U. S. DEPARTMENT OF COMMERCE

The EMERGING DIGITAL ECONOMY II

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Last spring, I released *The Emerging Digital Economy*, the Department of Commerce's first report measuring the development of electronic commerce. I wrote then that the report aimed to provide us with a clearer understanding of the "promise" of electronic commerce – "a future with more opportunity and prosperity" for all Americans.

That promise is being fulfilled. This past year, electronic commerce has grown beyond almost everyone's expectations. Every day, more people are finding new ways to provide innovative products and services electronically. The Internet is changing the way businesses do business, from the acquisition and servicing of customers, to the management of their relations with suppliers. It is revolutionizing our access to information and the way we communicate, shop, and entertain ourselves. While the numbers are still small, when compared to our overall economy, they are growing more rapidly and provide more evidence that electronic commerce will be the engine for economic growth in the next century.

This year's report provides more information about that growth and the changes that are taking place in our economy. It details the extraordinary contribution that telecommunications and information technology are making to the longest peacetime economic expansion in history.
It provides fresh evidence that our Nation's massive investments in these sectors are producing gains in productivity and that these sectors are creating new and higher paying jobs faster than any other sector.

But we are not yet able to give a complete picture of the Internet's effects on our economy. Although we have begun to systematically collect data on electronic commerce, specifically on retail sales using the Internet, we are still studying how to ensure that the statistical information provided by the government takes into account the stunning upheavals brought about by the Internet. We want to ensure that businesses and policy makers have the best possible data and that we are gathering and disseminating that data in the most efficient way possible. We look forward to working with the private sector – businesses, non-profits, academic institutions – to identify ways to best measure the emerging digital economy.

We intend to issue this report annually to better communicate the dramatic changes taking place. At the same time, the Department of Commerce will continue to work to ensure that electronic commerce is able to flourish. In particular, we are making every effort to establish a legal framework that facilitates electronic commerce around the globe, to protect consumers and their privacy, and to enable everyone in our country, rich and poor, urban and rural, of whatever race or ethnic background, to fully participate in this remarkable economic transformation.

William M. Daley

EXECUTIVE SUMMARY

Electronic commerce (business transactions on the Web) and the information technology (IT) industries that make "e-commerce" possible are growing and changing at breathtaking speed, fundamentally altering the way Americans produce, consume, communicate, and play.

- Growth in the available measures of e-commerce (*e.g.*, estimates of the value of e-commerce business transactions) is outpacing last year's most optimistic projections. As a share of the retail portion of the economy, however, e-commerce remains quite small-- less than 1 percent.

- IT-producing industries (*i.e.*, producers of computer and communications hardware, software, and services) that enable e-commerce play a strategic role in the growth process. Between 1995 and 1998, these IT-producers, while accounting for only about 8 percent of U.S. GDP, contributed on average 35 percent of the nation's real economic growth.

- In 1996 and 1997 (the last years for which detailed data are available), falling prices in IT-producing industries brought down overall inflation by an average 0.7 percentage points, contributing to the remarkable ability of the U.S. economy to control inflation and keep interest rates low in a period of historically low unemployment.

- IT industries have achieved extraordinary productivity gains. During 1990 to 1997, IT-producing industries experienced robust 10.4 percent average annual growth in Gross Product Originating, or value added, per worker (GPO/W). In the goods-producing subgroup of the IT-producing sector, GPO/W grew at the extraordinary rate of 23.9 percent. As a result, GPO/W for the total private nonfarm economy rose at a 1.4 percent rate, despite slow 0.5 percent growth in non-IT-producing industries.

- By 2006, almost half of the U. S. workforce will be employed by industries that are either major producers or intensive users of information technology products and services. Innovation has increased demand for high paid, "core IT workers" (*e.g.*, computer scientists, engineers), created new IT occupations, changed skill requirements for some non-IT occupations, and raised minimum skill requirements for many other jobs. Wage gaps between workers in IT industries and all other workers continue to widen.

- The pervasiveness of information technology, the variety of its benefits to producers and consumers, and the speed of economic change in the digital era have tested the limits of established indices of economic performance. Federal statistical agencies have taken steps to improve data collection and analysis, but much remains to be done.

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Robert J. Shapiro
Under Secretary of Commerce for Economic Affairs

Revolutions, by their nature, create new and unanticipated opportunities, challenges and risks for those caught up in them. We all find ourselves in the midst of a technological revolution propelled by digital processing. All around us, in ways and forms we cannot fully appreciate, new digitally-based economic arrangements are changing how people work together and alone, communicate and relate, consume and relax. These changes have been rapid and widespread, and often do not fit the established categories for understanding economic developments. As a result, early efforts to take the measure of these changes have often seemed to be inventories of what is not yet known.

This emerging digital economy regularly surprises those who study it most closely. In 1997, for example, private analysts forecast that the value of Internet retailing could reach $7 billion by 2000 -- a level surpassed by nearly 50 percent in 1998. In the last year, forecasters tripled their previous estimates of the near-term growth expected in business-to-business electronic commerce. It is clear that tracking Internet business, especially in a timely way, requires new economic measures and measurement techniques. The Economics and Statistics Administration, and the Census Bureau and Bureau of Economic Analysis which are part of it, are taking important steps on this path. The Census Bureau, for example, will measure the dollar value of e-commerce sales for the next *Annual Survey of Retail Trade*. Census has also developed and implemented a new system for classifying industries and economic activities, the North American Industrial Classification System, which includes extensive and detailed coverage of the information sector. In addition, Commerce Department officials are working with their foreign counterparts to develop appropriate international indicators of information industries, and to address common concerns related to privacy, security and other matters.

This report, *The Emerging Digital Economy II*, is part of the Commerce Department's ongoing mission to understand, measure and explain important changes in the U.S. and world economies. This report is also a response to the broad interest in the publication last year of *The Emerging Digital Economy*. *The Emerging Digital Economy II* both updates the first edition of the report and includes new sections and analyses of information technology (IT)-using industries, the role of IT industries in driving economic growth, and globalization of the digital economy. Like its predecessor, this report is incomplete, because the subject is always changing and moving ahead.

CHAPTER I

ELECTRONIC COMMERCE IN THE DIGITAL ECONOMY*

"The newest innovations, which we label information technologies, have begun to alter the manner in which we do business and create value, often in ways not readily foreseeable even five years ago."

Alan Greenspan
Chairman, Federal Reserve Board
May 6, 1999

Two facets of the "digital economy," electronic commerce (*i.e.*, business processes which shift transactions to the Internet or some other non-proprietary, Web-based system) and the information technology (IT) industries that make e-commerce possible, are growing and changing at breathtaking speed. Not only were we unable to foresee five years ago how advances in information technology would "alter the manner in which we do business and create value," but the rate of change is racing ahead of estimates that only a year ago appeared optimistic. This chapter looks at the dimensions and growth of e-commerce, while the following chapters examine IT industries and their impact on various facets of the U.S. economy.

The value of e-commerce transactions, while still small relative to the size of the economy, continues to grow at a remarkable rate. More significant than the dollar amount of these transactions, however, are the new business processes e-commerce enables and the new business models it is generating. Both the new Internet-based companies and the traditional producers of goods and services are transforming their business processes into e-commerce processes in an effort to lower costs, improve customer service, and increase productivity.

Driven by customer demand and business imperatives, the digital economy is becoming truly global. The United States continues to lead the world in many measures of the utilization of digital technology. However, this lead is diminishing.

Gauging the Growth of E-Commerce

Electronic commerce is a means of conducting transactions that, prior to the evolution of the Internet as a business tool in 1995, would have been completed in more traditional ways—by telephone, mail, facsimile, proprietary electronic data interchange systems, or face-to-face contact. Indicators gathered from a variety

*This chapter was written by Patricia Buckley, senior policy advisor in the Office of Policy Development.

of private sources show rapid growth, not only in current e-commerce, but in the infrastructure that will support future e-commerce development.

Setting the Stage for E-Commerce: An Increasingly Wired World

While individual private estimates of Internet access and size vary significantly from each other, taken together they indicate remarkable growth.[1] For example, *The Industry Standard* reports that from 1998 to 1999 the number of web users world-wide increased by 55 percent, the number of Internet hosts rose by 46 percent, the number of web servers increased by 128 percent, and the number of new web address registrations rose by 137 percent.[2] In addition, according to a recent study by International Data Corporation (IDC), between 1998 and 1999 revenues of U.S. Internet service providers (ISPs) will rise by 41 percent. IDC projects that these ISP revenues will continue growing at a compound annual rate of 28 percent through 2003.[3] By any measure, the ability of consumers and businesses to reach the Internet and to engage in e-commerce is increasing rapidly.

According to Nua, an Internet strategy firm, as of May 1999, 171 million people across the globe had access to the Internet, over half of them in the United States and Canada.[4] (Figure 1.1) Not only do the United States and Canada occupy a large absolute share of the Internet world, they also have a high level of Internet participation on a per capita basis. More disaggregate data derived from a variety of sources show the percentage of the population with access to the Internet, either at home or at work, by country or country group. (Figure 1.2) Relative to population, the United States, Canada, the Nordic countries[5], and Australia have at least twice the level of Internet access so far achieved by the United Kingdom, Germany, Japan, and France.

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[1]Specific estimates from private sources are included in this report to be illustrative of developing trends. Their inclusion does not signify Department of Commerce validation of the individual numbers themselves or the methodologies used to produce them. Disparities among private estimates 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.

[2]"My How We've Grown," Maryann Jones Thompson, *The Industry Standard*, April 26, 1999. (http://www.thestandard.com)

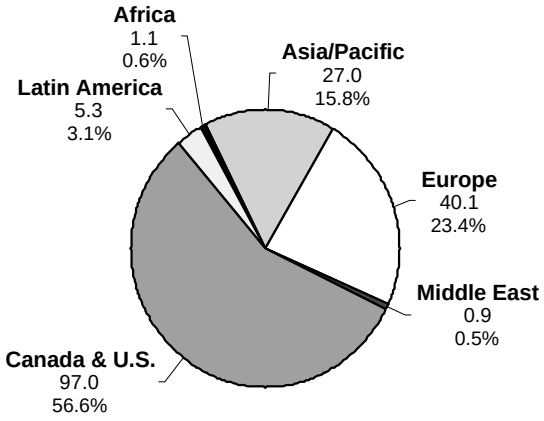
[3]"The U.S. Internet Service Provider (ISP) Market Will Add Nearly $4.5 Billion of Revenue Annually over the Next Three Years," IDC Research, press release, April 19, 1999. (http://www.idc.com)

[4]For complete survey results, definitions, and methodology see http://www.nua.ie/surveys.

[5]The Nordic countries are Denmark, Finland, Iceland, Norway, and Sweden, plus the three autonomous territories of Greenland, the Faroe Islands, and Aland.

Figure 1.1

Number of People with Internet Access, by Region
May 1999
(millions)

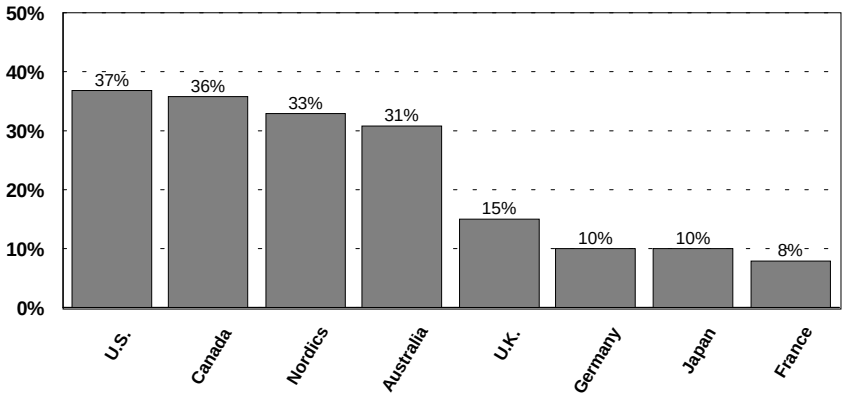


TOTAL: 171 million

Source: Nua, current as of June 8, 1999

Figure 1.2

Percent of the Population with Internet Access at Home or at Work
1998



Sources: United Kingdom Department of Trade and Industry; Australia Bureau of Statistics, Statistics Canada, DSA Analytics, and International Data Corporation.

Within the United States, the growth in Internet access has occurred more rapidly at higher income levels and varies among various demographic groups and geographic areas. The "digital divide" between certain groups of Americans increased between 1994 and 1997, resulting in a widening gap between those at upper and lower income levels, and between both Blacks and Hispanics as compared with Whites. Rural areas lagged behind urban and central cities with respect to rates for online access. In July 1999, the National Telecommunications and Information Administration will release updated and expanded data on the digital divide and uses of the Internet, based on a December 1998 Census Bureau survey.[6] Similarly, throughout the world, lower income countries have lower rates of Internet access when compared to the higher income countries included in Figure 1.2. In Mexico, a nation of close to 100 million, for example, only about 1 million people have access to computers and only 10 percent of those presently access the Internet.[7]

Not only is the Internet growing larger, but the ways it is used are changing. According to Media Matrix, as recently as 1996, education sites dominated the top 15 list of most visited sites. The top 15 that year included *no* e-commerce sites. Today, nearly all of the top web-site destinations offer content, communications, community, and commerce.[8] Sending or receiving email, obtaining information about a hobby, general news, and information for business continue to outrank online shopping as popular online activities.[9] The fact that Internet advertising revenues more than doubled between 1997 and 1998 suggests the growing importance that businesses are placing on this new way of reaching customers.[10]

The Rise in E-Commerce

Public and private efforts to develop economy-wide measures of e-commerce are continuing. Available evidence of the growth in e-commerce comes primarily from the industry and firm sources. This evidence is impressive:

- Dell Computer's online sales more than doubled during 1998 rising to more than $14 million per

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[6]The issue of differential rates of Internet access in the United States is discussed in another series of Department of Commerce reports, *Falling Through the Net* and *Falling Through the Net II* issued by National Telecommunications and Information Administration (NTIA). NTIA will release an updated and expanded study in July 1999. (http://www.ntia.doc.gov)

[7]"Marketplace@internet.com.mx", Pav Jordon, *Business Mexico,* The American Chamber of Commerce of Mexico, November 1998, pp 42-46.

[8]"Media Metrix Chronicles the 'History' of the Internet," Media Metrix press release, March 18, 1999. (http://www.mediametrix.com)

[9]"IntelliQuest Study shows 83 Million U.S. Internet Users and 56 Million Online Shoppers," IntelliQuest Research, April 19, 1999. (http://www.intelliquest.com)

[10]"Internet Advertising Revenues More Than Double in 1998," Internet Advertising Bureau, Press Release, May 3, 1999. (http://www.iab.net)

day and accounts for 25 percent of the company's total revenues. During the quarter ended April 30, 1999, online sales rose further to an average of $18 million per day and now account for 30 percent of the company's $5.5 billion first quarter revenues. Dell expects this percentage to increase to 50 percent by 2000.[11]

- During first quarter 1999, Travelocity.com had gross sales of more than $128 million, a 156 percent increase over the same period last year, and registered 1.2 million new members.[12]

- Users of Quicken Mortgage, Intuit's online mortgage provider, arranged for $400 million in loans in the first three months of 1999 compared to $600 million in mortgage loans for all of 1998.[13]

- During the first quarter of 1999, according to Piper Jaffray, online brokerages broke their fourth quarter 1998 records by adding another 1.2 million accounts and $100 billion in new assets, and increasing the average number of daily trades by 49 percent.[14]

In light of the recent growth in e-commerce, many private forecasts made just a year ago have been revised upward. As we cited in last year's *Emerging Digital Economy Report*, in early1998, forecasters were suggesting that business-to-business e-commerce might rise to $300 billion by 2002. Most forecasters now consider that estimate to be too low. For example, Forrester Research estimates that business-to-business e-commerce will rise to $1.3 trillion by 2003.[15] Similarly, early1998 estimates suggested that Internet retailing might reach $7 billion by 2000. In all likelihood, this level was exceeded *last year*; current private estimates of 1998 online retail trade range between $7.0 billion and $15 billion. Forecasters now project online retail sales in the range of $40 billion to $80 billion by 2002. And even these increased forecasts of both business-to-business and business-to-consumer e-commerce may prove to be low if a recent study financed by Cisco Systems, which estimates that 1998 total e-commerce (business-to-business plus business-

[11]"E-Commerce an 'Online Earthquake' for American Business," Mary Beth Regan, Cox News Service, *Computer News Daily*, April 14, 1999. (http://www.nua.ie) and "Dell Earnings Rise 45 Percent on 41- percent Revenue Growth: Internet Increasing Company's Competitive Advantage," Dell Computer Corporation press release, May 18, 1999. (http://www.dell.com)

[12]"Travelocity.com Continues as Online Travel Industry Leader," Sabre news release, June 3, 1999. (http://www.sabre.com)

[13]"Jostling for Share of E-Mortgages," David Cay Johnson, *The New York Times*, May 31, 1999, C3.

[14]"Online Brokerages Surpass Wildest Expectations Average Daily Trades up 49% in Q1 1999," U.S. Bancorp Piper Jaffray, press release, April 26, 1999. (http://www.piperjaffray.com)

[15]"U.S. Online Business Trade will Soar to $1.3 Trillion by 2003, According to Forrester Research," Forrester Research, press release, December 17, 1998. (http://www.forrester.com) As a reference, Forrester estimated that business-to-business e-commerce in 1998 totaled $43 billion.

to-consumer) was $102 billion, is a more accurate estimate.[16]

Standard definitions of e-commerce must still be established. Current market research estimates of aggregate online retail trade generally purport to include only those transactions ordered *and* paid for online. But they must rely on data supplied by individual companies who may not keep information that way. Individual companies sometimes include as online sales transactions those transactions that were conducted *substantially* online, but which also include a critical non-Internet component. For example, although eBay encourages sellers to establish an account tied to a credit card, they will accept one-time payments by check or money order. Similarly, Dell Computer's online revenues include sales where, although the majority of the transaction occurred online, the final steps were conducted over the telephone.

The Internet plays an important role in a much larger number of transactions than those completed online. In addition to the shoppers who choose items online, but pay for them off-line, the Internet is an important source of research that influences off-line ordering and purchasing, particularly for big ticket items such as autos. In an analysis of the impact of the Internet on 1998 consumer spending, Cyber Dialogue estimates that while sales ordered and paid for online were $11.0 billion, sales to consumers that were ordered online, but paid for off-line were more than $15 billion and the value of off-line orders influenced by the Internet was approximately $51 billion.[17]

Compared with businesses and consumers overseas, U.S. businesses and consumers appear to have a greater desire and willingness to transact business online. A recent survey of Chief Financial Officers conducted by the Financial Executives Institute and Duke University indicates that the proportion of U.S. companies that sell their products over the Internet will jump from 24 percent in 1998 to 56 percent by 2000.[18] In a 1998 survey of U.S. online households (which they estimate at 33 percent of all U.S. households), Odyssey, a market research firm, found that 47 percent had made online purchases within the last than six months.[19] In comparison, a recent Australian Bureau of Statistics survey indicates that only 7 percent of Australian adults who accessed the Internet in the 12 months prior to November 1998 reported using the Internet for shopping.[20] In addition, IDC reports that only about 11 percent of Western European web users actually

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[16]"The Internet Economy Indicators," Anitesh Barua, Jay Shutter, and Andrew Whinston. Initial report results issued June 10, 1999. (http://www.internetindicators.com)

[17]"Only Half of Net Purchases are Paid for Online," Maryann Jones Thompson, *The Industry Standard*, March 1, 1999. (http://www.thestandard.com/metrics)

[18]"CFO Survey: Company Internet Sales and Purchases to Jump; Few Price increases, Stronger Earnings Ahead," FEI/Duke University Corporate Outlook Survey, March 29, 1999. (http://www.duke.edu)

[19]"Forty-Seven Percent of Online Households Have Made Purchases Online, Reports Odyssey's Homefront Study," *Business Wire*, March 22, 1999.

[20]Australian Bureau of Statistics, "Use of the Internet by Householders," March 1,1999. (http://www.abs.gov.au)

made an online purchase during the final quarter of 1998.[21]

Willingness to conduct business online is influenced by a variety of factors. In some countries concerns over privacy and security of credit card purchases deter e-commerce expansion. In other countries, political and regulatory issues are discouraging factors.[22] The deterrent cited most often, however, is the cost of Internet access. For example, a study by DSA Analytics reports that "Japanese Internet users are accessing the Internet more frequently than in the past, but they are not appreciably increasing the total amount of time they spend online. Most Japanese Internet users note that the cost of local phone calls is a major disincentive to greater use."[23]

Conversely, a factor facilitating e-commerce growth in the United States is the flat rate pricing structure of local residential telephone calls. In addition, most Internet providers have also gone to a flat per month fee. These advantages combine to give prospective U.S. Internet shoppers the opportunity to browse and purchase without being concerned by per minute charges. The pricing structures in most other countries are not so conducive to online shopping.

Another determining factor in the growth of e-commerce is the availability and cost of broadband access. Increased private investment in high-speed networks will facilitate the distribution of information, particularly bandwidth-intensive applications which use graphics and video. The availability of this increased bandwidth will enable Web-sites to more closely mimic the "real" store shopping experience as well as encourage Internet innovators to construct multimedia environments and deliver them with little delay.[24]

As countries deregulate their telecommunications markets, they quickly see lower prices translate into increased e-commerce activity. In Germany, for example, Forrester reports that since the 1998 telecommunications deregulation, start-ups and local telephone companies have designed new pricing and service plans to make Internet access more attractive. These plans include special Internet dial-up rate plans and all-in-one offers which include phone call and access fees.[25] Likewise, in the United Kingdom, one of the most liberalized telecommunications markets in Europe, domestic U.K. companies are using innovations

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[21]"1998: The Year the Internet Broke in Western Europe," International Data Corporation Press Release, January 28, 1999. (http://www.idc.com)

[22]For examples see "Asia's Net Snoops are Wasting Their Time," *Business Week*, Feb 1, 1999, p. 64.

[23]"The Internet user and Online Commerce in Japan, 1999, Executive Summary," DSA Analytics. (http://www.dsasiagroup.com)

[24]The Administration's directive on "Successes and Furth Work on Electronic Commerce," specifically charges the Secretary of Commerce, in consultation with the Federal Communications Commission, to encourage the deployment of advanced telecommunications capabilities for all Americans. November 30, 1999. (http://www.pub.whitehouse.gov)

[25]"German Telecom Deregulation Trickles Down to the Net," The Forrester Brief, January 22, 1999. (http://www.forrester.com)

in pricing and content to offset some of the advantages that U.S. companies gained by being early into U.K. markets. For example, in less than five months, Dixons, a large U.K. consumer electronics retailer, has taken the lead in British consumer Internet subscriptions. Dixons subscribers pay only the cost of a local phone call to get on-line, the ISP service is free.[26]

Increasingly Global Markets

The U.S. lead in worldwide e-commerce is diminishing as other countries increase their participation in the global digital economy. For example, although the number of Internet users in the United States and Canada continues to grow, the U.S. and Canadian share of world Internet users has declined from 62 percent in 1997 to 57 percent in May 1999.[27]

Developing needed infrastructure and expanding access to the Internet are areas of extreme interest to all countries and these are being explored, not only by individual countries, but in various international fora such as the Organization for Economic Cooperation and Development(OECD)and Asia-Pacific Economic Cooperation (APEC), and in discussions on the Free Trade Area of the Americas (FTAA). In addition, the White House has directed that an initiative be developed to help accelerate the spread of the Internet and e-commerce to developing countries.[28]

Just as rates of Internet access are uneven within the United States, so too will global expansion of Internet access occur unevenly. Even in Europe, which is cited by a recent study as the "fastest growing and most interesting market for Internet development" outside of North America, transition to the global digital economy may be highly diverse.[29]

Recognition of the benefits that can arise from full participation in the information economy is not limited to the world's developed nations. For much of the world, however, e-commerce and the movement to a digital economy in general are constrained by a lack of critical infrastructure. Both on national and transnational levels, developing countries are struggling to determine how they too can benefit from the emerging digital economy, given other needs and the condition of their electric and telephonic infrastructure. Even in a country such as South Africa, which has made great strides in recent years, the problems are formidable. In 1994, less than 40 percent of South African households had electricity; now 63 percent of households are connected to the electricity grid. In 1994, about a quarter of all homes had

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[26]"European Retail Set to Spiral," The Forrester Brief, March 16, 1999. (http://www.forrester.com)

[27]Nua Internet Surveys. (http://ww.nua.ie)

[28]"Successes and Further Work on Electronic Commerce," Presidential Directive, The White House, November 30, 1998. (http://www.pub.whitehouse.gov)

[29]Marius Meland, "Europe: The Next Frontier," *Forbes*, March 29, 1999. (http://www.forbes.com)

telephones; now 35 percent are linked to the telephone system.[30] For developing nations, the productivity potential of the digital economy offers both hope and worry: with sufficient investment, it can provide the means to accelerated development, but without the needed investment, developing nations may find themselves falling even further behind in an increasingly wired world.

It is important that governments set policies that will facilitate, not hinder, Internet development. The five principles first set out in a report released by the President and Vice President in 1997, "A Framework for Global Electronic Commerce,"--private sector leadership, avoidance of undue restrictions, establishment of a legal environment based on a contractual model of law, recognition of the unique qualities of the Internet, and facilitation of global e-commerce--have provided a useful starting point for national and international discussions of how to foster e-commerce development.[31]

Recognizing the global shift to e-commerce, providers are responding. One estimate indicates that the amount of non-English language material available on the Web is growing so quickly that by 2003 more than half the content will be in a language other than English, up from 20 percent today. In addition, improvements in translation services (by people and machines) and browsers that recognize characters of different languages will greatly expand the amount of content usable by the entire worldwide Internet citizenry.[32]

As the Internet moves the world toward truly global markets, it seems likely that Internet transactions will grow large enough to measurably impact trade flows. However, the size and direction of those impacts remain uncertain. It is clear that the opportunity the Internet offers to access new markets has attracted attention, and Web-sites are being developed specifically, in some cases, to expand global reach. Recently, US-Style.com launched the first online community-based shopping mall targeting Japanese consumers seeking American goods and services. This e-commerce site is written in Japanese and features a Japanese user interface and customized versions of select U.S. retailers' existing web sites.[33]

Many U.S. companies have been able to leverage their position in the U.S. market into strong global positions by customizing their goods and services to local markets and, in many cases, joining with local partners. However, U.S. businesses also face real competition as evidenced by the many new products and services coming from firms outside of the United States. For example, Japan is the launch site for the world's first integrated credit/debit/cash card[34] and the Nordic countries are pioneering the market for

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[30]Address by President Nelson Mandela to the South African Parliament, February 5, 1999. (http://www.anc.org.za)

[31]"A Framework for Global Electronic Commerce," The White House, July 1, 1997. (http://www.ecommerce.gov)

[32]Leslie Helm, "World Wide Web Living Up to Its Name," *Nando Times News*, March 28, 1999. (http://www.techserver.com)

[33]"US-Style.com Opens Japanese Online Market to American Retailers," Business Wire News Alert, May 18, 1999. (http://www.newsalert.com)

[34]"Credit, Debit, Cash Function on a Single Card," *Computing Japan*, January 1999, p 34.

wireless e-commerce.[35] Notwithstanding this growth in global competition, U.S. producers of everything from infrastructure equipment to Internet content should continue to experience strong advantages in the worldwide information technology market--advantages conferred by continued improvements in the production of high-quality, innovative goods and services.

E-Business: Defining New Business Models

The impact of e-commerce on the economy extends far beyond the dollar value of e-commerce activity. Businesses use e-commerce to develop competitive advantages by providing more useful information, expanding choice, developing new services, streamlining purchasing processes, and lowering costs. The Internet also imposes price discipline as customers have access to price and product information from many sources.

Retail E-Commerce

Many of the advantages of e-commerce were first exploited by retail "e-businesses" such as Amazon.com, eTrade, and Auto-by-tel that were created as Internet versions of traditional bookstores, brokerage firms, and auto dealerships. Freed from the geographic confines and costs of running actual stores, such firms could deliver almost unlimited content on request and could react and make changes in close to real-time. Compared to traditional retail or catalogue operations, this new way of conducting business is changing cost structures.[36] The emergence of these e-businesses has made their "brick and mortar" competitors consider their own e-commerce strategies, and many now operate their own online stores (*e.g.*, Barnes and Noble, Merrill Lynch).

E-businesses do more than simply provide alternative shopping sites to real-world stores; they can also expand existing markets and even create new ones. Not included in the cost savings listed above are the additional value that Internet-based businesses can provide in terms of increased information and choice and time savings. These advantages make it possible for buyers and sellers to come together in significantly more efficient ways than would otherwise be possible. For example, musicfile.com serves as a clearing house where music collectors and retailers can post their out-of-print vinyl records and CDs and buyers can post their "wants". This site "is like having dozens and dozens of used record and CD stores at your finger tips."[37]

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[35]Marius Meland, "Europe: The Next Frontier," *Forbes*, March 29, 1999. (http://www.forbes.com)

[36]See *The Emerging Digital Economy Appendices*, 1998 for examples of changing cost structures in airline ticketing, banking, term life insurance, and software. (http://www.ecommerce.gov)

[37]"MUSIC; Long-Gone Releases Caught by the Web," Dean Johnson, *The Boston Herald*, May 30, 1999.

The move toward providing goods and services through a digital medium does not need to be "all or nothing." Businesses can use digital technology to augment their existing supply channels. Borders Group, Inc. announced that it will install Sprout, Inc.'s digital print-on-demand technology in its distribution center which services both Borders.com and Border stores. This new technology, which Sprout is also marketing to other book retailers and publishers, provides the ability to produce single-copies of bound paperback books, not only in distribution centers, but also at in-store production facilities after the book has been sold to the end consumer. This just-in-time production "reduces the cost of storing and shipping books for publishers and retailers, lowers the threshold for keeping slow-moving titles in print, increases the in-store exposure of titles not already on the shelf, and eliminates the risk of returns."[38]

Business-to-Business E-Commerce

Many of the same advantages that arise from retail e-commerce, hold for business-to-business e-commerce. For example, e-commerce can permit businesses to increase services they can offer their business customers. Milacron, Inc, a producer of industrial consumable products for metalworking, recently launched an e-commerce site designed to give the more than 100,000 smaller U.S. metalworking businesses an easy-to-use and secure way of selecting, purchasing, and applying Milacron's more than 50,000 metalworking products. From this new site, these small customers are provided with a level of technical service beyond that supplied previously to even Milacron's largest customers.[39]

By opening an immediate and convenient channel for communicating, exchanging, and selecting information, e-commerce is allowing firms to reconsider which functions they should perform "in-house" and which are best provided by others. The new technology has helped to create new relationships and to streamline and augment supply chain processes. As these changes are occurring, the roles of logistic and financial intermediaries (*e.g.*, FedEx, UPS, American Express) are expanding. For example, American Express offers an enhanced purchasing card which supports online purchasing by facilitating the process of placing an order, fulfillment, reconciliation, data management and program maintenance. These shifts in process can result in significant cost savings. A study completed by American Express and Ernst & Young Management Consulting estimates that an enhanced purchase card used in conjunction with an e-purchasing system can help companies streamline the purchasing process for a total savings of up to 95 percent compared with manual purchase orders.[40]

In addition, e-commerce capabilities are giving birth to entirely new classes of business intermediaries.

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[38]"Borders to Roll Out Sprout's Print-on-Demand Technology in Distribution Center," Borders Group, Inc. press release, June 1, 1999. (http://www.BordersGroupInc.com)

[39]"Milacron Launches E-Commerce Web Site for 100,000+ Smaller Metalworking Shops," Milacron news release, January 6, 1999. (http://www.milacron.com)

[40]"American Express Announces Expansion of Online Corporate Purchasing Through New Alliances and New Solution Set," American Express press release, May 25, 1999. (http://www.americanexpress.com)

Forrester Research groups the new business activities under three headings: aggregators, auctions, and exchanges. These new activities attack different inefficiencies and provide different opportunities:

- **Aggregators create a business community:** Aggregators pool supplier content to create a searchable one-stop shopping mall with predefined prices for buyers within a business community. For example, Chemdex serves this function for the buyer community of research scientists. These cyber-stores help geographically dispersed buyers and sellers find each other fast.

- **Auctions create markets and reduce sellers' losses:** Auctions pit buyers against each other to purchase seller surplus. On the Web, sellers and buyers can participate in multiple, real-time auctions simultaneously–without accruing physical-world search and travel costs.

- **Exchanges create stable online trading markets:** Like stock exchanges, online exchanges provide vetted players with a trading venue defined by clear rules, industry-wide pricing, and open market information. An online industry spot market can operate at a fraction of physical-world cost.[41]

Government Data Collection Activities

Federal statistical agencies are working to understand and measure e-commerce more effectively, but many issues remain that must be resolved. Some of the measurement issues, such as those related to the difficulty in measuring output and quality changes in services industries, are not new. Questions such as, "what is the output of a lawyer?" or "how does the existence of ATM machines improve the quality of the services banks can deliver?" have been the subject of much research. Finding solutions to the services measurement issues has taken on a new urgency, however, as the move toward a digital economy has increased the importance of these industries to the economy. Further, the digital economy is blurring definitions. Some products, such as CD's, that are now considered goods, have the potential of becoming services in the process of being downloaded. Finally, the rapid rate at which the digital economy is evolving, has businesses themselves changing faster than our ability to capture them in particular categories.[42]

In response, the Census Bureau has launched a multi-faceted initiative to deliver the first official measures of U.S. e-business; document the effects of e-business on key economic performance measures; and propose

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[41]"Anatomy of New Market Models," Varda Lief, Forrester Research, February 1999. (http://www.forrester.com)

[42]Such efforts are not limited to the United States. For other countries' discussions of the digital economy, see for example the United Kingdom's, "Our Competitive Future: Building the Knowledge Driven Economy," at http://www.dti.gov.uk/com/competitive, Australia's, "Putting Australia on the New Silk Road," at http://www.dfat.gov.au/nsr/clearway, and Canada's "The Canadian Electronic Commerce Strategy," at http://e-com.ic.gc.ca. Other nations are also confronting the difficult measurement challenges associated with the digital economy. Industry Canada, for example, has established an ambitious research agenda which includes measuring Internet connectivity, developing definitions for and indicators of e-commerce, and assessing the effectiveness of the use of information technology by government agencies.

a flexible data collection program to meet future e-business statistical needs. The Bureau will ask about the dollar value of e-commerce sales to the *Annual Survey of Retail Trade* and publish in late 2000 or early 2001, the first official U.S. data on e-commerce, covering online retail trade for the calendar years 1998 and1999.

The Bureau of Economic Analysis (BEA) has also established an action plan to develop new measures reflecting e-commerce and to take account of the effects of the digital economy on overall economic activity. BEA is focusing specifically on improving price indexes and real output measures, developing new estimates of software investment, improving its measures of output for financial and other services that are major IT-using industries, and working to strengthen estimates of capital stock to reflect the growing importance of high-tech equipment.[43]

The initiatives of both the Census Bureau and BEA include plans to work more closely with the private sector to better understand the impacts of the digital economy on process changes and output. In addition, the agencies are exploring ways to supplement their data collection efforts with data collected privately and are examining new opportunities to move to online data collection.

On a more general level, the Federal statistical agencies are in the process of shifting industry groupings from the Standard Industrial Classification (SIC) system that began 60 years ago to the new North American Industry Classification System (NAICS). NAICS adds new categories, such as the Information Sector, and classifies businesses consistently by production process. Jointly developed with Canada and Mexico, the system makes possible comparisons with these major trading partners. And the system is easily updated to reflect the changing economy. The Census Bureau's recently released *1997 Economic Census* provides the first official NAICS-based U.S. statistics.

The U.S. Government is also working with our trading partners, both individually and in various fora such as the OECD and APEC, and in discussions on the FTAA to develop appropriate and comparable indicators of the information economy and to resolve e-commerce issues relating to privacy, security, taxation, and domain names.

[43]"GDP and the Digital Economy: Keeping Up With the Changes," Brent R. Moulton, paper presented at *Understanding the Digital Economy Conference*, May 25-26, 1999. (http://www.digitaleconomy.gov) Further details on BEA's efforts are detailed in Chapter III.

CHAPTER II

INFORMATION TECHNOLOGY INDUSTRIES*

Information technology (IT) producing industries (*i.e.*, producers of computer hardware and software, communications equipment and services, and instruments) are a critical source of U.S. economic strength.[1] (Table 2.1) Between 1995 and 1998, the IT-producing industries contributed, on average, more than one-third of total real economic growth.

In addition, in both 1996 and 1997 (the last years for which detailed data are available), declining prices in IT-producing industries brought overall inflation down by 0.7 percentage points. The steep declines 7 percent declines in IT prices for both 1996 and 1997 pulled down *overall* inflation below 2 percent. This development helps to explain the remarkable ability of the U.S. economy to keep inflation at bay and interest

Table 2.1
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, nec	Retail trade of software
Magnetic and optical recording media	Computer integrated systems 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 and communications equipment	Cable and other pay TV services

*This chapter was written by David Henry, senior industry analyst, and Dennis Pastore, economist, in the Office of Business and Industrial Analysis.

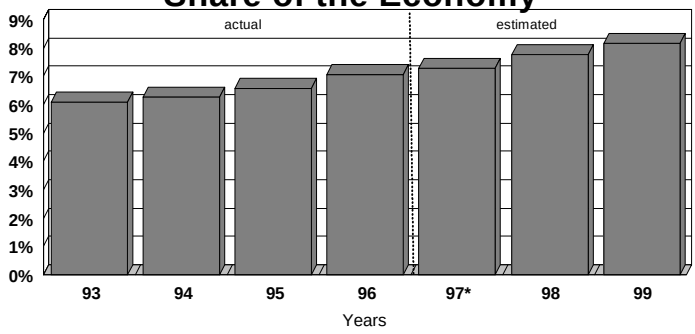
[1]IT industries are listed in Table 2.1 according to Standard Industrial Classifications. The Census Bureau has released only summary statistics for 1997 using the North American Industrial Classification System (NAICS) industry code. Industries listed in Table 2.1 are the same ones identified as IT industries in the Commerce Department's 1998 report on *The Emerging Digital Economy*.

rates low in a period of historically low peacetime unemployment. This chapter examines IT-producing industries and their contributions to economic growth, price stability, trade, and industry spending on IT equipment. (See the Appendix for the sources of data and methodologies underlying the findings in this chapter.)

IT-Producing Industries' Growing Share of the U.S. Economy

We estimate that IT-producing industries' share of the economy, in current dollars, will rise from 6 percent in 1993 to over 8 percent in 1999, following a gradual upswing which began in 1995. (Figure 2.1) The growth of these industries reflects both the surge in IT-related production of goods and services tracking the growth of the Internet since 1995, and spending by all industries to address the "Y2K" computer problem.[2]

Figure 2.1
IT-Producing Industries' Share of the Economy



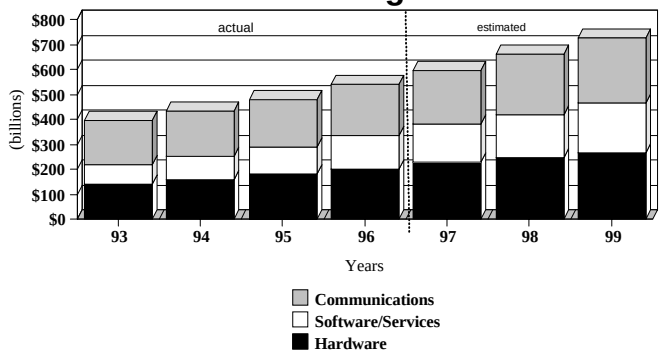
Source: ESA estimates derived from BEA and Census data for 1993-1996.
ESA estimates for 1997-1999 derived using DOC's "Industry and Trade Outlook '99"

*97 data are estimates since the Census has not yet released detailed industry data for 1997, which are needed for these calculations.

The computer services and software industries are estimated to grow an average 10.7 percent per year between 1993 and 1999. (Figure 2.2) Communications services are expected to grow by an average 4.6 percent in the same period. Hardware grew an average 14.2 percent between 1993 and 1995 and is expected to grow at a 9.9-percent rate through 1999. In contrast, the U.S. economy at large grew at a 5.0 percent rate (in current dollars) between 1993 and 1995, and at the same rate again from 1995 through the first quarter of 1999.

[2]Industry shares of nominal GDP are calculated on the basis of Gross Product Originating (GPO). These industry shares show the contribution of each private industry to GDP.

Figure 2.2
GPO Growth
in All IT-Producing Industries

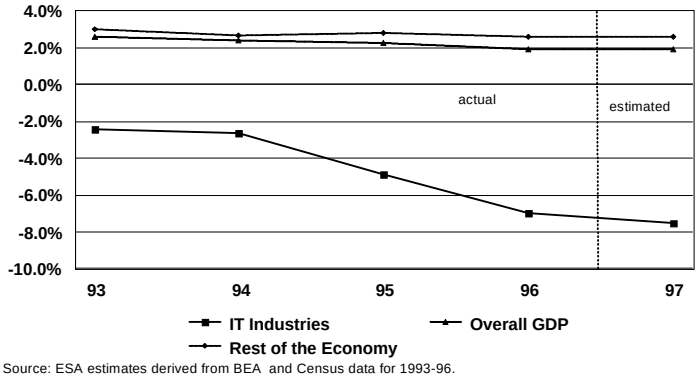


Source: ESA estimates derived from BEA and Census data for 1993-1996.
ESA estimates for 1997-1999 derived using DOC's "Industry and Trade Outlook '99."

Price Declines in IT-Producing Industries

One of the most surprising trends in recent years has been the decline in overall inflation in the context of three years of four percent GDP growth and the lowest unemployment rate in a generation. Falling prices for IT goods and services have contributed to keeping inflation in check. (Figure 2.3, Table 2.2) During both 1996 and 1997 (the last years for which detailed data are available), prices in the IT sector fell by 7 percent. As a result, overall inflation was 1.9 percent compared with the 2.6 percent inflation in the non-IT producing sector of the economy, a difference of 0.7 percentage points. But the contribution that IT makes to keeping inflation down goes beyond that 0.7 percentage points. The steep declines in IT prices in 1996 and 1997 meant that overall inflation dropped by 0.4 percentage points (from 2.3 percent and 1.9 percent) even as inflation in the non-IT producing sectors of the economy declined by 0.2 percentage points (from 2.8 percent to 2.6 percent). We know that other industries were using IT equipment and services in ways that reduced their costs, but we cannot estimate how much the use of IT contributed to lowering their inflation.

Figure 2.3
Price Changes in IT-Producing Industries
and the Rest of the Economy



Source: ESA estimates derived from BEA and Census data for 1993-96.
ESA estimate for 1997 derived using DOC's "Industry and Trade Outlook '99."

Table 2.2
Price Change:
IT-Producing and All Other Industries

	1993	1994	1995	1996	1997
			(Percent)		
IT-Producing Industries	-2.4	-2.6	-4.9	-7.0	-7.5
Rest of the Economy	3.0	2.7	2.8	2.6	2.6
GDP	2.6	2.4	2.3	1.9	1.9

Source: ESA estimates based on BEA and Census data.

Changes in GDP Accounting to Keep Up with the IT Sector

Falling prices in the IT sector and their effect on overall inflation are a boon to businesses and consumers, but they have brought headaches to economists charged with measuring or explaining inflation-adjusted (real) growth in the economy.

The basic question "How fast is the economy growing?" is relatively straightforward only if everything has the same rate of inflation or growth in output. Although that never happens in the real world, relative prices were long considered stable enough to justify a "fixed weighting" scheme for GDP accounting for five years at a stretch. The extraordinary output and price performance of the IT sector, as depicted in Figures 2.2 and 2.3, respectively, was in large part responsible for the decision by the Bureau of Economic Analysis (BEA) to revise its basic method for measuring real growth of the economy.

It was becoming clear that the assumption of relatively stable prices for five years at a stretch was distorting the picture of growth. As fixed weights were updated every five years, they brought disturbingly large revisions to real growth rates for previous years. As a result, four years ago the BEA shifted from the traditional "fixed weighting" scheme to the current "chain weighting" scheme. By incorporating recent prices, the new chain weighting method has the advantage of more accurately gauging real growth. The distortion from using old pricing can be seen by contrasting the strong 3.9 percent growth rate measured with chain weights for 1998 with the misleadingly high 6.6 percent growth rate that would have resulted if the estimates had been made using fixed weights.

The gain in accuracy from chain weighting has one important, but too little appreciated, drawback. The real dollar output measures for narrow sectors can no longer be added to give the total for a larger category. As a result, economists can no longer compute shares (such as that of the IT sector) of real output and then compare them over time. The problem created for analysts by the non-additive characteristics of chain-weighted dollars, is reflected in a May 10, 1999 *Wall Street Journal* "Outlook" article which misreports real business spending on PCs and other equipment as a percentage of real GDP, as well as in a chart in last year's *Emerging Digital Economy* report indicating the IT share of business equipment spending. Fortunately, as shown on the next page, the contribution of an individual sector to economic growth in a broader category can still be calculated.

IT Contribution to Real Growth Continues To Increase

While the share of the economy attributable to IT-producing industries grew from 6 percent in 1993 to 8 percent in 1998 in current dollars terms, this increase understates the importance of these industries because their prices are falling. A better way to gauge the importance of IT-producing industries is to look at their contribution to real growth. Over the last four years, IT industries' output has contributed more than one-third to the growth of real output for the overall economy. (Table 2.3 and Figure 2.4)

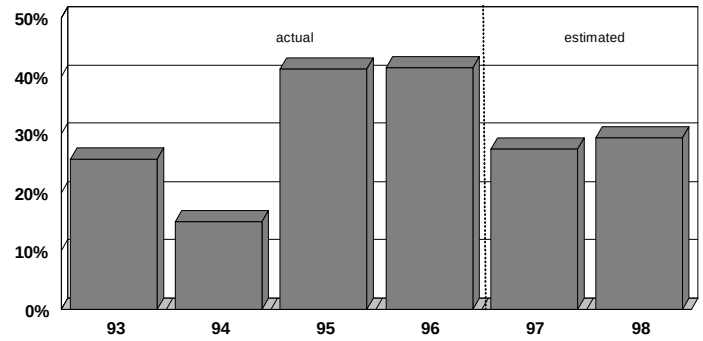
Table 2.3
IT- Producing Industries:
Contribution to Real Economic Growth

	93	94	95	96	97est	98est
(1) Change in Real			(Percent)			
Gross Domestic Income* (GDI)	2.2	4.1	2.9	3.5	4.2	4.1
			(Percentage Points)			
(2) IT Contribution	0.6	0.6	1.2	1.5	1.2	1.2
(3) All Other Industries	1.6	3.5	1.7	2.0	3.0	2.9
(4) IT Portion			(Percent)			
of GDI Change (2)÷(1)	26	15	41	42	28	29

*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.

Source: ESA estimates derived from BEA and Census data for 1993-1996.
ESA estimates for 1997-1998 derived from DOC's "Industry and Trade Outlook '99."

Figure 2.4
IT-Producing Industries: Contribution to Real Economic Growth



Source: ESA estimates derived from BEA and Census data for 1993-96.
ESA estimates for 1996-98 using DOC's "Industry and Trade Outlook '99."

The estimates above are based on inflation adjusted "income side" data, that is the incomes attributable to IT industries. To provide a check on those numbers, we can also look at "product side" numbers based on spending data for some IT products (computers, peripherals, and parts; video and audio products; telecommunications services; and cable TV). Unfortunately, to make these calculations, we must omit spending for some important goods and services, including many other electronic products, software, and computer services. On this narrower basis, the IT sector has contributed about a quarter of recent years' growth. (Table 2.4)

Table 2.4
Computers and Telecommunications:
Contribution to GDP Growth

	93	94	95	96	97	98
			(Percent)			
Computers and equipment*	12	10	26	20	18	20
Telecommunications**	4	3	5	4	3	4
Total	16	13	31	24	21	24

*Includes Computers, peripherals, and parts and Video and audio products.
**Includes cable TV
Source: BEA

U.S. Trade in IT Goods and Services

Between 1993 and 1998, IT-producing industries accounted for an increasing share of U.S. foreign trade. Combined exports and imports of goods by IT-producing industries rose 11.7 percent annually (against 8.1 percent for goods from all other industries), raising the IT-producers' claim on the nation's $1.5 trillion commodity trade flow from 16 to 19 percent.[3] Exports and imports of services by IT-producing industries grew even faster, raising the IT share of U.S. trade in private services to just over 5 percent.

Goods Trade

Between 1993 and 1998, exports of goods by IT-producing industries registered 11.9 percent annual growth (against 7.6 percent for all other types of goods). U.S. firms have continued to make a strong showing in the high-end segments of the IT product market--*e.g.*, computers, semiconductor devices, and instruments. IT goods imports rose at about the same rate as exports.

Increases in both exports and imports raised the negative balance in goods trade by IT-producing industries from $33 billion in 1993 to $55 billion in 1998. Census data indicate that as much as one-half of the "exports" and "imports" of IT equipment actually represent sales between related parties, in effect, intra-company and intra-group transfers.

Services Trade

Between 1993 and 1997, exports and imports of services from IT-producing industries grew at 13.2 percent per year (compared with 8.5 percent for other private services), reaching $20.7 billion in 1997.[4] With exports of IT services increasing at 17.2 percent per year between 1993 and 1997 compared with 9.5 percent for imports, the long-term prospect for surpluses seems good.

The faster growing component of this services trade, computer-related services (including sales and purchases of computer and data processing services, data base and other information services, as well as income generated from software royalties and license fees) increased at more than 25 percent per year, almost two and

[3]Commodity trade measured on Census basis.

[4]Trade in private services measured on balance of payments basis. Total trade in private services equaled $395 billion in 1997, the last full year for which data on services trade are available.

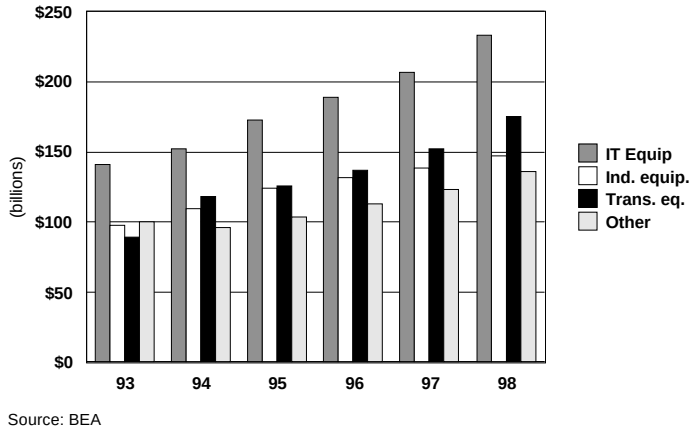
a half times the average rate of growth in services trade overall. Computer-related services accounted for 41 percent of the nation's trade in IT services by 1997, a substantial rise from just over 27 percent in 1993. This component of IT services has achieved trade surpluses averaging $4.2 billion per year from 1993 through 1997. In contrast, trade in telecommunications services, the other segment of IT services, expanded more slowly and generated average deficits of $4.2 billion per year.

Not captured in the trade figures are substantial sales of computer services abroad by majority owned foreign affiliates of U.S. companies. These exceeded $28 billion in 1996, with sales by suppliers of computer and data processing services increasing at about 30 percent per year.

Industry Use of IT Equipment

IT equipment continues to be the largest category of industry spending for all types of capital equipment—*i.e.*, producers' durable equipment (PDE). In current dollars, industry spending on IT equipment rose from $142 billion in 1993 to $233 billion in 1998 and has consistently accounted for about one-third of all such spending. (Figure 2.5)

Figure 2.5
Industry Spending on IT Equipment in the 1990s (Current $)



Source: BEA

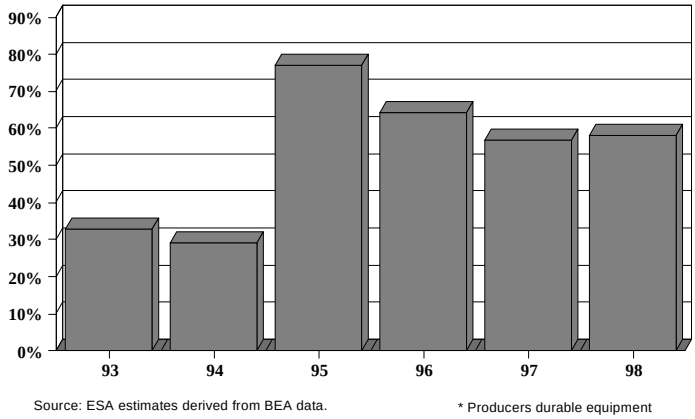
Between 1993 and 1998, prices of IT equipment declined relative to prices of the other types of capital equipment. In inflation adjusted terms, spending on IT equipment contributed more than *half* of the growth in equipment spending. (Table 2.5 and Figure 2.6)

Table 2.5
Contribution of IT Equipment*
to Growth in Capital Equipment**

	93	94	95	96	97	98
(1) Change in real spending for capital equipment	10.5	11.0	11.5	10.9	12.1	16.5
	(Percent)					
(2) Contribution of real spending for IT equipment	3.5	3.8	6.9	6.9	6.8	9.6
(3) Contribution of real spending for all other types of capital equipment	7.0	7.2	4.6	4.0	5.3	6.9
(4) IT's contribution to change in real capital equipment spending	33	35	60	63	56	58
	(Percentage Points)					
	(Percent)					

Source: ESA estimates derived from BEA data.
* Defined by BEA as Information processing and related equipment.
** Producers durable equipment

Figure 2.6
Contribution of IT Equipment
to Growth in Capital Equipment*



Chapter III

CONTRIBUTION OF INFORMATION TECHNOLOGY TO GROSS PRODUCT ORIGINATING PER WORKER *

Information technology (IT) industries have been the digital era's engines of economic transformation. In IT-*producing* goods industries especially, the rate of increase in gross product originating, or value added, per worker (GPO/W) has been extraordinarily rapid.[1]

Economists have been puzzled, however, because measured GPO/W growth in many IT-*using* industries—especially IT-using service industries which dominate this group—has declined despite massive IT investments. Observers have long suspected that this apparent paradox was due partly to a lag in productive applications of the new technologies and partly to problems of measurement. Accumulating case evidence and years of unprecedented U.S. economic strength have begun to suggest that this analysis is right.[2]

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

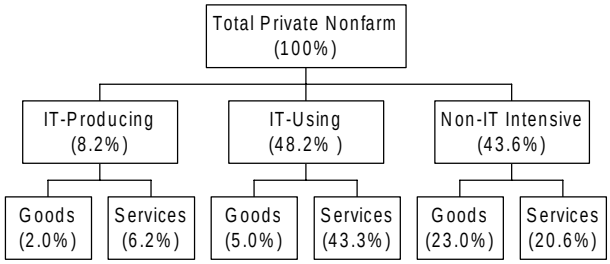
[1]According to the Bureau of Economic Analysis (BEA), "Gross product, or gross product originating (GPO), by industry is the contribution of each private industry and government to gross domestic product (GDP). An industry's GPO, often referred to as its 'value added,' is equal to its gross output (sales or receipts and other operating income, commodity taxes, and inventory change) minus its intermediate inputs (consumption of goods and services purchased from other industries or imported)."

The contributions of IT-producing industries to the economy's overall output and inflation performance are explored in Chapter II of this report. The labor productivity measure of GPO/W differs from the "output per worker" and "output per hour" measures used by the Department of Labor's Bureau of Labor Statistics (BLS) which do not net out intermediate inputs. Available data on GPO by industry and employment permit comparisons of growth rates of GPO/W among IT industry groups. However, BLS does not compute labor productivity statistics that correspond exactly to the industry groups defined in this report. Of course, a more complete analysis of productivity would examine the relationship of output by industry not just to labor input but to other inputs as well. Nevertheless, this partial analysis of the relationships to labor input provides sufficiently revealing insights to merit presentation.

[2]Nobel Laureate Robert Solow sparked initial interest in the productivity paradox in 1987 with the observation that "You can see the computer age everywhere but in the productivity statistics." See Robert M. Solow, "We'd Better Watch Out," *New York Times Book Review*, July 12, 1987, p. 36. More recently, Solow has acknowledged that: "My beliefs are shifting on this subject.... I am still far from certain, but the story always was that it took a long time for people to use information technology and truly become more efficient. That story sounds a lot more convincing today than it did a year or two ago." These remarks are reported by Steve Lohr, "Computer Age Gains Respect of Economists," *The New York Times*, April 14, 1999. Similarly, in a recent wide-ranging review of IT's positive influence on the economy, Federal Reserve Board Chairman Alan Greenspan observed that "the evidence for technology-driven acceleration in productivity is compelling, but not conclusive." His remarks were made at *The American Economy in a World Context*, 35th Annual Conference on Bank Structure and Competition of the Federal Reserve Bank of Chicago, May 6, 1999.

This chapter evaluates the impacts of information technology by comparing trends in growth rates of GPO/W in the total private nonfarm economy and across three major industry groups defined as IT-producing, IT-using, and non-IT intensive.[3] IT-producing industries have been defined and listed in Chapter II of this report. IT-using industries are defined below. Non-IT intensive industries are those which are considered neither IT-producing nor IT-using. In the following analysis, these three groups are further divided into either goods producing or service producing industries, as shown in Figure 3.1.

Figure 3.1
Selected Industry Groups
And Their Share of Total Private Nonfarm GPO*



*Average nominal share 1990 to 1997.
Source: BEA's Nominal GPO by Industry.

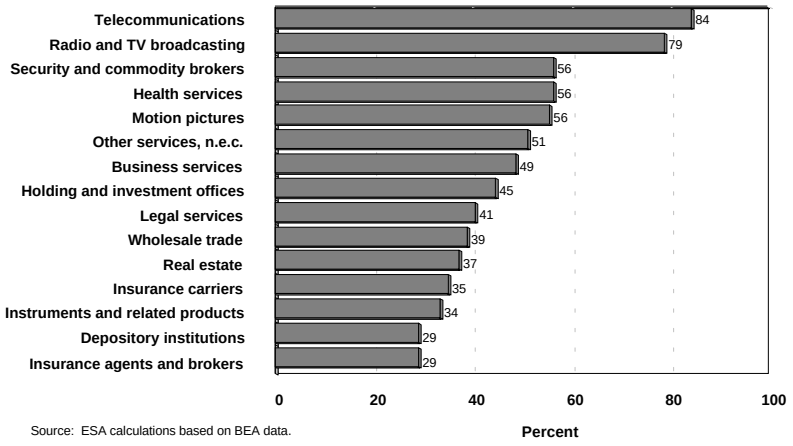
IT-Using Industries

This study recognizes industries as IT-using if they are among the top 15 industries in relation to either of two measures: IT capital stock as a share of total equipment stock (net of depreciation), or IT investment per employee. Figure 3.2 lists the top industries by IT share of equipment stock (1996). In 6 cases (Telecommunications, Radio and TV broadcasting, Security and commodity brokers, Health services, Motion pictures and Other services, n.e.c.), the IT equipment share exceeded half of the industry's equipment stock.

Figure 3.3 lists the top 15 industries in terms of IT investment per worker. The top 4 industries (Telecommunications, Nondepository institutions, Pipelines, except natural gas, and Radio and TV broadcasting) in this ranking, invested over $17,500 in IT equipment per employee. Several industries rank in the top 15 by both measures, with the Telecommunications industry ranking first in both cases.

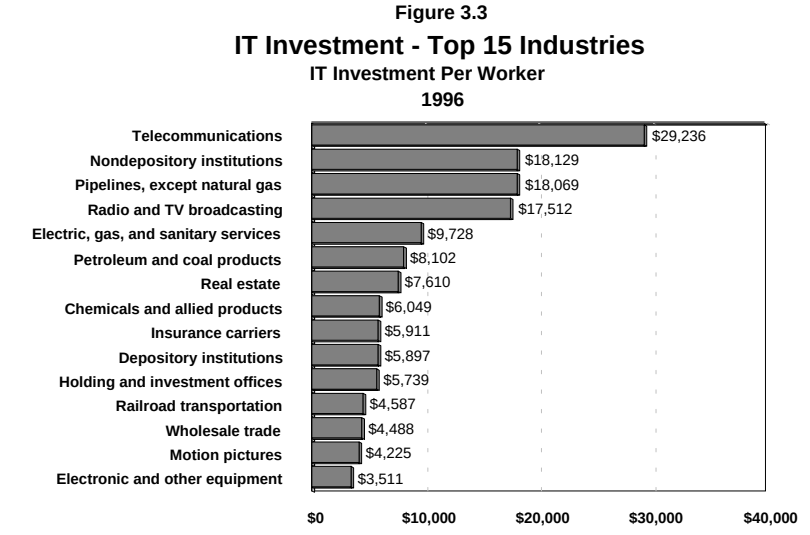
[3]In this chapter, nonfarm product equals gross domestic business product less gross farm product. Gross domestic business product equals gross domestic product less gross product of households and institutions and of general government.

Figure 3.2



Source: ESA calculations based on BEA data.

Figure 3.3



Source: ESA calculations based on BEA data.

Table 3.1 provides a consolidated list of IT-using industries.[4] Parts or all of some of these industries such as Telecommunications and Radio and TV broadcasting have also been identified in this report as IT-producing industries. Because of this overlap, the computations of GPO/W (presented below) net out the GPO and workers corresponding to the IT-producing components to avoid double-counting. Of the 22 industries listed in the table, 4 are manufacturing or goods-producing industries (Instruments and related products, Chemicals and allied products, Petroleum and coal products, and Electronic equipment) and the remaining 18 are service industries.

Table 3.1
Industries Considered Major Users of IT Equipment

Telecommunications	Security and commodity brokers
Radio and TV broadcasting	Business services
Other services, nec	Health services
Motion pictures	Holding and investment offices
Legal services	Wholesale trade
Insurance carriers	Real estate
Instruments and related products	Insurance agents and brokers
Depository institutions	Nondepository institutions
Pipelines, except natural gas	Petroleum and coal products
Chemicals and allied products	Electronic equipment

Growth of GPO/W in IT-Producing Goods Industries

IT industries have achieved extraordinary gains in GPO/W. During 1990 to 1997, IT-producing industries experienced robust 10.4 percent average annual growth in GPO/W. In the goods-producing subgroup of the IT-producing sector, GPO/W grew at the extraordinary rate of 23.9 percent. As a result, GPO/W for the total private nonfarm economy rose at a 1.4 percent rate, despite slow 0.5 percent growth in all non-IT producing industries. (Table 3.2 and Figure 3.4) Part of the explanation for the rapid rise of GPO/W in IT-producing goods industries is that this group includes computers and related equipment producers, and semiconductor manufacturers that have been hotbeds of invention and innovation. The computer and semiconductor industries registered annual GPO/W growth rates of 30.0 percent and 47.5 percent, respectively, over the 1990 to 1997 period.

The above result is roughly consistent with the common empirical finding from IT productivity studies that IT has made positive contribution to overall output growth and modest GPO/W growth. One explanation for the modest total private nonfarm GPO/W growth is that, despite rapid growth in the nation's IT equipment stock between 1990 and 1997, IT equipment still represented a relatively small share (7.9 percent of the

[4]Some industries that fail to meet the criteria employed here to identify major users of IT are nonetheless major markets for IT equipment. The retail trade industry is one example. The retail trade industry ranks 13th in terms of its IT net capital equipment stock, but since this industry has a large overall equipment stock, the share of IT equipment ranks only 28th. In terms of annual (1996) IT investment, the retail trade industry ranks 10th. However, since this industry has a relatively large workforce, its annual investment per employee ranks 45th.

Table 3.2

Gross Product Originating Per Worker in IT-Producing, IT-Using, and Non-IT Intensive Industries*

Industry Group	SIC	Annual Growth Rate from 1990 to 1997 (%)
Total Private Nonfarm		**1.4**
IT-Producing		**10.4**
Goods		23.9
Services		5.8
IT-Using		**-0.1**
Goods		2.4
Services		-0.3
Non-IT Intensive**		**1.1**
Goods		1.3
Services		1.3
All Industries Other Than IT-Producing		**0.5**
Illustrative IT-Producing Industries		
Semiconductors	3674	47.5
Computers & equipment wholesalers	5045pt.***	33.9
Computers & related equipment	357125789	30
Magnetic & optical recording media	3695	13.2
Telephone & telegraph equipment	3661	12.6
Electron tubes	3671	9.5
Radio broadcasting	4832	4.3
Passive electronic components & printed circuit boards	3672,5-9	3.6
Telephone & telegraph communications	48129	3.3
Household audio & video equipment	3651	3.2
Cable & other pay TV services	4841	2.9
Instruments for measuring electricity	3825	1.3
Television broadcasting	4833	0.3
Computers & equipment retailers	5734pt.***	-0.5
Analytical instruments	3826	-2.2
Industrial instruments for measurement	3823	-2.8

*See Appendix Table for levels.

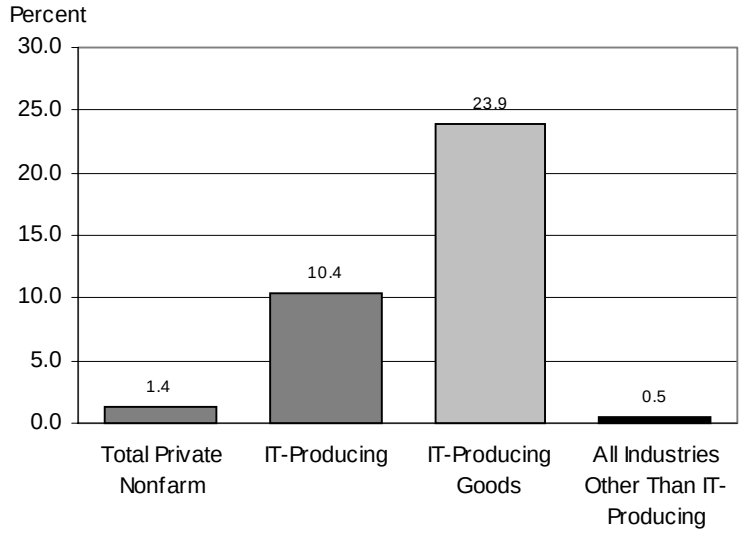
**Neither IT-producing nor IT-using

***Pt. signifies part of the industry.

Source: Derived from GPO and employment data compiled in Chapters II and IV of this report.

total nominal net stock of capital.[5] A complementary explanation is that while the total net capital stock, including structures, has been growing at an average annual rate of 2.3 percent, total private sector employment has risen 1.8 percent annually. That is, the overall capital/labor ratio has risen at a rate of 0.5 percent per year, which remains low relative to periods when labor productivity was rising more rapidly.

Figure 3.4
Average Annual GPO/W Growth Rates
(1990-97)



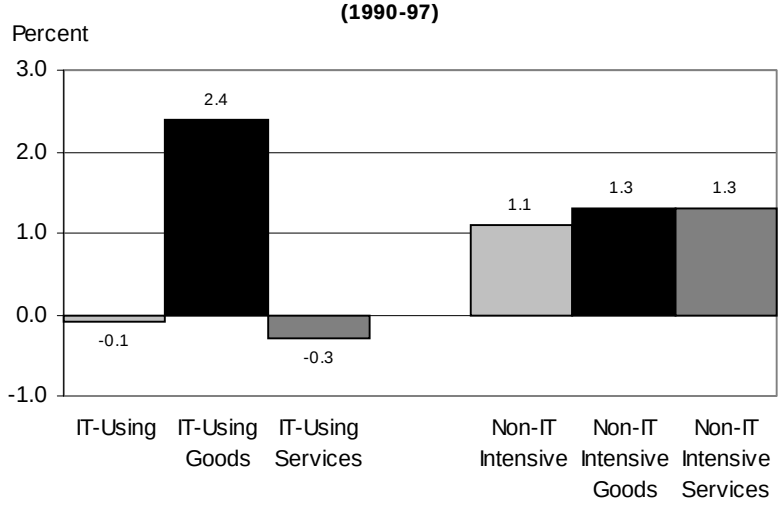
Source: OBIA calculations based on BEA GPO data from Chapter II and BLS employment data from Chapter IV.

[5]IT equipment includes office, computing, and accounting machinery (OCAM), in addition to communications equipment; instruments; and photocopy and related equipment. The narrower OCAM category of equipment has grown at a faster 21.5 percent per year rate between 1990 and 1997 but constituted on average an even smaller (1.6 percent) share of total nominal net capital stock in the total private nonfarm economy.

GPO/W in IT-Using and Non-IT Intensive Industries

In contrast to IT-producing industries, IT-using industries' GPO/W *declined* at a 0.1 percent rate, on average, over the 1990 to 1997 period.[6] (Figure 3.5) Within this group, however, performance was mixed. The IT-using goods subgroup, for example, showed a fairly robust average annual growth rate of 2.4 percent. Industries in this subgroup include: chemicals and allied products (SIC 28); petroleum and coal products (SIC 29); electronic equipment (part of SIC 36); and instruments (part of SIC 38). The GPO/W growth rate in these industries appears to derive its strength largely from the direct substitution of IT equipment for labor and other inputs in a period of rapidly falling IT prices.[7]

Figure 3.5
Average Annual GPO/W Growth Rates in IT-Using and Non-IT Intensive Industries
(1990-97)



Source: OBIA calculations based on BEA GPO and BLS employment data compiled for this report.

[6]Economists have struggled, especially in recent years, to account for the effects of large IT investments on service industry productivity growth. Jack E. Triplett, "Economic Statistics, the New Economy, and the Productivity Slowdown," *Business Economics* (April 1999), pp. 13-17, noted that IT investments are heavily concentrated in computer-using industries that are largely providers of *services*. However, most of these services produce intermediate, not final, outputs that do not affect aggregate productivity measures. As a result, even if productivity growth has been very rapid in the computer-using service industries, this growth cannot affect aggregate productivity directly because the contribution of intermediate products cancels out in the end in computing aggregate productivity. Therefore, to understand the role of IT in productivity, Triplett concludes that research should examine the impact of IT at the *industry level*. Moreover, because of the concentration of IT investments in industries that produce intermediate outputs, the examination should also look at productivity in the downstream industries that use these intermediate outputs.

[7]Kevin Stiroh, "Computers, Productivity, and Input Substitution," *Economic Inquiry*, 36 (1998), 175-191, confirms this inference. Dale Jorgenson and Kevin Stiroh, "Information Technology and Growth," *American Economic Review*, May 1999, (*Papers and Proceedings)*, 89(2), arrive at broadly the same conclusion. Their assessment is that the benefits

Figure 3.5 also shows that, among goods industries, those that make more intensive use of IT inputs had faster improvements in GPO/W than that of non-IT intensive industries. However, there are different and puzzling results among services industries. Those service industries making more intensive use of IT inputs appear to have had worse results than other service industries. In fact, over the 1990 to 1997 period, estimated GPO/W for IT-using service industries declined at an average annual rate of 0.3 percent despite strong investment in IT.

Table 3.3 shows that within the IT-using industries subgroup, eight IT-using service industries had positive average GPO/W growth rates ranging from 0.1 percent for "nondepository institutions" to 11.0 percent for "security and commodity brokers." The performance of these industries is broadly consistent with expectations. However, the bottom seven industries in Table 3.3 had negative growth in GPO/W ranging

Table 3.3

GPO/W in IT-Using Service Industries[8]

IT-Using Service Industry	SIC	Average Annual Growth Rate (%) 1990-97
Security & commodity brokers	62	11
Railroad transportation	40	9.2
Pipelines, exc. natural gas	46	9
Electric, gas, & sanitary services	49	4.4
Insurance carriers	63	3.5
Wholesale trade, less IT-producing	50,51pt.*	1.5
Real estate, less nonfarm housing	65	0.2
Nondepository institutions	61	0.1
Other services	83-87,89	0
Depository institutions	60	-0.1
Holding & other investment offices	67	-0.2
Insurance agents	64	-0.5
Legal services	81	-1.3
Motion pictures	78	-1.6
Health services	80	-2.2
Business services, less IT-producing	73pt.*	-2.6

*Pt. signifies part of the industry.

Source: OBIA calculations derived from BEA GPO and BLS employment data compiled for this report.

of IT are appropriated by the investing firms and industries, and show up directly in improvements in labor productivity and the MFP growth in IT-using industries is not much affected.

[8]Two IT-using service industries (Telecommunications and Radio and TV broadcasting), out of the 18 listed earlier in Table 3.1, are excluded from Table 3.3 because they have been categorized as IT-producing industries in Chapter II.

from (-2.6) percent for "business services" to (-0.1) percent for "depository institutions" (banks and thrifts). An important reason for the declining GPO/W of the IT-using group is that this group is dominated by service industries, many of which are notorious for the difficulty in conceptualizing and measuring their outputs.[9]

Depository institutions (SIC 60), one of the larger service industries intensively using IT inputs, provides a good case in point. This industry has been bringing new and better services to customers through the innovative use of IT inputs for ATM machines, telephone banking, and online transactions. At the same time, its employment has been declining. The industry's relatively strong profitability lends further support to the supposition that it is efficiently providing valuable new products for the market. Yet, the available numbers for the industry indicate that its GPO/W declined from 1990 to 1997. The measurement problems that may account for this anomaly are further discussed in the final section of this chapter.

IT-Producing Goods Industries Also Contribute Significantly to Multifactor Productivity Growth

A change in multifactor productivity (MFP) reflects the change in output that is over and above that accounted for by the change in combined inputs of labor, capital, and intermediate inputs.[10] While MFP reflects many influences, it is generally believed that technological change is one of the primary contributors. The information technology revolution has been widely faulted for having failed to generate broad-based MFP improvement. However, IT-producing industries—as opposed to IT-using industries, where the lack of a broad-based MFP improvement is a puzzle—play a conspicuous role in the nation's overall productivity performance as evidenced by BLS numbers.

Available data do not allow direct estimation of MFP growth for the IT-producing group of industries. However, recent BLS estimates (which are published at the two-digit SIC level for manufacturing industries only) show that industrial machinery and equipment (SIC 35) and electronic and other electric equipment (SIC 36)—the two-digit industries of which computers, semiconductors, and related equipment are a small part—exhibit the highest rates of MFP growth among manufacturing industries. Between 1990 and 1996, electronic and other electric equipment (SIC 36)—which includes semiconductors, electron tubes, and passive electronic components, *etc*. —ranked highest in MFP growth within the manufacturing sector, with an 8.9 percent average annual growth rate. Industrial machinery and equipment (SIC 35)—which includes computers and related equipment—ranked second highest, with a 4.6 percent MFP growth rate.

The performance of these industries, driven by their IT-producing subcomponents, is especially impressive when considered in relation to the MFP growth rate of only 1.7 percent found by the Bureau of Labor

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[9]Z. Griliches, "Productivity, R&D, and the Data Constraint," *American Economic Review*, Vol. 84, No. 1, (1984), pp. 1-23.

[10]In contrast, a change in labor productivity reflects a change in output that is over and above that accounted for by the change in hours of all persons/workers engaged in production. See Bureau of Labor Statistics, "Multifactor Productivity Trends, 1997," February 11, 1999.

Statistics for manufacturing as a whole.[11] The manufacturing MFP growth rate would have been much lower without the two industries encompassing the IT-producing goods industries.

Measuring Service Industry Performance

Some of the challenges posed in measuring the emerging digital economy are illustrated in the analysis of GPO/W by industry presented in this report. One might expect that industries making more intensive use of IT inputs have thereby substantially raised the value of their own output per worker. Yet, the available data suggest otherwise. Massive IT investments by many U.S. service industries during the 1980s appeared to have yielded few, if any, measured gains in GPO/W.[12]

Explanations for this "productivity paradox" have focused partly on a range of measurement issues. Performance measurement in service industries, such as the banking and thrift industry, poses several particularly vexing problems on both the output and input sides. On the output side, it is difficult to identify generally acceptable units of an industry's output and then to quantify the rapid qualitative changes. Compared with manufactures and other goods, many service outputs are hard to define and even harder to measure, in part because of the heterogeneity of their outputs.[13] For example, services delivered to intermediate or final users may be bundled inseparably with other goods or services (*e.g.*, by institutions providing multiple financial services or retailers whose marked-up prices cover overhead and marketing as well as product costs). For some key industries, BEA's current method of computing GPO by industry

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[11]This finding of a high MFP growth rate among IT-producing industries is consistent with Stiroh's finding (see footnote 7) that: "The computer-producing sector shows strong multifactor productivity growth that reflects the fundamental technological progress behind the computer revolution. Although aggregate multifactor productivity growth is low, the computer-producing sector made a substantial contribution to its modest revival in the 1980s."

[12]A number of studies, indeed, have reported negative correlation between IT investment and productivity growth in service industries. For a discussion of these findings, see E. Brynjolfsson (1993) "The Productivity Paradox of Information Technology: A Review and Assessment, "*Communications of the ACM*, Vol. 36, No. 12, pp. 66-77. Several recent studies, however, suggest that IT investments have begun to generate significant productivity returns. For example, Brynjolfsson and Hitt using data from a variety of sources to estimate production functions for 380 large firms, estimate productivity returns to investment at 50 percent for manufacturing firms and 60 percent for service firms, with two- to three-year lags. E. Brynjolfsson and L. Hitt (1993), "Is Information Systems Spending Productive? New Evidence and Results, "International Conference on Information Systems, Orlando, FL. See also J.B. Quinn and M.N. Baily (1994), "Information Technology: Increasing Productivity in Services," *Academy of Management Executive*, Vol. 8, No. 3, pp. 28-51; and S. Roach (March 1995), *America's Productivity Revolution*, Special Economic Study M9, Testimony to the House Budget Committee.

[13]M. K. Sherwood, "Difficulties in the Measurement of Service Outputs," *Monthly Labor Review* (March 1994), discusses these issues and other sources of difficulty in measuring service outputs. He notes that in the case of services meant to produce some changes in recipients, it is not always clear where the value resides. For example, when a doctor gives medical advice, the patient can expect a bill whether or not he gets well. T. M. Stanback and T. Noyelle, "Productivity in Services: A Valid Measure of Performance?," *Skills, Wages, and Productivity in the Service Sector* (Westview Press, San Francisco, 1990), discuss the problems of defining units of intermediate services (e.g., legal, engineering, advertising services) tailored to the requirements of the purchasing firms. They observe that the true productivity of intermediate service providers lies in solving customer's problems rather than in increasing the volume of their business (e.g., billable hours) per unit of output.

estimates changes in the industry's output by making a linear extrapolation of labor input. By construction, this puts a tight upper bound on GPO/W growth.

Netting out the value of inputs for a gross product originating measure presents another daunting challenge. The banking and thrift industry may well have made more effective use of IT inputs than some other industries. If so, should that industry not also share in the credit for originating gross product? Using gross product originating tends to give more credit to the IT-producing industries and less to the IT-using industries that make better use of IT inputs.

The problems of mismeasured service sector output are mitigated, however, by taking account of the fact that many of these industries (*e.g.*, business services, legal services, accounting services) are producing intermediate services that are sold to other businesses. To the extent that intermediate purchases are mismeasured, the error affects the allocation of output among industries—that is, too little output growth may be attributed to the service sector and too much may be attributed to manufacturing. The gross domestic product is affected by service sector mismeasurement only to the extent that their output represents deliveries to final demand, e.g., consumption by households and government, investment or net exports.

In carrying out its strategic plan, BEA has been conducting conceptual work on improving its measures of banking and other difficult-to-measure goods and services. Later this year BEA plans to introduce an improved measure of real banking services that will better reflect the impact of information technology. For several years BLS has been engaged in a multi-year effort to expand the producer price index to cover the service sector. This work has led to significant advances in defining output concepts for important services industries. BEA is improving its gross product originating data to expand coverage and incorporate these and other improved price measures. BLS, BEA, and the Census Bureau have participated in recent research seminars sponsored by the Brookings Institution on important IT-using service sector industries, such as insurance, business services, and other financial services.[14] While measurement issues abound, the statistical agencies consider improvement of service sector measurement to be an important priority and are making progress in solving many of the difficult problems.

[14]Edwin R. Dean, "The Accuracy of the BLS Productivity Measures," *Monthly Labor Review* (February 1999), pp. 24-34, describes additional efforts in this direction involving the above government statistical agencies in cooperation with the National Bureau of Economic Research and the Brookings Institution. See also the related papers by L.P. Eldridge, "How Price Indexes Affect BLS Productivity Measures," *Monthly Labor Review* (February 1999), pp. 35-45 and William Gullickson and Michael J. Harper, "Possible Measurement Bias in Aggregate Productivity Growth," *Monthly Labor Review* (February 1999) pp. 47-67.

CHAPTER IV

LABOR MARKETS IN THE DIGITAL ECONOMY*

The diffusion of information technologies (IT) and growth in electronic commerce have affected the way businesses operate, forcing them to adopt flexible organizations and generating operational efficiencies. Small businesses are competing globally and multinationals are expanding their global operations. Increased competition, global access and organizational change are affecting labor markets by influencing employment demand, wages and skill requirements.

This chapter examines trends in employment demand, wages and skill requirements in information technology industries. It finds increasing employment demand in IT industries, accompanied by rising wages and skill requirements. By 2006, almost half (49 percent) of the private workforce will be employed either by industries that produce IT equipment or services or by industries that are heavy users of IT equipment or services, up from 44 percent in 1989. Expanding Internet usage and electronic commerce are contributing to increased demand for "core" IT workers (computer scientists, engineers, programmers and systems analysts) but are also generating new IT occupations, changing skill requirements for some non-IT occupations and raising the minimum skill requirements for many lower skilled jobs.

As skill requirements have risen, so have wages paid to IT workers. The wage gap between IT workers and all other workers continues to widen. In 1997, workers employed in IT-producing industries earned $53,000 compared with the economy-wide average of $30,000. Labor markets are beginning to respond. A significant and growing training infrastructure is emerging to train workers for low to medium skill IT jobs – for example, through community colleges and proprietary training and certification programs. At the high end, enrollment in U.S. four-year computer science programs has doubled in the past three years. Additionally, government, business and education have begun a number of joint initiatives to help increase the supply of IT workers.

This analysis also finds evidence of a "churning" effect of employment gains and losses among IT industries and occupations. The same innovations in computing and telecommunications technologies that are rapidly creating jobs in some industries are causing jobs to be lost in other industries. New occupations are being created while others are being redefined. This has increased the need for continuing education and worker retraining. Workers today are finding that they must be "multi-skilled" and commit to a lifetime of learning and retraining in order to remain flexible in rapidly changing labor markets.

The first half of this chapter evaluates statistical evidence of the effects of IT on industry-level employment, wages and skill requirements. The second half focuses on existing labor market imbalances and provides examples of how the government and the private sector are responding.

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*This chapter was written by Sandra Cooke, economist in the Office of Business and Industrial Analysis and Patricia Buckley, senior policy advisor in the Office of Policy Development.

Employment and Wages in IT Industries and Occupations

Employment in Information Technology Industries [1]

Employment growth in IT-producing industries continues to outpace average employment growth. From 1989 to 1997, employment in IT-producing industries grew 2.4 percent annually compared with the 1.7 percent annual rate of growth for all private industries. (Appendix Table 4.1) However, just since 1996, IT-producing industries added 350,000 jobs, a one year increase of 7.7 percent (to 4.8 million) compared with average employment growth of about 3 percent. Among the four IT-producing industry groups, software and services is the fastest growing group (8.3 percent annually) and is now the largest (1.43 million workers), slightly surpassing communications services with 1.42 million workers. Hardware industries have experienced only slight employment gains despite some high-growth sub-industries, and the communications equipment subgroup actually lost jobs.

In IT-producing industries, technological advances and e-commerce are causing both job creation and destruction. This "churning" effect occurs as demand increases even as technology renders some processes and equipment obsolete, as technology is directly substituted for labor, or as technology complements labor, allowing fewer workers to maintain the same level of output. IT sub-industries that produce computer hardware and communications equipment have lost jobs as technological changes have automated some processes. The trend away from mainframe-oriented processing to network-based, client-server computing has redistributed some computer equipment manufacturing jobs. Increased outsourcing is reflected in increased employment in IT-producing industries that provide computer maintenance and other support services. However, some industries that cut jobs early in the 1990s have started adding jobs in the last couple of years.

Aggregate employment growth by IT-producing industries should continue to outpace average employment growth. The Bureau of Labor Statistics (BLS) projects that by 2006 employment in IT-producing industries will reach almost six million workers.[2] (Figure 4.1) Software and services will again lead the other IT-producing industry groups in employment growth, almost doubling employment during the 10-year period, to more than 2.5 million workers.

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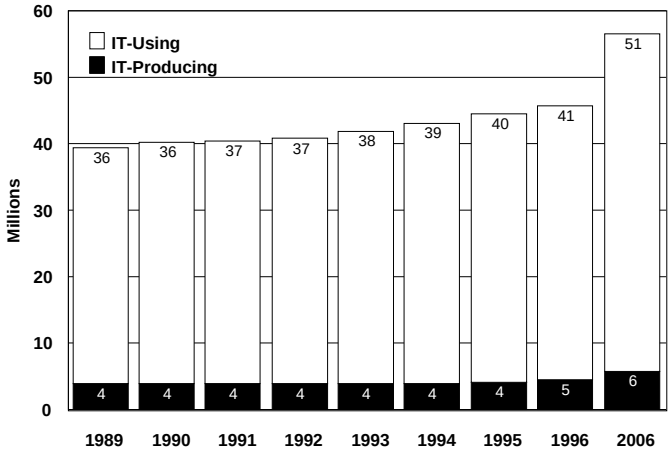
[1]As explained in Chapter III, IT industries consist of IT-producing and IT-using industries. Any reference in this chapter to "IT industries" includes both IT-producing and IT-using industries.

[2]The Bureau of Labor Statistics (BLS) is the source of all employment and wage data used in this chapter. BLS projections of employment by industry and by occupation are estimated bi-annually and were last produced for the 1996-2006 time frame. Employment estimates are available by industry and by occupation for 1997; however, they are not directly comparable to the 1996-2006 estimates and, therefore, comparing rates of change in employment levels from 1997 to 2006 would give misleading results. Consequently, this analysis discusses industry employment change from either 1989 to 1997 or 1996 to 2006.

IT-using industries employed almost 43 million workers in 1997, most of which were in the wholesale trade, financial, business, and health services sub-industries.[3] (Appendix Table 4.2) While on average, employment in IT-using industries has not grown as fast as that of IT-producing industries, the IT-using industries have consistently contributed 40 to 50 percent to annual employment growth since 1992.

From 1996 to 2006, the IT-using share of total employment will increase from 41 to 44 percent of the nation's private workforce and employment will grow from 41 to 51 million workers. (Figure 4.1) When combined with the projected increase in employment demand by IT-producing industries, these two groups will employ *almost half* of the domestic private workforce by 2006. (Appendix Table 4.2)

Figure 4.1
Employment in IT-Producing and IT-Using Industries
(1989 to 1996 and 2006)

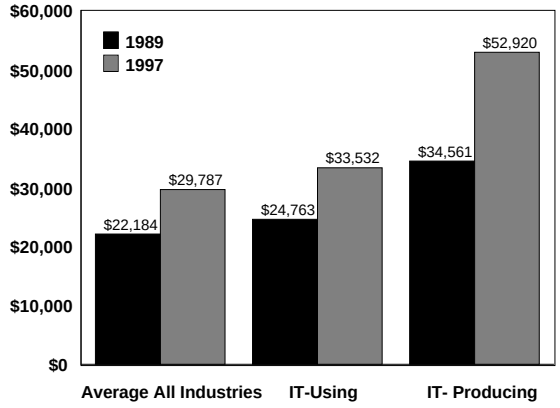


Source: ESA estimates based on BLS data.

Earnings of IT Workers

The gap in wages paid by IT-producing industries and the average for all industries continues to widen--up $2,000 between 1996 and 1997. Workers in IT-producing industries earned almost $53,000 in 1997, compared with about $30,000 for all private employees. (Figure 4.2) In 1997, earnings per worker in *every* IT-producing industry exceeded the national average. (Appendix Table 4.3)

Figure 4.2
IT Industries Pay Higher Than Average Wages



Source: ESA estimates based on BLS data.

[3]Heavy users of IT equipment (defined in Chapter III) include producers of chemicals, petroleum products, electronic and other electric equipment and instruments and related products and providers of services including motion pictures, railroad transportation, pipelines, exc. natural gas, electric, gas and sanitary, wholesale trade, finance, insurance, real estate, business, health, legal and other services, n.e.c.

Among workers in IT-producing industries, the software and services industries earned the highest annual wages, almost $59,000. This group also had the fastest increase in annual wages–6.4 percent per year since 1989. Average earnings per worker in the other major IT industry groups ranged from about $48,000 to $53,000 per year.

Overall, IT-using industries pay wages that are 12.6 percent higher than the average for all industries, $33,500. (Figure 4.2) Within this group, annual wages per worker are highest among the securities and commodities brokerages ($113,000) and holding/investment companies ($71,000) and lowest among business services, other services, n.e.c., and real estate, all with annual wages less than $30,000.[4] (Appendix Table 4.4)

Employment and Education Requirements of IT Occupations

IT workers are needed throughout the economy to design, manufacture, operate, repair and maintain IT equipment and services. Therefore, this analysis broadly defines IT occupations to include not only "core" IT occupations (computer scientists, engineers, systems analysts and programmers), but also workers in occupations responsible for operating and maintaining the IT infrastructure.[5] (Table 4.1)

Table 4.1
IT-Related Occupations

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

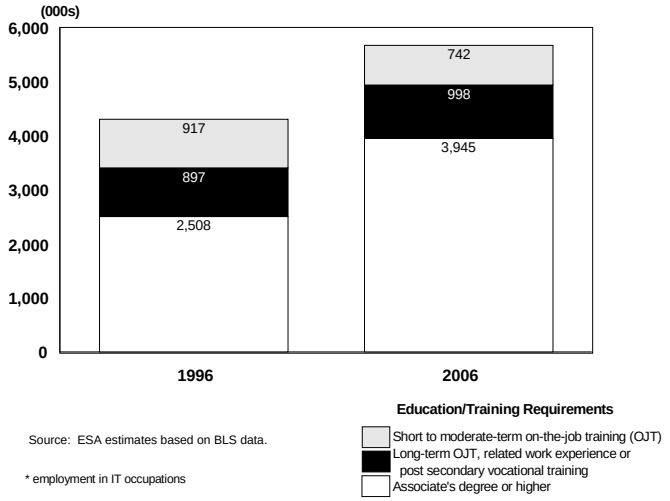
[4]Business services (SIC 73) ranks among the lowest paying industries because it excludes high-paying software and services (SIC 737) industries which were already counted among the IT-producing industries.

[5]Note that the focus of a forthcoming study by the Commerce Department's Technology Administration, "The Digital Dilemma: Building Infotech Skills at the Speed of Innovation," is on "core" IT workers. Since this report uses the broader definition of IT occupations, the employment estimates presented here are by definition higher than those provided by the Technology Administration. (http://www.ta.doc.gov)

Employment in "core" IT occupations in 1996 was 1.5 million; however, employment in the more broadly defined IT occupations was 4.3 million. Roughly 1.4 million (33 percent) of workers in IT-related occupations were employed by IT-producing industries, 1.7 million (39 percent) by IT-using industries and 1.2 million (27 percent) worked in non-IT intensive industries. BLS projects that 5.7 million workers will be needed to fill jobs in IT-related occupations (new and existing) by 2006, of which 2.6 million will be in "core" IT occupations. IT-producing industries will increase their share of workers in IT occupations to 40 percent.[6] (Appendix Table 4.5)

The demand for workers in IT occupations requiring at least an associate's degree is expected to grow by 57 percent over the decade while the demand for less educated workers is expected to decline. (Figure 4.3 and Appendix Table 4.5) In addition, by 2006, employers will need more than one million more "core" IT workers (occupations requiring at least a 4-year degree) than were needed in 1996. On the other hand, lower skilled, lower paying positions like computer operators and duplicating machine operators are expected to decline.

Figure 4.3
Future Employment Demand Favors Highly Educated IT Workers *



At the same time that demand for workers to fill IT-specific jobs is increasing, workers in a variety of non-IT occupations find themselves using computers and computerized devices to perform their jobs. Occupations ranging from auto mechanics to cashiers to delivery personnel are often now required to use high-tech, timesaving devices to perform their jobs. United Parcel Service (UPS) executives note that just 10 years ago, no one would have thought their truck drivers would have to pass a computer proficiency test in addition to a driving test.[7] However, there are instances where IT has lowered skill requirements or "de-skilled" workers. For example, workers at retail establishments use scanners for inventory-control and check-out services. Empirical research suggests that overall, IT is driving more skills upgrading than "de-skilling."[8] BLS projections suggest that this trend of rising minimum skill/training requirements will continue. From 1996 to 2006, employment in occupations requiring at least an associate's

[6]Since some workers with IT-related occupations are employed by IT industries, IT industry employment estimates discussed earlier in this chapter are not additive with IT occupation employment estimates in this section.

[7]Jim Kelly, "Those Who Can...Those Who Cannot: Winners and Losers in the Digital Age," *Vital Speeches of the Day*, November 15, 1998.

[8]See literature review on the effects of IT on employment growth, skill requirements and wages in "Science and Engineering Indicators, 1998," National Science Foundation.

degree will increase faster than average; employment in those requiring less education will grow slower than average.[9]

As e-commerce spreads, the employment effects will be felt throughout the economy. Workers that provide shipping and delivery services, online content, desktop publishing, *etc.* will be in demand. At the same time, demand for some occupations including travel agents, stock brokers, bank tellers and communications equipment operators, may decline as consumers make more purchases and other transactions online and bypass traditional delivery methods or as they just choose the direct route to gathering information.

Some workers are finding that their job requirements have naturally progressed towards IT-related duties. For example, many mathematicians, statisticians, economists and operations research analysts also perform computer programming, database administration and other problem-solving functions. Even graduates in many non-science and engineering fields are employed in IT-related occupations, since employers are willing to train workers who possess strong analytical and problem-solving skills in addition to a basic aptitude for learning and applying technical concepts.

This constant change in job duties and skill requirements has increased the need for continuing education and on-the-job worker retraining. Today, more than one-fourth of all undergraduates are over thirty years old and of those over thirty, one-fifth are enrolled in full-time programs.[10] Workers are finding that they must be "multi-skilled" and must commit to a lifetime of learning and retraining in order to remain competitive in rapidly changing labor markets.[11]

Earnings and Education Requirements of IT Occupations

Earnings in IT occupations are directly linked to skill level or educational attainment.[12] IT occupations requiring more education, *e.g.*, computer scientists, engineers, and systems analysts, many of which require at least a college degree, paid from $50,000 to $70,000 in 1997. (Appendix Table 4.6) Lower skilled workers such as communications equipment operators, which require short to moderate term on-the-job training, earned $18,000 to $28,000.

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[9]"Occupational Employment Projections to 2006," *Monthly Labor Review,* November 1997, p.82.

[10]Speech by Alan Greenspan before the American Council on Education, February 1999.

[11]For further evidence of changing skill requirements and the need for affordable education and training opportunities, see "21st Century Skills for 21st Century Jobs," an inter-agency report released in January 1999 in conjunction with Vice President Gore's skills summit. (http://www.vpskillsummit.org)

[12]The literature on labor demand and changing skill requirements confirms that computerization has contributed to the trend of rising skill/education requirements and the subsequent rise in wages for those with more education over the past couple of decades. It is very difficult to disentangle the extent to which computerization, by raising skill/education requirements, has contributed to wage inequality apart from other factors. See "Technological Change, Computerization, and the Wage Structure," presented by Larry Katz at the "Understanding the Digital Economy" conference on May 26, 1999. (http://mitpress.mit.edu/ude.html)

The Internet and e-commerce are creating a number of new occupations that may be too new for the existing labor pool to satisfy and too new for government data collection agencies to quantify. For example, the Internet is driving demand for skilled workers to design web pages, create graphics, and write programs to maintain web sites. These webmasters or web designers, earned on average $50,000 in 1998, according to a recent Computerworld salary survey of 1750 companies.[13] At the high end, Chief Information Officers earned $116,000 while lower skilled positions such as entry level help desk operators paid $26,000 to $30,000 and PC support technicians earned $30,000 to $34,000. New e-commerce occupations include consumer behavior consultants, who track consumer spending patterns and network security specialists, who guard against computer hackers. Workers in each of these occupations earn on average over $100,000 annually.[14]

Labor Market Imbalances

In addition to paying the higher wages and salaries, companies also have been increasingly willing to consider non-salary requests (*e.g.* alternative work schedules, telecommuting, child and elder care assistance, pets in the workplace) to attract and retain the workers they need. As higher salaries and increased workplace flexibility have increased the available pool of technical expertise, the demand for those workers has raced ahead. Organizations, both public and private, continue to experience real difficulty in recruiting and retaining employees with specialized IT skills.[15]

Accessing the Global Labor Market

To provide an immediate increase in the number of highly skilled workers available for employment in the United States, Congress acted last year to increase temporarily the annual number of visas available for high-skilled workers (H-1B non-immigrant visas) from 65,000 to 115,000 for fiscal years 1999 and 2000, 107,500 in fiscal year 2001, then returning to 65,000 per year in fiscal year 2002. The 1999 cap was reached in June.

In addition to bringing workers in, companies can access global labor markets by sending the work out. The advances in technology that have contributed to the strong growth in demand for IT skills make it possible to rearrange work processes and distribute work over the globe in a variety of ways. This redistribution can

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[13]Earnings are national averages and vary based on geographical location and years of experience. Also, duties of some occupations such as webmaster differ from company to company. Source: Computerworld 1998 survey. (http://www.computerworld.com)

[14]OECD, "The Economic and Social Impacts of Electronic Commerce: Preliminary Findings and Research Agenda," February, 1999.

[15]The market for IT workers is quite segmented with skill requirements and worker availability varying widely across IT occupations. See the forthcoming study by the Commerce Department's Technology Administration, "The Digital Dilemma: Building Infotech Skills at the Speed of Innovation,"which explores in depth the unique nature and complexity of the market for IT workers. (http://www.ta.doc.gov)

be as simple as outsourcing specific activities to a firm located outside of the United States, and as sophisticated as establishing a virtual design team, where team members collaborate over networks while remaining physically distant.

The strong demand for additional skilled IT workers is not unique to the United States; our trading partners have also expressed a need to increase their IT skills base. While this labor imbalance has the potential to limit the evolution of the digital economies of developed nations, it has even more serious implications for less developed countries. Information technology itself should be an important development tool allowing LDCs to move forward faster. However, the demand in the industrially advanced countries makes it difficult for much of the developing world to keep their limited pool of IT workers at home.

Increasing the Supply: Initiatives to Support IT Skill Development

Initiatives designed to increase the U.S. IT skills-base are being developed and implemented at a remarkable rate, although most are too new to have generated many graduates. Across the country, educational institutions working together with the state and local governments are forging new partnerships with local businesses to develop courses that deliver the needed content. At the federal level, the Administration recently unveiled a $60 million plan to help train workers for high-skill jobs in industries facing skill shortages.[16] This collection of activities brings together government, educators, and private businesses in a variety of combinations, targeting diverse populations and in many cases making use of the technology itself to deliver the IT coursework. (See box, p. 45) There are also concerns about expanding access to new technologies in underserved communities so that students and workers in these communities can become technically proficient.[17]

The fact that the initiatives are being implemented independently and each aims at a particular segment of the IT skills spectrum increases the likelihood that these programs will have a positive impact. No single, centrally administered program could operate with the speed, flexibility, and efficacy of the myriad of individually operating programs. Many skills in highest demand at present were almost unheard of two or three years ago. Indeed, one of the first obstacles faced, particularly in the programs aimed at high schools and two-year colleges, is "training the trainers." With the growing acknowledgment that coordination is necessary to quickly respond to the changing skill needs forced by the digital economy, the various interested parties, students, educators, businesses, and government are working together to change the existing models of technical education.

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[16]"Vice President Gore Announces New Efforts to Prepare America's Workers and Employers for the 21st Century," White House Press Release, Office of the Vice President, January 12, 1999. (http://www.vpskillsummit.org)

[17]The Commerce Department's National Telecommunications and Information Administration (NTIA) has compiled and reported telephone, computer, and modem penetration rates across geographical areas and demographic groups which will help policymakers identify where inequalities exist. An updated and expanded version of NTIA's analysis will be released in July 1999. (http://www.ntia.doc.gov)

Expanding the Skills Base: Some Representative Initiatives

Go for IT!: The U.S. Department of Commerce's Technology Administration maintains a web site with a searchable database of over 200 IT worker development programs throughout the country. (http://www.ta.doc.gov/go4it) Teachers can find educational tools for teaching IT skills to their students, workers can locate training opportunities for upgrading IT skills, students can search for scholarship and internship information, non-profit agencies can get grant and other funding sources and companies can find model programs they can replicate to develop a skilled workforce in their own communities.

Maryland Applied Information Technology Initiative (MAITI): Initiated in July 1998, with an appropriation from the State of Maryland, MAITI is designed to make Maryland a national center for information technology business development. Working with Maryland's institutions of higher education, the principal goals of MAITI include doubling the number of IT professionals produced by these schools, and strengthening college and university IT research and development activities. (http://www.onestopshop.umd.edu/MAITI)

TECH CORPS: A national non-profit volunteer organization established in 1995 and funded by corporate sponsors is improving K-12 education by helping educators to use technology in schools. TECH CORPS volunteers conduct teacher training seminars, mentor students and staff, repair and install computers, participate on technology planning teams, work side-by-side with teachers in the classroom, assist teachers with the integration of technology into the curriculum, and support a wide variety of other local technology activities. Because states have differing needs and resources, TECH CORPS programs are implemented through state organizations. Currently 42 states and the District of Columbia have TECH CORPS chapters. (http://www.ustc.org)

Talent Alliance: In a non-profit initiative launched in 1997, corporations are collaborating to ensure that employees have the skills they need throughout their working lives and that companies have the workforce talent they need. Member companies include Armstrong World Industries, AT&T, Ceridian, Complete Business Solutions, DuPont, GTE, Johnson & Johnson, Lucent Technologies, Metropolitan Life Insurance, TRW, Unisys, and United Parcel Service. The Talent Alliance is currently developing an Internet career management services system to provide distance learning. (http://www.talentalliance.org)

Cisco Systems Networking Academy Program: In partnership with school districts throughout the United States, Cisco Systems has developed a four-semester program on the principles and practice of designing, building, and maintaining networks. The Networking Academies are localized to individual needs of high schools and junior or community colleges, and feature hands-on, project-driven training in high-demand job skills. There are currently Networking Academies in 28 states. (http://www.cisco.com) Microsoft, Novell, and IBM have similar partnerships.

A LOOK AHEAD

Although we have learned much in the year since we published the first *Emerging Digital Economy* report, there is much more to be discovered and understood. We better appreciate the growing impact of the digital revolution on America and the world's consumers and businesses, we have begun to gauge the economic importance and impact of the IT sector, and our federal statistical agencies have formulated plans to effectively measure and analyze e-commerce.

During the recent Department of Commerce conference on these subjects, *Understanding the Digital Economy: Data, Tools, and Research,* (May 25 and 26, 1999), a range of public and private experts explored many important issues for the digital economy. The conference included discussions of the macroeconomic implications of IT; its impact on business organizations, market structure and small firms; new issues of access and competition for the digital economy, and the effects of IT on employment and the workforce. Immediately following this Conference, the Berkeley Roundtable on the International Economy held another conference on IT's global aspects, *The Digital Economy in International Perspective: Common Construction or Regional Rivalry?*[18] Both conferences served not only to expand our understanding of the digital economy, but also to highlight where more research is urgently needed.

The decision by the Department of Commerce to publish the *Emerging Digital Economy* report every year signifies our commitment to ongoing research. Thus far, we understand and can measure only a few of the pieces of the digital economy. Even as we do, many of those pieces are changing, more are emerging, and the shape of the whole is rapidly evolving. Future reports will be devoted to developing a coherent picture of the digital economy, to help both American businesses and government do their best in this critical area.

[18]Information on *Understanding the Digital Economy* can be found at http://www.digitaleconomy.gov and information on *The Digital Economy in International Perspective* can be found at http://e-conomy.berkeley.edu.