even at this level, employment in IT-producing firms in 1998 accounted for less than 5 percent of total private employment.

Figure 5.1
Employment in IT-Producing Industries



Source: Bureau of Labor Statistics

The overall growth in IT-producing industry employment masks a churning of IT jobs, with significant job increases in some areas and significant declines in others. Among all IT-producing industries, software and computer services recorded the fastest employment growth.[2] Job positions in these areas nearly doubled, from 850,000 in 1992 to more than 1.6 million in 1998. (Appendix Table 5.1) Over the same period, job growth in the hardware and communications services industries was close to the growth in overall employment. Within these areas, computer hardware retailers and pay television service providers saw the fastest growth, while other sub-industries experienced job reductions, including manufacturers of computers, electron tubes and some types of communications equipment. (See Appendix Table 5.1 for industry detail.)

A vibrant economy always produces significant job creation and job destruction. However, some recent job churning appears to be directly related to several factors associated with the digital revolution:

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[1] IT-producing industries produce IT infrastructure and provide services that enable electronic commerce and the Internet. See Chapter 3 for a list of IT-producing industries. Note: the focus of this analysis is on the IT workforce only and not the effects of technology on the general workforce.

[2] Software and computer services include computer services management, rental and leasing, computer programming services and prepackaged software, all of which have grown at well above average rates for the past decade.

- Many information technologies have short life cycles, and employers intent on quickly getting a product or service to market often prefer to hire workers skilled in new technologies rather than retrain their current workers.[3]

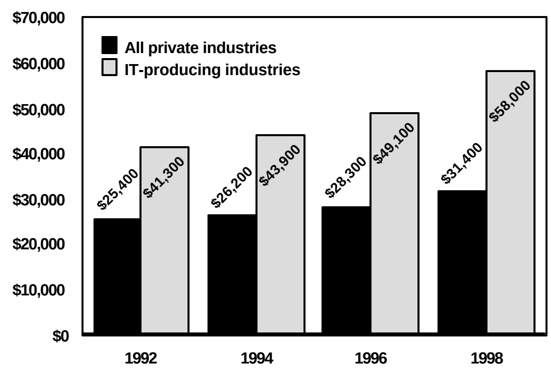
- Computing and communications technologies have lowered barriers to entry, especially to markets that provide information technology and other services. These technologies provide small businesses with size and resource advantages usually available to larger, established companies.[4] By using the Internet, they can compete outside of local markets, even in global markets. The same technologies allow foreign companies greater access to U.S. markets. More players in the market means more job churning as there will be winners and losers.

- Employment in IT-producing industries is also affected by the increasing use of outsourcing to other industries. For example, Fortune 1000 companies outsource an estimated 60 percent of their e-commerce projects.[5]

IT Industry Wages Consistently Higher Than Average

The average annual wage for workers in IT-producing industries was $58,000 in 1998, or 85 percent higher than the $31,400 average wage for all private workers. Since 1992, wages paid by IT-producing industries have grown by 5.8 percent per year, compared with private-industry average wage growth of 3.6 percent annually. As a result, the wage gap between these IT workers and all workers widened by more than $10,000, or two-thirds, over this period. (Figure 5.2)

Figure 5.2
Annual Wages Per Worker in IT-Producing Industr



Source: ESA estimates based on BLS data.

Among workers in all IT-producing industries, those in software and computer services industries, including computer

[3] Carol A. Meares and John Sergeant, "The Digital Workforce: Building Infotech Skills at the Speed of Innovation," Office of Technology Policy, U.S. Department of Commerce, 1999.

[4] Don Tapscott, "Strategy in the New Economy," *Strategy and Leadership*, November/December, 1997.

[5] Saroja Girishankar, "In Focus: E-Commerce Outsourcing – Internet Time Forces Anxious Enterprises to Seek Outside Help," *Internetweek*, June 28, 1999.

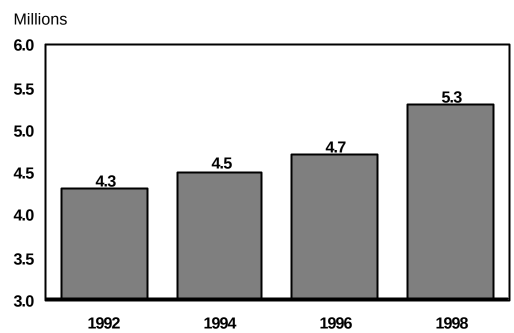
programming services and software development, earned the highest average wage of $65,300 in 1998. (Appendix Table 5.2) The wages of these workers also grew at the fastest rate over this period, an average of 6.7 percent per year.

All IT-producing industries paid wages that were higher than the total private industry average wage in 1998, and almost all of them had higher than average annual wage growth from 1992 to 1998. Nonetheless, some IT jobs and non-IT jobs in IT industries remain low-skilled, low paying positions. The wages for these positions have increased very slowly, if at all.[6]

IT OCCUPATIONS

Employment in IT Occupations Accelerates After 1994

Figure 5.3
Employment in IT Occupations



Source: Bureau of Labor Statistics

One could define the class of jobs considered "IT occupations" in many different ways. The broadest definition would recognize that, as the economy becomes more digitized, most occupations will involve the manufacture or operation of equipment that includes forms of information technology, such as a computer chip. A more narrow definition might include only the "core" IT occupations of computer scientists, computer engineers, systems analysts and computer programmers; these are the IT positions that require the most education and skills, are the highest paid, and are in greatest demand. Here, we adopt a middle ground and include as "IT occupations" those positions involved in creating, operating and maintaining the IT infrastructure required to facilitate e-commerce and other Internet or network-related activities. (See Table 5.1 for list of IT occupations.)

Employment levels in these IT occupations were flat during the early 1990s and have risen steadily since 1994. In 1992, there were 4.3 million workers in these IT occupations. By 1998 the number had grown to 5.3 million. (Figure 5.3) The fastest growth occurred among the core IT occupations, where the number of jobs increased by 957,000 between 1992 and 1998, or almost 80 percent.

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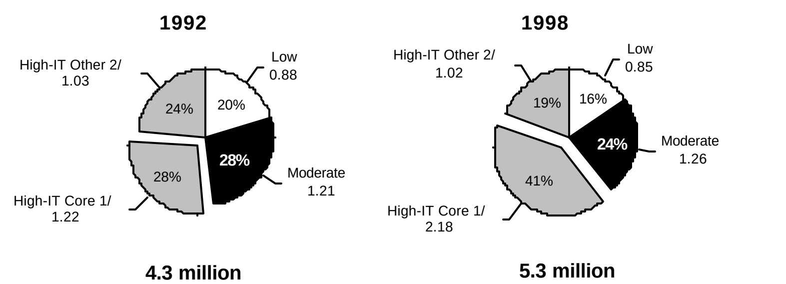
[6] Aaron Bernstein, "Down and Out in Silicon Valley," *Business Week*, March 27, 2000, reports the fact that the success of IT-producing industries in Silicon Valley has rapidly raised the cost of living, but the earnings of workers in low-end jobs have not kept pace.

Highest Skilled IT Workers in Demand

The number of highly-skilled IT workers, or IT workers in occupations that generally require at least an associate degree, increased from 2.2 million in 1992 to 3.2 million in 1998. The fastest growth occurred among those with the highest skills – core IT occupations – who increased their share of total IT employment from 28 percent to 41 percent. (Figure 5.4 and Appendix Table 5.3)

Between 1994 and 1998, total high-skilled IT employment increased 35 percent, more than three times as much as the national average, and core IT occupations grew more than five times faster than all other jobs. By contrast, employment in lower-skilled IT occupations, such as computer operators, communications equipment operators and billing and posting clerks, declined from 926,000 to 852,000, or 9 percent. During the same period, employment among moderately-skilled IT workers, including telephone and electronic equipment installers, assemblers and repairers, grew somewhat more slowly than the national average.

Figure 5.4
Employment in IT Occupations, by Level of Education and Training Requirements
(Millions)



Education/Training Requirements
LOW: Short to moderate-term on-the-job training (OJT)
MODERATE: Long-term OJT, related work experience or post secondary vocational training
HIGH: Associate degree or higher

1/ Computer scientists, computer engineers, computer programmers and systems analysts.
2/ IT managers, electrical engineers and engineering technicians.

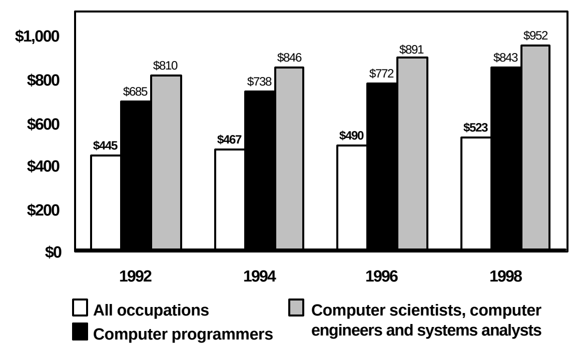
Source: ESA estimates based on BLS data.

Private surveys and interviews with Chief Information Officers provide additional insight into the specific IT skills in greatest demand. The growth in e-commerce, for example, has increased demand for workers with Internet-related technical skills, including network specialists, help desk/end user support staff and Internet/intranet developers. E-commerce growth has also increased the demand for workers with a knowledge of sales, marketing and business planning. Many IT workers that used to work in back offices are now required to learn how to deal with customers and convince them to make online purchases.[7] In addition, as more firms outsource for IT services, demand has increased for project managers and people who can negotiate and manage vendor contracts.[8]

High Skilled IT Occupations Pay High Wages

The earnings of IT workers vary greatly, based on their skills and educational levels. For example, the Bureau of Labor Statistics (BLS) estimates that in 1998 computer engineers, who typically have at least a bachelor's degree, earned an average of $59,900. (Appendix Table 5.4) By contrast, lower skilled occupations such as billing, posting and calculating machine operators, which usually do not require a college degree, earned on average only $21,300.

Figure 5.5
Median Weekly Earnings of Core IT Workers



Source: Bureau of Labor Statistics

Historical wage data are available for only a few IT occupations, including core IT workers. From 1992 to 1998, weekly earnings of computer programmers increased from $685 to $843 or 23 percent. (Figure 5.5) The median weekly earnings of computer scientists, computer engineers and systems analysts, although higher than average, increased from $810 in 1992 to $952 in 1998, or at the same 17.5-percent rate as the average for all occupations.

Private wage surveys provide more current wage estimates of new occupations and new skills in great demand. According to *Computerworld's* 13th annual survey, 1998 and 1999 pay increases for IT positions averaged 4-to-5 percent, much less than the 11 percent increase in 1997.

RHI Consulting estimates that starting salaries for IT workers in 2000 will be 6.8 percent more than in 1999, with jobs related to Internet development, networking, consulting, and systems integration seeing even larger than average increases. IT consultants with skills such as the ability to work with Oracle, PeopleSoft and SAP software can earn more than $100 per hour, depending on level of expertise.[9]

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[7] Bob Weistein, "E-commerce Puts Techies Front and Center," Chicago Sun Times, July 18, 1999.

[8] Cole Gomolski, "IT Job Market, Now and Later," *Computerworld*, October 28, 1999.

[9] RHI Consulting press release, December 2, 1999 and 2000 Salary Guide. RHI Consulting collects and reports starting salaries for IT workers. Starting salaries, unlike occupational averages, exclude bonuses and other factors that could influence pay, such as seniority and past job performance.

Earnings in IT occupations also vary by geographic location and company size, as they do for many other industries. *Computerworld* estimates that in 1999, webmasters/web designers earned on average $53,100, including bonuses.[10] However, this compensation ranged from $43,800 in New England to $59,600 in the Pacific region. Further, larger companies with more than $500 million in revenue paid webmasters/web designers an average of $58,600, compared to smaller companies with less than $100 million in revenue which paid an average of $48,400.

IT LABOR MARKET IMBALANCES

The IT Worker Supply Debate

The question of whether the U. S. is producing an adequate supply of IT workers has been much debated in recent years. There is no single common definition of "IT worker" and no agreed-upon method for identifying an occupational shortfall. In theory, market forces will eventually resolve any imbalance between supply and demand. However, the evidence on short-term market responses is inconclusive.[11]

The Bureau of Labor Statistics examined the available national employment and wage data for core IT occupations over the period 1992 to 1997. They reasoned that an imbalance should produce above-average growth in both employment and wages, and below-average unemployment rates. BLS found that while the unemployment rates for core IT occupations were consistently lower than the national average for this period, employment and wage growth had not been consistently above average for *all* core IT occupations. They concluded that the evidence on IT labor market imbalances remains ambiguous.[12]

A more detailed examination of employment and wages in core IT occupations supports this judgment. Between 1992 and 1994, employment among computer programmers fell; in the following four years, this employment grew by an average of 5 percent a year. Over the same period, the number of computer scientists, computer engineers and systems analysts grew at a 16.5 percent annual rate. (Figure 5.6) The fact that median weekly earnings for both occupations grew at 3.0 and 3.4 percent annually – little faster than the 2.9 percent national average – seems inconsistent with a serious imbalance in labor supply and demand. One possible explanation is that businesses have been using non-wage benefits such as stock options to attract employees. Other reasons may be that the rapid growth of employment in these areas

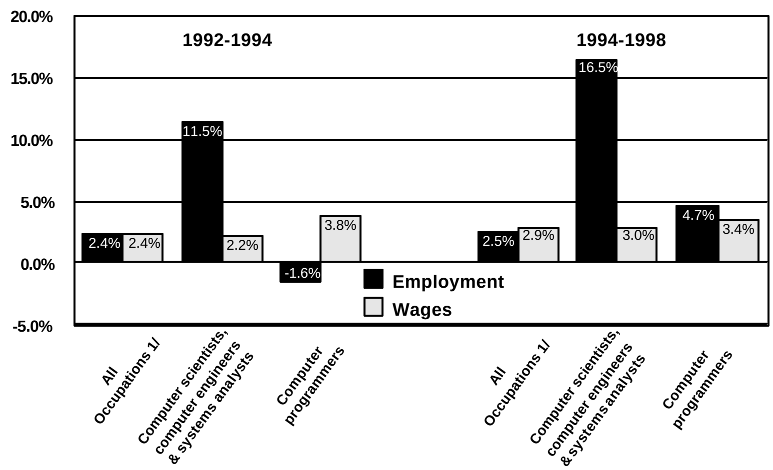
[10] *Computerworld's* 13th Annual Salary Survey, September 6, 1999 (www.computerworld.com).

[11] Carolyn Veneri, "Can Occupational Labor Shortages be Identified Using Available Data?" *Monthly Labor Review*, March 1999.

[12] The BLS analysis concluded that there is no single empirical measure of labor market tightness, nor does it appear that one can be easily developed. Labor market data such as employment and wage trends and unemployment rates for a specific occupation should be examined in addition to supply information including demographic characteristics, employer requirements for education and training and education by field of study. For IT occupations in particular, analysis should be done on a case by case basis and should focus on one or a group of closely related occupations.

has reduced the median experience and skill level, suppressing median wage growth, or that high relative pay and a sense of job security may be keeping down additional wage gains. Finally, the recent moderate growth in wages may also indicate that growth in the supply of IT workers (whether from foreign sources or graduates from IT and other technical training programs) is keeping pace with demand.

Figure 5.6
Employment and Median Weekly Earnings in Core IT Occupations
(Average annual rates of growth)



Source: ESA estimates based on BLS data.

1/ For employment, total employment; for wages, wage and salary workers only.

A study by the Computing Research Association evaluated past assessments of the supply of IT workers.[13] The study found evidence of temporarily tight labor markets in specific regions and occupations and argued that such tightness should be expected in any field undergoing rapid technological change. The report further noted that more useful findings could be produced by segmenting the market by geographical area or occupation, but that the data needed to conduct such analyses do not exist. Several Federal initiatives are currently underway to improve IT-related employment data collection.[14]

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[13] Peter Freeman and William Aspray, *The Supply of Information Technology Workers*, Computing Research Association, Washington, DC: 1999.

[14] The National Research Council, in response to a Congressional mandate, will deliver two reports to Congress by October 1, 2000 on 1) older workers in the information technology field and 2) high technology labor market needs.

The U.S. Department of Commerce's Technology Administration (TA) in July 1999 released *The Digital Workforce: Building Infotech Skills at the Speed of Innovation* which demonstrates the complexities of trying to define and measure the IT workforce. The TA will continue to be heavily involved in monitoring the needs of the IT workforce and making policy recommendations.

Meeting the Demand for IT Workers

As the importance of IT to the American economy continues to grow, so will the demand for IT workers. In response, government and business are taking steps to increase the numbers of IT workers.

One such step is the Federal Government's H-1B visa program, which admits foreign skilled workers to the United States. Congress raised the H-1B visa limit from 65,000 to 115,000 in 1998. This year, this ceiling was reached in March, with employers demanding 50,000 more H-1B visas than at the same time in 1999.[15] Consequently, several bills have been introduced in Congress to either raise the limit (up to 200,000) or to temporarily remove the cap. Although many workers who enter the country under the H-1B visa program hold jobs other than IT jobs, a recent Immigration and Naturalization Service (INS) survey found that over 60 percent of H-1B visa petitioners are IT workers.[16] Applying the INS estimate to the current H-1B visa limit of 115,000 suggests that the H-1B program currently fills over 70,000 IT jobs, equivalent to 28 percent of the average annual demand for IT workers with at least a bachelor's degree during the 1996 to 1998 period.

A number of public/private partnerships also have been created to increase the supply of IT workers from various sources, including the current pool of workers, retired people, and high school and college students. Outlined below are some representative examples of recent initiatives by the Federal government, public/private partnerships, and private companies to increase the supply of IT workers and raise the technical IT competency of American workers.

Federal Efforts

- The Department of Labor (using funds from the $500 H-1B visa filing fee) plans to award grants of $12.4 million in FY 2000 to train U.S. workers for IT and health care jobs often filled by immigrants. The Department also will fund an additional $40 million for projects to train workers in local markets. Under these programs, private companies seeking IT workers can work with local governments and educational institutions to develop training. (www.dol.eta.gov)

The Bureau of Labor Statistics' recently revised Standard Occupational Classification (SOC) provides more IT occupational detail than in previous years. The revised SOC classification was used in the 1999 Occupational Employment Statistics Survey and will be reflected in the 2000-2010 employment projections and in the 2002-03 edition of the Occupational Outlook Handbook. Both will be released in late 2001. (http://stats.bls.gov/soc/soc_home.htm)

[15] INS statistics reported in Wall Street Journal article. See Marjorie Valbrun,"Immigration Foe's Reversal Bodes Well for Silicon Valley," Wall Street Journal, May 2, 2000.

[16] U.S. Immigration and Naturalization Service, "Characteristics of Specialty Occupations Workers (H-1B)", February 2000. Preliminary survey results are for the May 1998 to July 1999 period.

- The Department of Education is providing $135 million in grants to train 400,000 teachers to use information technologies more effectively in the classroom. (www.ed.gov/PressReleases/08-1999/wh-0824.html)

- The Department of Commerce's Technology Administration created and maintains the GO4IT website that provides access to a searchable database containing descriptions of a wide variety of IT work force initiatives around the country.(www.go4it.gov) The Department of Labor maintains America's Career Kit consisting of America's Career InfoNet (www.acinet.org), America's Job Bank (www.ajb.dni.us) and America's Learning Exchange (www.alx.org).

Public/Private Partnerships

- Cisco Systems, the Communications Workers of America, Arizona State University and the Departments of Labor and Education are developing an online system to help retired military personnel and others to assess and improve their IT skills.

- The National Association of Manufacturers encourages its member companies to spend at least 3 percent of their payroll on worker training.

- The Department of Labor with the American Society for Training and Development are expanding America's Learning Exchange, (www.alx.org) a clearinghouse for information on education and training, financial aid and skills analysis.

- The Department of Education and the Conference Board disseminate information about the economic benefits of workplace learning to U.S. businesses and unions.

Private Efforts

- Ford Motor Co., Intel Corp, Delta Airlines and American Airlines recently announced plans to provide computers and low-priced Internet access to all their employees, as a way of raising the technical literacy of their workforce.

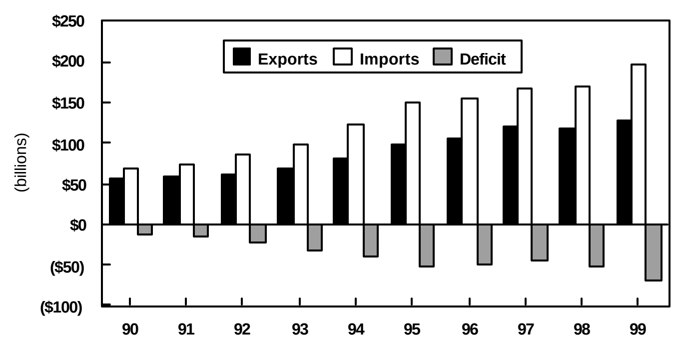
- Some firms are taking advantage of distance learning systems, such as those provided by Saba Corp, which provide electronic learning platforms and infrastructure for a number of companies, including Qwest Communications, Ford, and Continental Airlines. Saturn, P&G and IBM also have intranets or online technologies that provide information and training services to employees, suppliers and customers throughout the world.

CHAPTER VI

TRADE IN INFORMATION TECHNOLOGY GOODS AND SERVICES*

American IT companies are powerful competitors in markets around the world. Yet the United States ran a trade deficit in information technology goods of almost $66 billion in 1999. (Figure 6.1, and Appendix Table 6.1) The growing imbalance in cross-border flows of IT goods overwhelms the small surpluses that the United States has earned in recent years in IT services trade. (Figure 6.2, below, and Appendix Table 6.2)

Figure 6.1
U.S. Trade of IT Goods



Source: International Trade Administration

The paradox of large trade deficits in an area where U.S. firms are world leaders is largely explained by the fact that America's leading IT firms are global operations that service foreign customers through their overseas affiliates, rather than by exporting goods made in this country. The most recent published data show that in 1997, when the United States exported $121.4 billion of IT goods and services, foreign sales by overseas IT affiliates of American companies totaled $196 billion.[1] In the same year, American-based

* This chapter was written by Dennis Pastore, Economist, in the Office of Business and Industrial Analysis.

[1] Sales by affiliates are reported on an industry basis while U.S. trade data are organized by type of product. For this reason, the comparison between sales (by IT firms) and exports (of IT products) is intended only as an indication of the relative magnitude of the difference. Furthermore, estimates of sales by U.S.- and foreign-owned affiliates involve only a subset of the IT industries, since aggregate data on sales by instrument manufacturing affiliates are too broad to be

IT affiliates of foreign companies reported U.S. sales totaling $110.5 billion. (Table 6.2) U.S. deficits in IT trade also reflect strong growth in the U.S. economy compared to the slower pace virtually everywhere else and the boom in IT investment by American firms.

TRADE IN IT GOODS

Both exports and imports of IT goods have exhibited strong growth in recent years, with imports growing faster than exports. Through the 1990s, U.S. exports of these goods, including pre-packaged software, rose at an average annual rate of about 9.5 percent. Over the same period, U.S. imports of IT goods increased at an average rate of 12.3 percent a year. As a result, the U.S. trade deficit in IT goods jumped from $11.5 billion in 1990 to $65.9 billion in 1999. (Figure 6.1) In fact, the United States has run trade deficits since 1983 in many categories of IT hardware, including semiconductors, household audio and video equipment, and computer storage devices.[2] Trade surpluses in computer peripheral equipment turned negative in 1994; and in 1999 the nation posted its first trade deficit in electronic computers. (Appendix Table 6.1)

At the same time, the United States continues to run trade surpluses in some high value-added IT products. The U.S. trade surplus in pre-packaged software reached $2.8 billion in 1999, a record level. The trade surplus in scientific instruments has also generally been on the rise. And following a long series of trade deficits dating from 1983, telecommunications equipment manufacturers enjoyed export surpluses in three of the five years after 1994.

TRADE IN IT SERVICES

The U.S. trade position in IT services strengthened throughout the 1990s. Exports of IT services, including royalties from the licensing of U.S. software, increased at an average annual rate of 13.2 percent from 1990 to 1998, while imports of IT services grew at a 6-percent rate. As a result, the United States ran trade surpluses in IT services of $0.9 billion in 1997 and $1.8 billion in 1998, the first such surpluses since BEA began collecting comprehensive data on services trade in 1986. (Figure 6.2, and Appendix Table 6.2)

Within IT services, U.S. exports of computer and information services, including software royalties, increased at a 23.7-percent average annual rate in the 1990s. Even though imports of these services rose

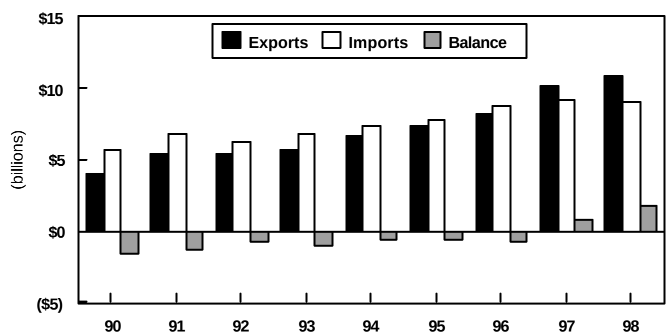
included, and data on sales by affiliates of producers of magnetic and optical recording media are unavailable. The affiliate total also includes sales by firms in the industries that manufacture prerecorded records and tapes (SIC 3652) and communications equipment, n.e.c. (SIC 3669). (Table 6.2) The total for IT exports has been adjusted accordingly. Altogether in 1997, the United States exported $0.8 billion of prerecorded records and tapes and communications equipment, n.e.c.

[2] The various classes of IT products include: computers and peripherals, prepackaged software, electronic components including semiconductors, several classes of scientific instruments, household audio and video devices, and telecommunications equipment, primarily telephones and broadcasting equipment.

even more rapidly, by 33.1 percent per year, in 1998 they still remained just under $1 billion, or less than one-seventh of the value of exports. In 1998, U.S. firms exported $4.0 billion in computer and information services, compared to $0.5 billion in imports of such services. In addition, software royalties paid by foreign firms to U.S. producers surpassed $3.2 billion, compared to U.S. software-royalty payments to foreign producers of less than $0.5 billion.

Figure 6.2

U.S. Trade in IT Services



Source: BEA

By contrast, U.S. payments to other countries for telecommunications services consistently outpace foreign payments to U.S. carriers. In 1998, the deficit was $4.4 billion, down modestly from the record $5 billion in 1996. (Appendix Table 6.2) The negative balance of payments on cross-border sales of telecommunications services is a reflection of calling patterns and differences in national telecommunications rates. More international calls originate here than in other countries because of the strong U.S. economy, relatively high U.S. income levels, and large immigrant populations in this country. In addition, because American markets are more open and competitive, foreign callers pay less to U.S. carriers to complete calls to the United States than Americans pay to foreign carriers to complete calls going the other way.

TRADE BETWEEN U.S. IT FIRMS AND AFFILIATED FIRMS ABROAD

Many U.S. IT firms, spurred by competition from low-cost foreign producers and the liberalization by a growing number of countries of controls on direct investment and capital flows, have moved lower value-added production overseas. As a result, intra-firm trade, defined as cross-border sales between parents and affiliates of U.S. and foreign multinational companies, accounts for a significant portion of our trade in IT products. In 1997, for instance, U.S. exports to affiliated firms in core IT hardware industries—computer and office equipment; electronic components and accessories; and audio, video and communications equipment—amounted to roughly 60 percent of U.S. exports of goods in these classes of IT hardware. (Appendix Table 6.1)

Trade between U.S. parent companies and their overseas affiliates has contributed to a *reduction* in the size of the U.S. trade deficit in information technology products. Trade between foreign parents and their U.S. affiliates has had the opposite effect. (Table 6.1) On balance, the combined impact of intra-firm trade remains positive. In 1997, exports by U.S. parents and U.S. IT affiliates of foreign-owned companies to affiliated firms overseas exceeded $65 billion, while imports from foreign parents or foreign affiliates of U.S. parents totaled $52 billion, resulting in a net surplus of $13.2 billion. (Table 6.1) In other words, the U.S. trade deficit in IT goods and services is due to the imbalance in trade between unaffiliated companies.

Table 6.1

Intra-firm Trade:
U.S. Trade Between Parent Firms and Their Affiliates
For Selected IT Industries, 1997
($ billions)

Exports from U.S. Operations

To: / *From:*	**Foreign Affiliates** / **U.S. Parents**	**Foreign Parents** / **U.S. Affiliates**	**Total**
Industry of Affiliate	(1)	(2)	(1)+(2)
Computers and office equipment	30.8	0.9	31.6
Electronic components and accessories	18.9	2.1	21.0
Audio, video, and communications equipment*	10.2	2.4	12.6
Total, Selected IT Industries	59.9	5.3	65.2

Imports from Foreign Operations

From: / *To:*	**Foreign Affiliates** / **U.S. Parents**	**Foreign Parents** / **U.S. Affiliates**	**Total**
Industry of Affiliate	(1)	(2)	(1)+(2)
Computers and office equipment	23.6	1.6	25.2
Electronic components and accessories	8.7	7.4	16.2
Audio, video, and communications equipment*	6.0	4.7	10.7
Total, Selected IT Industries	38.3	13.7	52.0

Intra-firm Balance of Trade

Industry of Affiliate	**U.S. Parents and their Foreign Affiliates** (1)	**U.S. Affiliates and their Foreign Parents** (2)	**Total** (1)+(2)
Computers and office equipment	7.2	(0.8)	6.4
Electronic components and accessories	10.2	(5.4)	4.8
Audio, video, and communications equipment*	4.2	(2.3)	2.0
Total, Selected IT Industries	21.6	(8.4)	13.2

*Includes prerecorded records and tapes and communications equipment, n.e.c.

Source: BEA

SALES BY U.S. AND FOREIGN IT AFFILIATES

As a group, American companies that make IT products for sale outside the United States are more likely to supply these markets with goods and services produced by their overseas IT affiliates, than to export to these markets from the United States. The global competitiveness of the U.S. IT industry is apparent in the comparison of sales by U.S. IT affiliates abroad with sales by foreign-owned IT affiliates stationed in the United States. In 1997, for example, foreign sales by U.S.-owned overseas affiliates in the computer and office equipment industry exceeded sales in this country by foreign-owned U.S. affiliates in the same industry by $67 billion. Similarly, the balance of sales in 1997 favored American-owned foreign providers of computer processing and information retrieval services by $41 billion and U.S.-owned foreign producers in the electronic components and accessories industry by $20 billion. In contrast, the comparable balance in the audio, video, and communications equipment industry was roughly zero, while U.S. sales by American affiliates of foreign firms in the communications services industry topped foreign sales by American-owned affiliates providing the same services overseas by $35.8 billion.[3] (Table 6.2)

Table 6.2
Foreign Sales by Majority-Owned Foreign Affiliates of U.S. Companies and U.S. Sales by U.S. Affiliates of Foreign Companies For Selected IT Industries, 1997
($ billions)

Industry of Affiliate	**Foreign Sales of Majority U.S.-owned Affiliates Abroad** (1)	**U.S. Sales of Foreign-owned Affiliates in the U.S.** (2)	**Balance** (1)-(2)
Computer and office equipment	81.0	14.0	67.0
Electronic components and accessories	40.0	20.0	20.0
Computer processing and information retrieval*	43.6	9.4	34.2
Communications services	8.9	44.7	(35.8)
Audio, video and communications equipment**	22.5	22.4	0.1
Total, Selected IT Industries	196.0	110.5	85.5

*Includes design, development, and production of software.
**Includes prerecorded records and tapes and communications equipment, n.e.c.

Source: BEA

[3] Exports of all goods from the United States to U.S. Majority-owned IT affiliates in Table 6.2 totaled $35.6 billion in 1997.

CHAPTER VII

WHAT IS NEW IN "THE NEW ECONOMY"?*

Compared to the period from 1973 to 1995, the American economy has turned in a remarkable record for the last four and a half years. Productivity gains, investment rates, and real wage growth are all higher; unemployment and inflation are lower; and the expansion has now set an all-time U.S. endurance record. Increasing confidence that the future of the real economy[1] will look more like the last four years than the preceding 22 years has led more analysts and even economists to accept the media label, "The New Economy." Although slowdowns and recessions will occur at some point, the economy's trajectory appears to have shifted upward.

The information technology sector has played a critical role in the economic success of recent years. Businesses across the economy have been investing heavily in IT hardware and software to harness the potential created by falling prices and by the increasing capacities of computer processing, storage media and communications links. Business strategies and even the structures of companies and industries are being transformed as communication within companies and among the members of corporate alliances occurs more rapidly, with more customized information, and with greater security, interactivity, and timeliness than before. The same quality (or "richness") of communication that once was limited to a narrow group of close contacts can now be extended to a much wider "reach" of contacts.[2]

The IT revolution is affecting everyone's life. The advances and spread of IT are part of the reason why we now have the lowest unemployment rate and fastest growth in real wages in three decades and the longest expansion on record. Consumers are making a small but increasing amount of their purchases online and using the Internet to make more informed purchases offline. IT is also transforming the way most firms operate. As employers substitute IT for labor, workers have to develop new skills.

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* This chapter was written by Lee Price, the Chief Economist of the Economics and Statistics Administration.

[1] Contrary to much of the media's discussion, economists do not consider the strong rise in equity prices year after year to be an essential component of the "New Economy." Indeed, at a recent White House Conference on the New Economy, William Nordhaus concluded that the IT revolution has generated a new economy in productivity terms, but worried that unrealistically high stock prices were damaging on several fronts: national saving, management decisions, compensation structures, and job choices. William Nordhaus, "What Is the Shape of the New Economy?", White House Conference on the New Economy, April 5, 2000 (http://www.econ.yale.edu/~nordhaus/homepage/white%20house%20remarks%20040400%20final.htm).

[2] Philip Evans and Thomas S. Wurster, *Blown to Bits: How the New Economics of Informtion Transforms Strategy*, Boston: Harvard Business School Press, 1999, pp. 24-25.

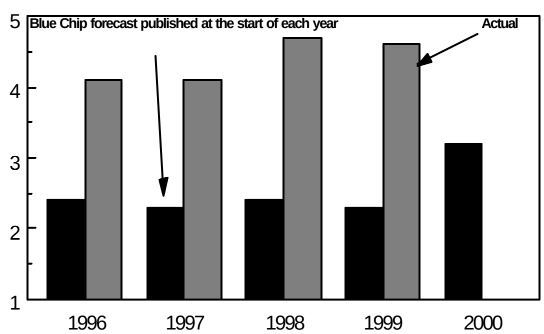
LONG TERM FORECASTS ARE BEING RAISED

The hallmark of the New Economy is higher sustainable growth due to faster improvement in labor productivity. Recently, most economists have begun to accept that the U.S. economy can sustain growth at a substantially higher rate than the 2.5 percent a year average for the 1973 to 1995 period. For example, the Blue Chip consensus growth forecast released in January of each year from 1996 to 1999 forecast growth for the coming year of 2.3 and 2.4 percent.[3] In each of those four years, actual growth surpassed 4 percent. (Figure 7.1) However, this past January, the consensus forecast for 2000 came in at 3.2 percent. Furthermore, the Blue Chip longer term outlook has also shifted upward. After many years of forecasting 2.45 to 2.7 percent average annual growth over the coming 10 years, the consensus in the latest forecast shifted up to 3.1 percent. (Figure 7.2) Since the U.S. labor force tends to grow by little more than 1 percent per year, the hike in growth forecasts strongly implies that in the last year Blue Chip economists have raised their expectations of annual labor productivity growth from roughly 1.5 percent to about 2 percent.

Figure 7.1

Actual vs. Forecast of Real GDP Growth

Percent change, fourth quarter to fourth quarter



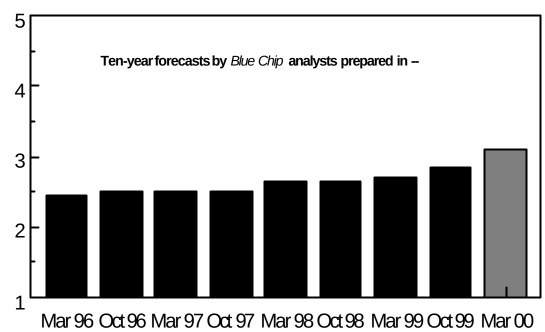
Sources: Blue Chip and BEA

(1996 to 1999 forecasts raised 0.2 percentage points to reflect revisions in methodology)

Figure 7.2

Forecasts of Longer-Term Real GDP Growth

Average annual rate of change



Source: Blue Chip

(1996 to 1999 forecasts raised 0.2 percentage points to reflect revisions in methodology)

This more sanguine view of our future economic prospects comes from greater confidence that the faster labor productivity of the last four years (see Figure 1.1), based significantly on developments in IT investment, has some staying power.[4] It is noteworthy that this optimism is still somewhat

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[3] Actual forecasts were 2.1 or 2.2 percent. For purposes of comparison, we have added 0.2 percentage points to account for definitional changes (e.g., treatment of software as investment and revision to the measure of banking) that BEA initiated in October 1999 and applied to prior years.

[4] The more optimistic outlook does not come from expectations of faster growth in hours worked. If anything, the

conservative, since the labor productivity growth assumed in the ten-year forecast is still much slower than the recent pace. However, since strong output growth tends to raise labor productivity growth, Robert Solow has recently cautioned, probably speaking for many economists, that he "will feel better about the endurance of the productivity improvement after it survives its first recession."[5]

IT can support higher rates of labor productivity gains and output growth, so long as IT innovation and price declines persist, and non-IT industries continue to invest heavily in IT products and services. Both of these conditions are expected to persist into the future. Experts in the semiconductor, computer, storage, and communications industries have expressed confidence that rapid rates of product innovation and price decline can continue for at least another decade. Experts in non-IT industries also have expressed confidence in their capacity to benefit enormously from further substantial investments in IT.

The prospect of healthier productivity gains over both a medium term and a longer run has significant implications for our future standard of living and a range of fiscal issues facing government at all levels. For example, faster productivity growth translates into more tax revenue, which in turns creates larger budget surpluses and longer positive balances for trust funds such as those for Social Security and Medicare. Faster productivity growth also means lower inflation, reducing the additional costs of COLAs for most entitlement programs.

IMPLICATIONS OF IT-FOCUSED INVESTMENT FOR THE BUSINESS CYCLE

The boom in IT investment has implications for the business cycle that go beyond the impact on underlying trend growth. As Martin Baily, chairman of the President's Council of Economic Advisers, has noted, the current nine-year-old expansion has not developed the "geriatric" conditions that we have come to expect after several years of solid economic growth. In particular, the improved labor productivity growth (see Table 4.1) has been a "fountain of youth" for the expansion. As previous postwar expansions matured, labor productivity and output slowed, inflation rose, real wages stagnated, and profits declined. The unusual pattern of conditions continuing to improve as this expansion has aged can be seen clearly by charting the progression of five basic indicators over the long business expansions of the 1960s, 1980s, and 1990s. (Figures 4.1, 7.3-7.6) Although real wages did continue to grow throughout the 1960s expansion, recent real wage growth has been even faster than in the 1960s. Although growth in real profits has slowed in recent years, by this stage in previous business expansions, profits were declining sharply.

continued reduction in unemployment leads many economists to anticipate slower hours growth in the medium term.

[5] Quote contained in Louis Uchitelle, "Productivity Finally Shows the Impact of Computers," *New York Times*, New York, March 12, 2000.

Figure 7.3

Real GDP Growth During Expansions

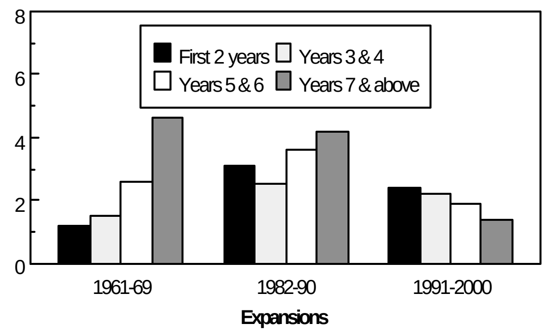
Percent change at annual rate

Source: BEA

Figure 7.4

Rate of Inflation During Expansions

Percent change at annual rate



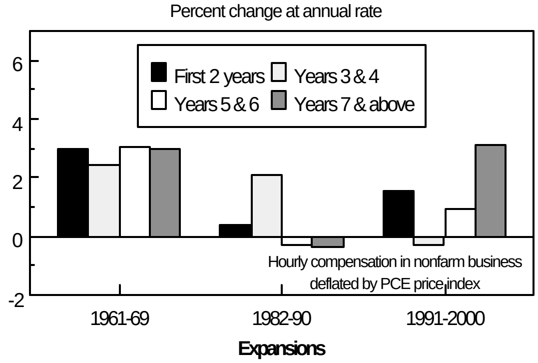
Source: BEA

Price index for gross domestic purchases

Figure 7.5

Growth of Real Hourly Compensation During Expansions

Percent change at annual rate

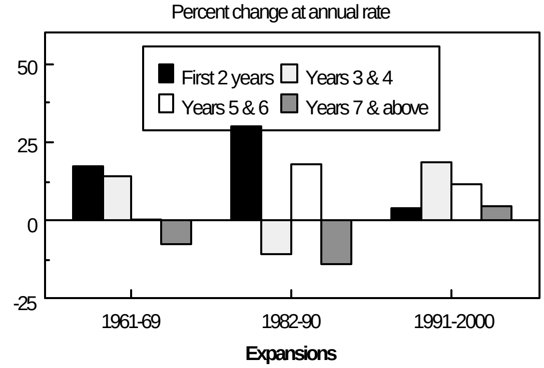


Source: ESA estimates based on BEA and BLS data.

Figure 7.6

Growth of Real Profits During Expansions

Percent change at annual rate



Source: ESA estimates based on BEA and BLS data.

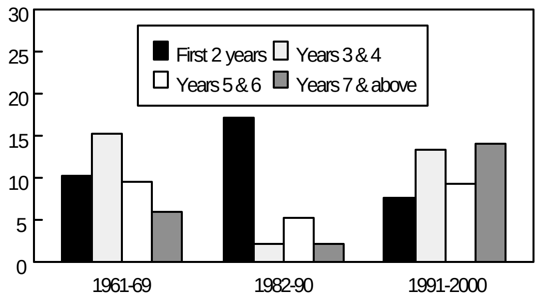
Profits in nonfinancial corporations deflated by GDP price index

The strong output growth and continued improvements in profits in the current expansion have, in turn, fueled unusual vigor in real spending for private investment generally and for research and development in particular. (Figures 7.7 and 7.8)

Figure 7.7

Growth of Real Private Investment During Expansions

Percent change at annual rate



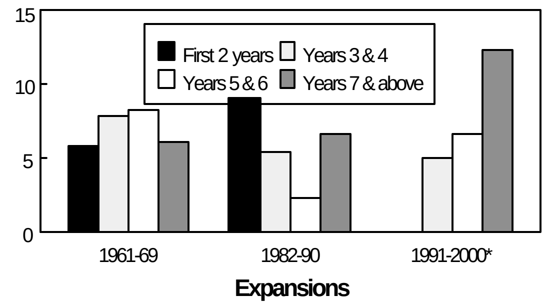
Source: BEA

Investment in equipment and software

Figure 7.8

Growth of Real R&D Expenditures During Expansions

Percent change at annual rate



Source: ESA estimates based on National Science Foundation and BEA data.

R&D spending funded by industry deflated by GDP price index
*Data through 1999

Much as IT has boosted growth in the expansion, it could have a dampening effect on the next business slowdown.[6] In the past, a substantial slowdown or decline in overall demand has led to even greater slowdowns or even declines in investment as capacity and inventories suddenly became excessive. At some time in the future, the economy will slow down, squeezing the corporate cash flow that helps finance new investment and creating involuntary excess capacity and inventories. While this should curb new investments to expand capacity, investments in IT should be far less affected. In most industries, IT investments do not expand capacity; rather, they provide general cost savings, reduce errors, provide the basis for more prompt and informed decisions, and increase customer satisfaction. For industries in which IT investments directly expand capacity to provide services (e.g., finance, real estate, retail) a slowdown in demand should directly slow IT investment. Because IT investments are commonly driven by pressures to keep pace with competitors, in terms of costs and satisfying customer demand for more responsive products, IT investment should weather a slowdown in demand better than capacity expanding investments

The spread of IT could also moderate the sharp declines in manufacturing inventories that occur in recessions. By improving communications with suppliers and customers, IT has facilitated manufacturers' efforts to limit their inventory exposure. As a result, durable goods manufacturers have reduced their inventory ratios from 16.3 percent of annual shipments in 1988 (the lowest period in the 1982-90 expansion) to just 12.0 percent in the last 12 months. (Figure 7.9)

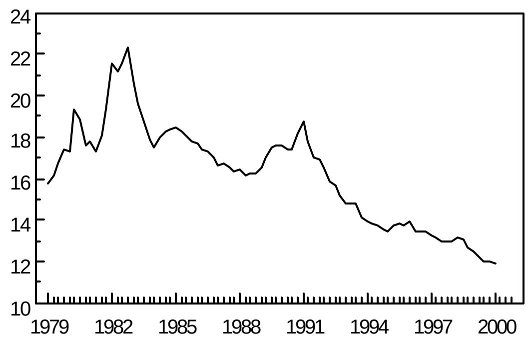
[6] At some point, U.S. demand growth will slow from its 5+ percent pace of recent years back to a level consistent with the growth of labor productivity plus growth of the labor force. In recent years, falling unemployment and a rising trade deficit have allowed demand growth to exceed trend growth in potential output. Neither of the first two trends can continue indefinitely.

If U.S. manufacturers of durable goods today held inventories at the 1988 inventory to sales ratio, they would be holding an additional $115 billion in inventory (Figure 7.10). The cost savings from reduced inventories takes several forms. First, there is the average savings of about $10 billion a year from not having to pay to accumulate as much new inventory in each of the eleven years. Second, the cumulative $115 billion in funds that would have been spent for inventory have been used to invest elsewhere or pay down debt. By this point, the financial benefit of the second effect exceeds the benefit from the first. Third, the companies are spared the expense of storing and securing one-third more inventory than they now hold. Fourth, they avoid the inevitable losses from holding inventories for products that lose favor in the marketplace. All told, lower inventories were a significant factor in the sector's $99 billion of profit in 1999 (and in keeping down prices to their customers).

Figure 7.9

Durable Goods Manufacturing Inventories

Percent of Shipments at an annual rate

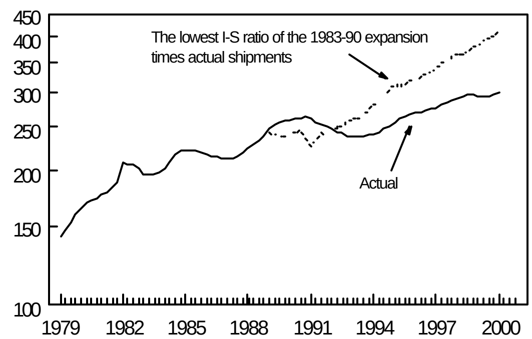


Source: Census Bureau

Figure 7.10

Durable Goods Manufacturing Inventories

Billions of dollars



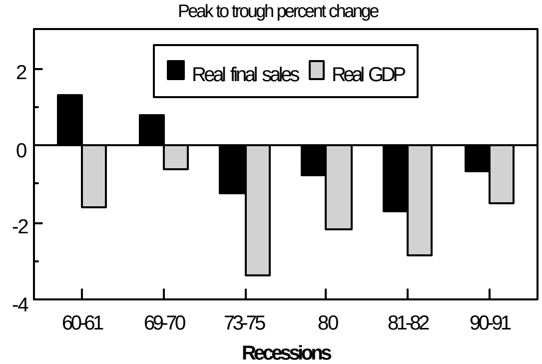
Source: ESA estimates based on Census data.

Adjustments to inventory have aggravated all recent recessions because, as Figure 7.11 indicates, recessions tend to have bigger declines in output than in sales. (Sales actually continued to rise during the recessions of 1960 and 1969.) Reductions in inventory accumulation account for the gap between the change in output and the change in sales. On average, inventory corrections in the six recessions since 1960 made the change in GDP 1.6 percentage points greater than the change in final sales. Today's leaner inventories should, other things equal, cushion the depth of the next recession by narrowing the gap between declines in output and demand.

Figure 7.11

Decline of Real GDP and Real Final Sales During Recessions

Peak to trough percent change



Source: BEA

WHY NOW? WHY HERE?

The U.S. labor productivity boom of the last four years has outpaced not only its own performance from 1973 to 1995, but also the labor productivity gains of other major industrial countries in recent years. Since information technologies and IT prices have been steadily improving since the early 1970s, why didn't U.S. labor productivity improve sooner? Since IT is readily available on the world market, why hasn't labor productivity accelerated in most other industrial countries?

The U.S. macroeconomic environment since the early 1990s has stimulated an investment boom. Both fiscal and monetary policy have contributed. The 1990s began with very large budget deficits projected to grow even larger. However, prudent policies to curb spending and raise revenues were introduced, and the fiscal picture has reversed. Another reason for the current long boom is that Federal Reserve policymakers have generally paid more attention to the fact that inflation has kept on falling, than to traditional concerns that low unemployment would reignite inflation. Back when the unemployment rate first reached the once-worrisome range of 5.5 percent to 6 percent, the Fed could have dampened growth to keep unemployment from falling further. Had they done so, the United States would not have seen the broad gains in output, investment, and labor productivity that have occurred.

Sound macroeconomic policies have helped lower unemployment and inflation, but they cannot account for the recent multi-year doubling of labor productivity growth. For that, look to more technologically based explanations. For example, there is the view that fundamental technological changes, from electricity to IT, take a very long time to generate labor productivity breakthroughs – and when they do, labor productivity rises very sharply. Comparing the economic history of electricity and electrical motors to our recent experience with computers, Paul David and Gavin Wright have documented that labor productivity in U.S. manufacturing grew less than 1 percent a year from the commercial introduction of electric motors in the three decades prior to the 1920s, and then soared to 5 percent per year in the 1920s.[7]

Another explanation uses the model of "recombinant growth" drawn from the biological sciences.[8] Hal Varian observes that "Every so often innovations come along that can be broken down into separate parts and recombined to create a host of new inventions." As businesses bring together different elements in creative combinations, some flourish while many others are ephemeral. Varian cites the historical examples of the periods following Eli Whitney's "uniformity system" to produce muskets, and Edison's invention of the "invention factory."[9] He also gives the more recent example of integrated

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[7] P.A. David and G. Wright, "Early Twentieth Century Growth Dynamics: An Inquiry into the Economic History of 'Our Ignorance'," Stanford: SIEPR Discussion Paper No. 98-3, 1999.

[8] Hal Varian, "The Theory of Recombinant Growth," *The Industry Standard*, February 23, 2000.

[9] Edison's "invention factory" did not invent the first or the best light bulb, electric wiring, power generator, or switch. But, recognizing the need for thin copper wire to compete with gas lighting, Edison and his team did create the first "lighting system" designed to optimize the interplay of all parts in a price competitive system. Using venture capital,

circuits leading to circuit boards for many modern devices and predicts that "the Web's components – URLs, CGI scripts, HTTP protocols and the HTML language" provide the basis for another period of recombinant growth. Recent and now predictable "recombinant growth" includes not only Web components but hardware innovations that can be creatively taken apart and recombined for innovative products.

Perhaps most important of all are the broad market conditions that support innovation. Deregulation has helped drive the development of the largest and most creative financial markets in the world, including equity markets, credit markets, and venture capital. Reallocation of resources is facilitated not only by nimble capital markets but by relatively few barriers to bankruptcy. Americans also enjoy a lower tax burden, and much more fluid and deregulated labor markets, than most other countries. Cultural factors probably also matter, especially the admiration many Americans feel for entrepreneurism and risk-taking.

PRODUCTIVITY ACCELERATION AND JOB DISPLACEMENT

Another important issue concerning the dynamics of the New Economy is their effect on jobs. In an aggregate or macroeconomic sense, the New Economy has been characterized by strong job and wage growth. With lower inflation and accommodating monetary policy, unemployment has fallen below 4 percent, the lowest rate since 1969. The unemployment rate of those with less education and experience has fallen along with the rates of everyone else, although it remains higher than those of better educated and experienced workers. Similarly, with everyone else, workers near the bottom of the ladder in recent years have enjoyed strong real wage growth.

The effect of the New Economy on jobs at an industry and firm level is more difficult to analyze. As shown in Chapter V, we can detect some important effects of IT on IT-related employment, but we can only speculate on the effect of IT on non-IT related jobs. The number of well-paid jobs in the IT producing and IT-using sectors is growing rapidly, even as the number of lower-paid IT-related jobs is shrinking. It is reasonable to assume that IT, by raising labor productivity, must displace jobs somewhere in the economy. However, there is no clear evidence about what types of jobs are displaced most rapidly by IT. A significant percentage of jobs in modern America involve collecting and/or processing information, and/or making decisions based on information; but some sectors, such as education and financial services, have a higher proportion of information-intensive jobs than other sectors. However, all sectors have information-based functions, such as sales, purchasing and finance, in which IT investments could displace many current jobs and raise labor productivity.

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he was the first to go beyond the "tinkering inventor" to create the first "invention factory" with teams assigned to develop specific related innovations, first in lighting, then in batteries, recording, and movie cameras.

AFTER SOFTWARE, SHOULD OTHER INTANGIBLE INVESTMENTS ENTER THE NATIONAL ACCOUNTS?

Among the statistical issues raised by the New Economy is the significance of business investments in intangibles. When the Bureau of Economic Analysis (BEA) recently reclassified software as a form of investment, rather than as business expenditure or intermediate input, this change substantially increased the size and growth of IT in our national accounts. Drawing the curtain to reveal a sector that grew from $28 billion in 1987 to $149 billion in 1999 had a catalytic effect on economists' perceptions of non-computer aspects of the IT sector. Much as businesses expect to earn a return on their investments in software over several years, business spending on intangibles such as training, workplace reorganization, and consultants can also be viewed as investments with long-term payoffs.

The work of Erik Brynjolfsson and his coauthors discussed in Chapter IV strongly suggests that such intangibles are important investments supporting and complementing tangible IT investments. Not long after BEA recognized software as investments, Federal Reserve Board Chairman Alan Greenspan urged that the national accounts go beyond software to include other intangible investments.[10]

The treatment of business spending on other intangible investments could have significant effects on a range of measures central to our understanding of the economy. Since such intangible investment has no doubt been growing faster than GDP, its inclusion as investments would raise our measure of GDP growth. This change also would likely improve our ability to account for growth attributable to specific inputs, and leave less unexplained.[11] Since these intangibles often complement computer and other IT investments, this change would also help resolve the paradox of the supernormal returns on computer investments found in some firm-level studies.

On the other hand, incorporating other intangible investments into the GDP measure would highlight the limitations of GDP as the almost-exclusive gauge of longer term growth trends. IT investments tend to have short lifespans and thus faster depreciation rates than average. As the IT share of investment rises, depreciation rises faster than GDP. Net Domestic Product (GDP less depreciation) provides a better indication of sustainable growth. As IT has become a larger share of total investment, the gap between GDP growth and NDP growth has widened. In the 1960s, GDP and NDP both grew at the same 4.4 percent rate. By 1999, however, GDP grew by 4.1 percent, but depreciation was growing so much faster that NDP grew by only 3.6 percent.

[10] Alan Greenspan, "Remarks," *Survey of Current Business*," January 2000, p. 12.

[11] The growth accounting framework, discussed in Chapter IV, makes an estimate of the contributions of capital and labor to growth, with the residual part of growth not accounted for by capital or labor often called multi- or total factor productivity. Although this residual is often viewed as an indicator of technical change, others have called it a "measure of our ignorance" of all the factors contributing to growth.

TO SOLVE THE PRODUCTIVITY PUZZLE, BETTER MEASURES OF SERVICE INDUSTRY OUTPUT ARE NEEDED

As a practical matter, the question of precisely how much IT has contributed to our stellar economic performance will remain largely a mystery at least until BEA develops ways of better measuring output in several key IT-intensive services industries. As noted in Chapter IV, the view that IT has made a large contribution to labor productivity growth, based on evidence at the macroeconomic and firm levels, cannot yet be confirmed at the industry level. As Dale Jorgenson and Kevin Stiroh caution:

> The apparent combination of slow productivity growth and heavy computer-use [in specific service industries] remains an important obstacle for new economy proponents who argue that the use of information technology is fundamentally changing business practices and raising productivity throughout the U.S. economy.[12]

The fact that official measures show flat or declining labor productivity for several IT-intensive service industries, such as health and business services, does not mean that labor productivity has not improved in those industries. The techniques used to measure output in these industries either assume no labor productivity change or otherwise fail to capture increases in their output fully.

A case in point is the measurement of output in the banking industry. Until recently, output in the banking industry was constructed with the same basis still used for some major service industries – assuming no labor productivity change – by using labor input growth as a measure for output growth. With its benchmark revisions released in October 1999, BEA adopted a new method for measuring bank industry output based on the industry's transaction activities. As a result, measures of the IT-intensive banking industry now indicate significant annual labor productivity gains, in contrast to the negative labor productivity changes portrayed under the old method.

Producing true output measures for all service industries presents a daunting task. The Bureau of the Census should do more complete surveys of service industries broken down into more detailed and current categories. Even with such data, BEA faces difficult conceptual challenges in developing satisfactory methods for measuring the output of health, legal, business, and other services. However, BEA has pioneered the use of creative new methods for measuring the quality, price and output changes for computers, semiconductors, and certain telecommunications equipment, along with the development and use of sophisticated methods such as chain-weighted indexes to properly gauge real output changes in a world with some sharply falling prices. Without these statistical advances, it would not have been possible to assess the contribution of IT at the macroeconomic level. (Indeed, the fact that the GDP accounts of other major industrial countries do not include these advances makes international growth comparisons very problematic.)

[12] Dale W. Jorgenson and Kevin J. Stiroh, "Raising the Speed Limit: U.S. Economic Growth in the Information Age," May 1, 2000, forthcoming in *Brookings Papers in Economic Activity*, p. 37 (http://www.economics.harvard.edu/faculty/jorgenson/papers/dj_ks5.pdf).

In the absence of more accurate measures of output for IT-intensive services industries, we cannot rule out the possibility that IT has made a very modest contribution to labor productivity outside the IT producing sector itself. With better measures of output for individual service industries' output, we may learn that IT has contributed strongly to service industry productivity or, conversely, that IT has not contributed as much to overall labor productivity improvement as technical change outside of IT, including organizational change.

THE DIGITAL DIVIDE: COMMUNITIES WITH LOW INTERNET ACCESS RATES

Internet access has grown across every group and state in America, but this growth has been most rapid among those households with higher incomes, more education, computers at work, white or Asian backgrounds, and headed by persons age 35 to 50.[13] Serious concerns about other groups that are currently "falling through the Net" are based on the fact that the Internet is *not* merely a place to shop, but also a space where students learn, people find employment, and communities communicate.

Robert W. Taylor, the director of the Defense Department agency that created the original Internet in 1969, co-authored a remarkably prescient paper in 1968, "The Computer as a Communication Device," raising concerns about what is now called the Digital Divide:

> For the society, the impact will be good or bad, depending mainly on the question: Will to be 'online' be a privilege or a right? If only a favored segment of the population gets a chance to enjoy the advantages . . . the network may exaggerate the discontinuity in the spectrum of intellectual opportunity.[14]

In more affluent and better educated communities, Internet access has reached a critical mass. Students are assigned to do their research on the Web, at home and not just in the library. Increasingly, job-seekers find job openings on the Web. Sign-up lists passed around at the PTA or other local organizations include a column for e-mail addresses, along with name and telephone number. In each instance, the Internet provides the means for communicating information critical for students, job-seekers, and members of organizations, that could not occur as effectively in other ways.

In 1998, 42 percent of all American households had computers at home, and 22 percent had Internet connections at home. Some groups, however, are better networked. Among the 5.5 million White, Asian, and Pacific Islander families with incomes of at least $75,000, living in a metropolitan area, headed by someone with at least a college education and age 30 to 55, 87 percent had computers at

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[13] National Telecommunications and Information Administration, (NTIA) U.S. Department of Commerce, "Falling Through the Net: Defining the Digital Divide," July 1999 (http://www.ntia.doc.gov/ntiahome/digitaldivide/).

[14] Robert W. Taylor and J.C.R. Licklider quoted in David Plotnikoff, "A Father of the Net Looks back and asks, 'What took so long?'", *San Jose Mercury News,* March 12, 2000 (http://www.mercurycenter.com/svtech/columns /modemdriver/docs/dp031200.htm).

home, and 68 percent had Internet connections. Among households with these levels of income, education, age and living in a metropolitan area, Black and Hispanic households were just as likely to have home computers – but roughly 14 percent less likely to have Internet access at home – as White, Asian, and Pacific Islander households in the same income, education and age group.[15]

At the other extreme, the 1.2 million Black and Hispanic urban households with incomes below $15,000, in which all adults lack a high school diploma or GED, and headed by someone age 30 to 55, only 7 percent had computers at home and only 2 percent had Internet service. Among Whites, Asians, and Pacific Islanders with similar low income, lack of education, and age, 14 percent had computers at home, and 5 percent had home Internet connections.[16]

Since 1998, more households have obtained computers and Internet access and alternative points of access, such as state employment commission offices, public libraries, and community centers and clubs, have expanded. When the results from a new Census Bureau August survey of households become available this Fall, we will learn the extent to which different groups have improved their access to the Web and capacity to create networks on the Internet.

Nonetheless, many Americans – particularly those with less income and education – are still missing out on the network benefits of the Internet age. And as more and more everyday activities migrate to the Internet, the gap in opportunities available to those on either side of the digital divide increases.

CONCLUSION

The dynamism of the New Economy presents opportunities and challenges for almost everyone. IT can offer cost savings, expanded markets, and more intense competition for private businesses in almost every industry. As employers are less readily finding workers with appropriate skills, they have had to provide more training for current employees and to modify technology to match the skills of available workers. Workers are more readily finding better paid jobs, but to do so they must often adapt to new technologies. Because many of the jobs potentially displaced by IT investments now require average or better education and skills, those displaced may well find new jobs quickly, possibly with the same employer. The New Economy is expanding the revenues for government, even as it presents many new and difficult policy issues. Finally, economists and statistical agencies are now able to obtain better information, more quickly, but they also have to redesign their frameworks to capture this fast-changing economy.

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[15] Calculations by the Office of the Chief Economist, U.S. Department of Commerce based on data from the Bureau of the Census' Current Population Survey Internet and Computer Use Supplement, 1998 (http://www.bls.census.gov/cps/computer/computer.htm) and published in NTIA's "Falling Through the Net: Defining the Digital Divide."

[16] *Ibid.*

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