Digital Economy 2002

ECONOMICS AND STATISTICS ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE
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DIGITAL ECONOMY 2002

ECONOMICS AND STATISTICS ADMINISTRATION

Office of Policy Development

AUTHORS

Chapter I .... Lee Price
lee.price@esa.doc.gov
George McKittrick
george.mckittrick@esa.doc.gov

Chapter II .... Patricia Buckley
patricia.buckley@esa.doc.gov
Sabrina Montes
sabrina.montes@esa.doc.gov

Chapter III .... David Henry
david.henry@esa.doc.gov
Donald Dalton
donald.dalton@esa.doc.gov

Chapter IV .... Jesus Dumagan
jesus.dumagan@mail.doc.gov
Gurmukh Gill
gurmukh.gill@esa.doc.gov

Chapter V .... Sandra Cooke
sandra.cooke@esa.doc.gov

Chapter VI .... Dennis Pastore
dennis.pastore@esa.doc.gov

Chapter VII .... Jacqueline Savukinas
jacqueline.savukinas@esa.doc.gov

Contributing Editors .... Jeffrey Mayer, Director of Policy Development
jeff.mayer@esa.doc.gov
Lee Price, Deputy Under Secretary for Economic Affairs
lee.price@esa.doc.gov

Digital Economy 2002

ECONOMICS
AND STATISTICS
ADMINISTRATION

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I am pleased to release *Digital Economy 2002* (*DE2002*), the Commerce Department's fourth annual report on the impact of information technology (IT) on the structure and performance of the U.S. economy. In my view, reports like this one fulfill a core element of the Commerce mission by providing the data and analyses that help policy makers, business people, and private investors make better economic decisions. Events of the past year – a recession and the terrible events of September 11 – have made our task more challenging than ever and, if possible, even more important.

In recent days, the economy has shown welcome signs of imminent recovery. *DE2002* shows that the recovery, when it comes, will have a firm foundation. Despite the recession, businesses continued through 2001 to build stocks of IT capital. In addition, owing partly to continuing IT innovation and deployment, inflation has remained low, and productivity growth, breaking the pattern of every recession since 1950, has been positive.

DE2002 also shows that the diffusion of information technology and the Internet have continued to expand opportunities for all Americans to communicate, shop, and learn. Today more than half of all Americans use the Internet; moreover, Internet use is increasing rapidly among all demographic, economic, and regional groups. At work and at home, IT and the Internet are swiftly becoming fixtures of our daily lives.

The IT revolution has been driven largely by private creativity and entrepreneurial courage. The American people's receptiveness to using and adapting new technology has also contributed to our success. However, achievement of the revolution's full potential will also demand skillful public action – to preserve the environment for continued innovation and investment, to enhance cyber security, to protect consumers and ensure respect for individual privacy, and to guarantee that all American businesses and all of America's people can participate freely, according to their own goals and talents, in the promise of the digital economy. On all sides, much remains to be done.

Donald L. Evans

Executive Summary

The second half of 2000 marked a turning point in recent economic experience and gave new urgency to questions about the nature and durability of the new economy.[1] Answers to these questions should be clearer on the far side of the slowdown. For analysts standing in the hollow of the process, however, the challenge is still to assess developments in IT-producing and -using industries since mid-2000 and to determine what that experience suggests about the future.

Digital Economy 2002 concludes that, despite an economic slowdown and recession, U.S. industries have continued to build the nation's IT capital stock, to marshal the human skills and IT services that make the installed base of IT capital more productive, and to create as a result the enduring foundation of a stronger economy.

THE NEW ECONOMY— BATTERED BUT ENDURING

- Falling profits in a slowing economy have weakened business investment, including IT investment. Nonetheless, demand remains at remarkably high levels by historic standards. In the fourth quarter of 2001, U.S. businesses invested in IT equipment and software at an annual rate of $408 billion, down 16 percent from the peak four quarters earlier. Because the gains throughout 2000 were so large and IT prices have been falling rapidly, real investment for all of 2001 was only 3 percent below the level for 2000. As a result, U.S. businesses have continued at a diminished rate to build net stocks of IT processing equipment and software.[2]
- In 2000, the composition of business IT spending shifted toward products and services likely to result in more productive use of IT hardware (*e.g.*, software and computer services). This trend continued in 2001; through the fourth quarter of the year, software spending declined slightly (at a 3-percent annual rate), but remained far stronger than other categories of IT investment spending.
- Employment patterns reflect the changes in business spending. Despite a 1.4 percent decline in the total private sector employment during 2001, employment grew by 0.5 percent in telecommunications services and 1.4 percent in computer software and services—industries whose outputs are likely to make the installed base of IT hardware more productive. IT-producing industries employed roughly 5.6 million workers in 2000 and paid twice the average private industry wage ($73,800 compared with $35,000).
- Only 18 percent of the acceleration in U.S. productivity growth between 1989-95 and 1995-2000 came from durable manufacturing industries (including semiconductors, computers, and communications equipment), with the remainder coming from IT-intensive industries[3] outside the durables sector and from industries that use IT less intensively. Of 55 industries in the U.S. nonfarm business sector, 30 contributed positively to productivity growth acceleration. Such dispersion of productivity

[1] We define the "new economy" as an economy in which IT and related investments drive higher rates of productivity growth. U.S. experience in the late-1990s suggests that new economies are capable of long periods of rapid output growth with low inflation and low unemployment. Events since July 2000 indicate that IT-related changes in the organization of production and the composition of employment also support atypically high rates of productivity growth in periods of economic slowdown.

[2] Net stock is the real value of installed capital minus depreciation plus new investment.

growth suggests that massive IT investments by U.S. industries are producing positive and enduring changes and in the nation's economic potential.

- IT-intensive industries have helped check inflation. Between 1989 and 2000, while inflation in less IT-intensive industries averaged 3.0 percent, inflation in the IT-intensive sector average only 1.3 percent. Overall inflation (net of food and energy price changes) during the period averaged 2.1 percent.
- During 1996-2000, when the economy grew by an average 4 percent annually, the IT-producing sector, which accounted for 7 percent of GDP (on average), grew by 21 percent a year (on average, in real terms), and was responsible for 28 percent of overall real economic growth.

SOURCES OF CONTINUING UNCERTAINTY

- Experience since the beginning of 2001 suggests that the dynamism of IT-producing industries is double-edged. During 2000, business investment in information processing equipment and software (calculated as an average of annualized quarterly rates) accounted for 37 percent of the growth in U.S. GDP. By contrast, in 2001—for the first time in a decade—reductions in business investment in IT equipment and software had a negative effect on economic growth.
- Investment aside, the IT sector retains a significant base of demand in the areas of business spending on current expenses, personal consumption, and government consumption. In 2000, when IT investment totaled $466 billion, businesses spent another $258 billion on expensed IT goods and services. In the same year, consumers paid $121 billion for computers, peripherals, and software, and another $44 billion for communications services; and IT expenditures by governments at all levels totaled over $20 billion.
- Though U.S. IT companies are widely seen as leaders in world markets, the United States in 2000 had a deficit in IT goods trade of $88 billion. In an increasingly integrated global economy, however, trade alone is a misleading indicator of competitive strength. In 1998, for example, in the five IT industries for which affiliate data are reported, foreign sales by majority owned affiliates of U.S. IT companies totaled $202 billion—almost twice the $113 billion in comparable U.S. IT exports that year.
- While globalizing production, U.S. companies have kept high value-added functions at home. In three major IT-producing industries,[4] plants located in the United States produce on average more than three-quarters of the total value added by companies in the United States and the majority-owned foreign affiliates of U.S. companies.[5] U.S. jobs in these industries pay on average more than twice as much as jobs at foreign affiliates in the same industries.
- Private estimates indicate that the surge in "dot-com" failures that began in mid-2000, peaked in the first half of 2001 and has begun to subside. By one estimate, as much as 10 percent of the 7,000 to 10,000 "substantial" Internet companies that have received some formal venture funding closed their doors between January 2000 and December 2001. Through the middle of 2001, these failures, and staff cuts at surviving dot-com companies and the Internet divisions of primarily off-line companies had resulted in an estimated 135,000 layoffs.
- To date, the Internet as a commercial medium has disappointed initial expectations. E-commerce as a share of total U.S. retail sales remains at approximately 1 percent. At the industry level, reliance on e-commerce has been widespread but uneven. In 1999, the Internet or more traditional EDI transactions accounted for 12 percent of manufacturing shipments and 5.4 percent of sales by wholesale merchants.

[3] ESA economists ranked 55 two-digit SIC industries in the U.S. nonfarm business sector based on industry ratios of IT equipment stock to full-time employment (in 1996). Then they calculated each industry's average share of nominal GDP for the years 1989-2000. Reading top-to-bottom, they divided their ranked list of industries at the point where the sum of industry shares of GDP equaled 50 percent. For the analysis reflected in this bullet, they defined the 29 industries above the dividing line as "IT-intensive."

[4] Computer and office equipment; household audio and video and communications equipment; and electronic components and accessories.

[5] Estimates based on 1998 Census annual survey data.

By contrast, e-commerce accounts for less than 1 percent of shipments among retailers and selected service providers.

THE FUTURE OF THE NEW ECONOMY

In early 2000, Nobel Laureate Robert Solow observed that he would "feel better about the endurance of the [post-1995] productivity improvement after it survives its first recession." On these terms, the acid test of the new economy is incomplete, but preliminary signs are encouraging. On each of the last eight occasions since 1950 when growth in nonfarm business output has turned negative for two consecutive quarters, productivity growth has also turned negative. During the economic downturn of 2001, by contrast, productivity growth remained at a remarkably robust 1.9 percent, well above the U.S. norm for the period 1973-95 and almost matching the 1995-2000 period.

Continued strong productivity growth in a period of economic weakness suggests that U.S. industries are continuing to benefit from past and current investments in IT equipment, software and services, and related human skills. In effect, even as these industries continue to build the foundations of future U.S. economic strength, they are realizing the benefits of the new economy.

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Preface

Kathleen B. Cooper

Under Secretary of Commerce for Economic Affairs

Digital Economy 2002 (*DE2002*) is the Department's fourth annual report assessing the effects of information technology (IT) on U.S. economic performance. At bottom, each of these reports has addressed the same question—whether the integration of IT into our systems of production and distribution has created an economy that can achieve unusually high productivity growth well into the future. None of the four has answered this question conclusively. But *DE2002* comes the closest.

This year's report has faced new challenges. The question may be the same, but answers are more elusive. The slowdown that began mid-2000 and economic repercussions of the terrible events of September 11, 2001 have prompted additional skepticism about the new economy. This skepticism may be excessive—its expectations tied too closely to current experience. Until 18 months ago, IT enthusiasts probably oversold the promise of the new economy. Today, however, the opposite effect holds sway—encouraging a similar overselling of the contrary claim that the new economy never was.

In fact, the idea of the new economy was never a promise or even a hope that IT—like some reincarnation of 1960s fiscal policy fine-tuning—would make economic cycles obsolete. Rather it describes IT-related changes in the organization of production and distribution, and in the composition of employment, that lift the economy to a higher path of productivity growth—not only in periods of expansion such as the one enjoyed by the U.S. economy in the late 1990s, but also in periods of slowdown. Thus, by achieving atypically strong productivity growth since mid-2000, the U.S. economy may be showing us how new economies behave in a slowdown.

Two years ago, Nobel Laureate Robert Solow suggested that he would feel better about the improvement in productivity growth after it had survived its first recession. On these terms, the test of the new economy is incomplete. But, as *DE2002* shows, despite the economic difficulties and growing skepticism, the preliminary signs are encouraging.

Chapter I

Setting the Stage: The "New Economy" Endures Despite Reduced IT Investment

by Lee Price with George McKittrick*

Despite slow growth beginning in mid-2000, outright recession in 2001, and cutbacks in IT investment, the "new economy" appears alive and well as we begin 2002. American businesses are still expanding their use of Information Technology (IT), the economy's productivity growth has remained robust and supported strong real wage gains for those employed, and inflation has been tame.

This *Digital Economy* report follows in the tradition of previous reports and focuses on the role of IT in the wider economy. This first chapter focuses on recent developments and what they may suggest for the new economy. Placing the 2001 decline in IT investment into perspective, the chapter finds that:

- the current level of IT investment still exceeds the levels prior to 2000;
- the IT capital stock continues to grow;
- businesses increased IT service employment to harness the benefits of IT investments in 2001; and
- IT has supported exceptional productivity gains despite the economy's slowdown and recession.

The chapter also notes that IT production appeared to be stabilizing by the end of 2001. The continued price declines and high rate of obsolescence for IT products are widely expected to generate a rebound in IT investment in 2002.

*Mr. Price is Deputy Under Secretary of Commerce for Economic Affairs, and Mr. McKittrick is an economist in the Office of Economic Conditions, Economics and Statistics Administration.

DISTRESS OF IT-PRODUCING COMPANIES

For most of the last decade, spending on information processing equipment and software grew much more rapidly than other types of investment. With the slowdown in the economy that began in 2000, profits and cash flow have fallen, and businesses have reduced investment. Although investment in other equipment had turned down by mid-2000, IT investment continued to grow through the end of 2000. In 2001, however, businesses cut back more aggressively on IT spending than on non-IT equipment. In just four quarters, nominal IT investment was slashed by 16 percent, with software investment down 3 percent; but computers and peripherals were down 29 percent (Figure 1.1).

Figure 1.1
NET CASH FLOW AND INVESTMENT IN EQUIPMENT AND SOFTWARE
Billions of dollars, Annual rate

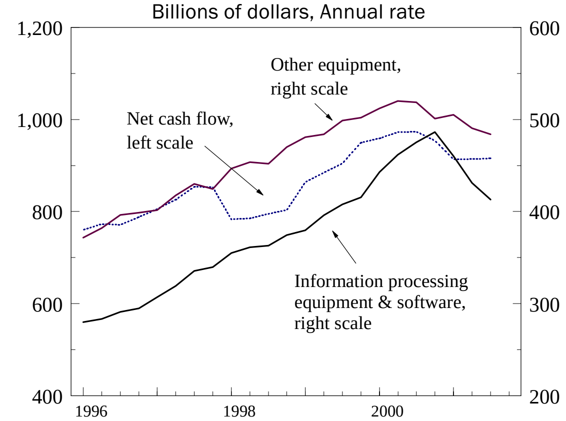


Figure 1.2

INFORMATION TECHNOLOGY EQUIPMENT PRODUCTION

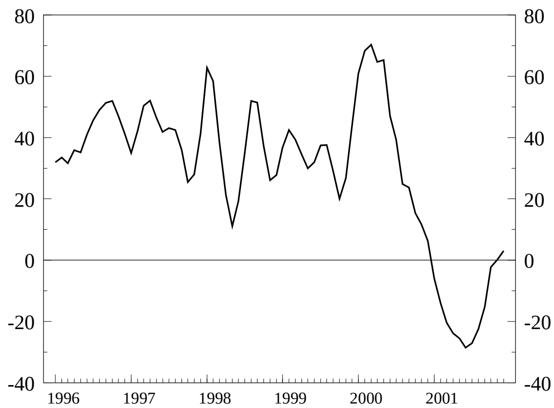


Figure 1.3

SHIPMENTS AND NEW ORDERS INFORMATION TECHNOLOGY

Billions of dollars, Annual rate

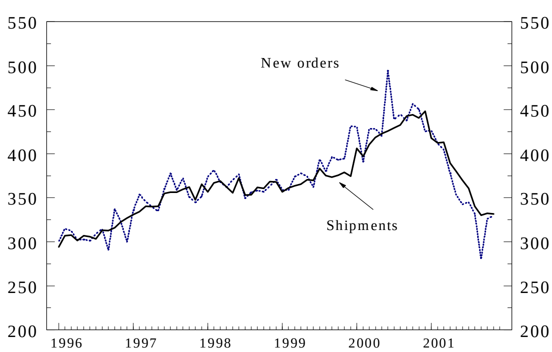
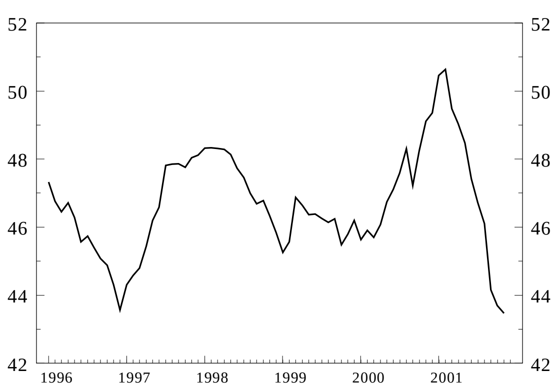


Figure 1.4

INVENTORIES INFORMATION TECHNOLOGY

Billions of dollars



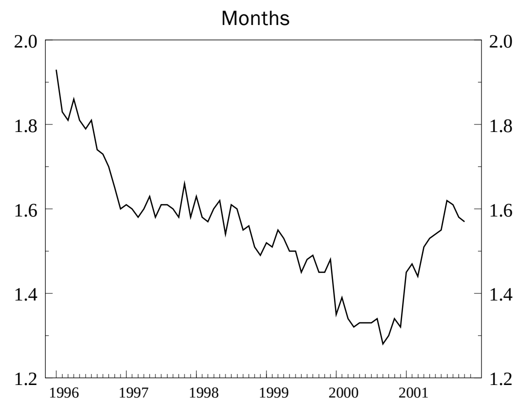
In the second half of the 1990s, production of IT equipment was growing at a torrid pace. By 1995, real output was expanding at an annual rate of 40 percent, a pace that continued for several years. After surging in late 1999 and early 2000, production of IT equipment decelerated for much of 2000, stopped growing, and was falling at a 20+ percent rate in the spring and summer of 2001. Despite the negative effects of September 11 and continued decline in production of telecommunications equipment, overall IT production grew at a 3.1 percent rate between September and December. (Figure 1.2)

The dollar value of IT shipments fell even more steeply (because of falling IT goods prices) for most of 2001, but also appeared to be stabilizing late in the year. After reaching a four-month plateau at the end of 2000 of more than $440 billion at an annual rate, IT shipments plunged by 25 percent over nine months to a new three month plateau ending in November 2001 at barely a $330 billion rate. Further indication that the IT goods sector was stabilizing comes from the data on new orders for information technology goods. New orders, which led shipments on the way up in 1999 and 2000 and again on the way down in 2001, bounced back in October and November to virtually the same level as shipments (Figure 1.3).

The drop-off in shipments presented producers of IT equipment with severe inventory problems in 2001 (Figure 1.4). Although inventories were rising for much of 2000, they presented little cause for concern because shipments were rising just as quickly. While nominal shipments peaked in December, inventory levels continued to grow through February. Inventory levels were cut sharply from March to November 2001, but shipments fell even faster through August. As a result, the inventory to shipments ratio has turned down only since September (Figure 1.5).

Experts point to several factors to account for the wide swings in IT equipment activity in recent years. On the up side of the IT spending roller-coaster, corporate IT budgets were ramped up in the late 1990s to address Y2K risks. Meanwhile, new firms emerged with commercial Internet strategies based on heavy IT spending and found ample funding from venture capital firms and the NASDAQ. Traditional firms stepped up investment in IT as a competitive response to the cost-cutting success

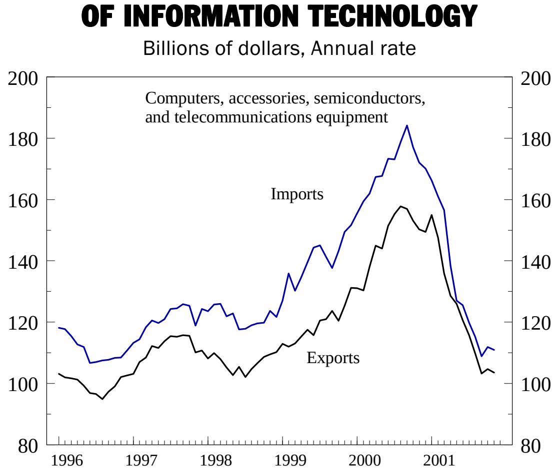
Figure 1.5
INVENTORY/SALES INFORMATION TECHNOLOGY



of some traditional firms deploying computer networks (e.g., Walmart, General Electric) as well as the market inroads of some Internet based firms in securities trading and book retailing. Excessively optimistic projections of growth in Internet traffic induced massive investments in telecommunications infrastructure.

The downward slide in IT investment spending in 2001 reflects not only the cash flow problems that have pulled down U.S. investment spending generally, but also several IT specific factors. Both new venture capital funding (discussed in Chapter 2) and the NASDAQ have retreated sharply since the first half of 2000, spawning and expanding far fewer IT-intensive businesses. As the Internet-based business model has met difficulties with profitability and market share, the spur to traditional businesses' IT investments has waned. Substantial overcapacity in large segments of telecommunications infrastructure has induced large reductions in spending on communications equipment. Finally, some financially healthy firms have decided to trim IT investment from levels that they have concluded were excessive and not contributing sufficiently to profitability.

Figure 1.6
EXPORTS AND IMPORTS OF INFORMATION TECHNOLOGY



DISTRESS FOR IT PRODUCERS NOT CONFINED TO U.S.

The retrenchment in IT production has occurred globally. Indeed, international trade figures provided one of the first indications of the worldwide downturn in IT equipment production. After the 1997-1998 Asian crisis abated, both imports and exports of IT equipment (semiconductors, computers and peripheral equipment, and telecommunications equipment) rose sharply for two years. On a seasonally adjusted basis, both exports and imports peaked in the three months ended in October 2000. Over the following 12 months, U.S. IT exports dropped by $50 billion and imports by $68 billion (both at annual rates). Both have declined by more than 30 percent. (Figure 1.6) U.S. exports equalled more than one third of IT producers' shipments in late 2000, and the export decline equalled almost half of the shipments decline during 2001. The export drop also reflects the weakness of foreign IT activity. By the same token, the large drop in U.S. imports has been a major setback for foreign IT production and contributed to economic slowdown and recession abroad.

The most timely IT production-related measures —real GDP, the Fed's industrial production, the Census Bureau's shipments and new orders, exports and imports—tell a consistent story of steep declines for most of 2001, but relative stability by the fall. The more forward looking data, those on new orders for IT producers, are also promising.

IT'S EXPANDING ROLE IN THE ECONOMY

With prices falling, the plunge in IT producers' revenues gives a very misleading picture of the role that IT still plays in the overall U.S. economy.[1] For

[1] *For a better perspective on the wider role of IT in the economy, we must use "real" or inflation adjusted dollars (although nominal dollars better capture the difficult financial straits of IT producing industries).*

Figure 1.7
INVESTMENT IN INFORMATION PROCESSING EQUIPMENT AND SOFTWARE
Billions of 1996 dollars, Annual rate

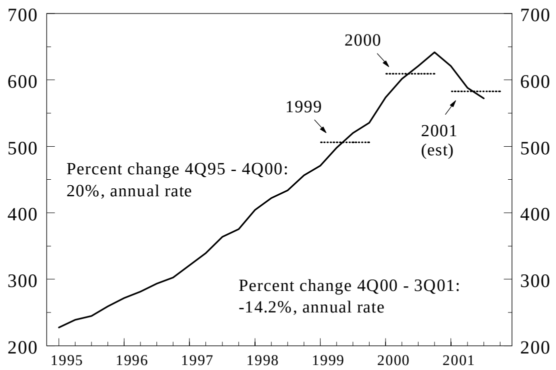


Figure 1.8
REAL NET STOCK OF INFORMATION PROCESSING EQUIPMENT AND SOFTWARE
Percent change from prior period

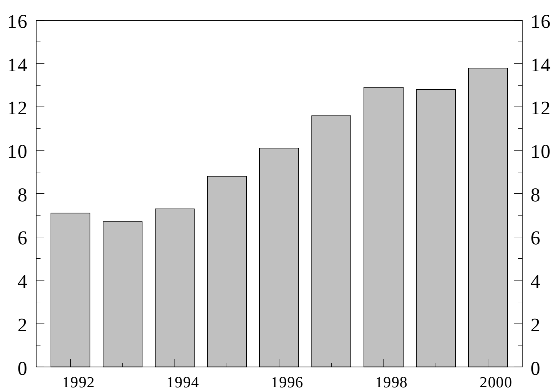
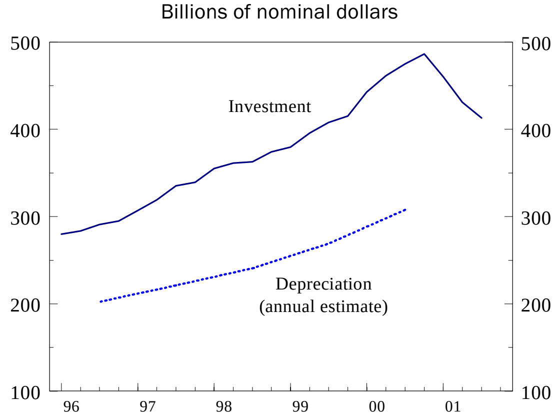


Figure 1.9
INFORMATION PROCESSING EQUIPMENT AND SOFTWARE
Billions of nominal dollars



example, in the fourth quarter of 2001 businesses spent $80.4 billion on computers and peripheral equipment, 20 percent less than in the first quarter of 2000. Because prices declined by 30 percent over that same period, however, businesses actually acquired 14 percent more equipment in 2001:Q4 than seven quarters earlier. Although computer and peripheral manufacturers would have preferred not to make such deep price cuts, others can take heart in the economy's higher real computer investment.

The level of U.S. real investment in IT soared at a 20 percent annual rate from the end of 1995 to the end of 2000. Even though real IT investment dropped 10.7 percent over the course of 200l, the level for the fourth quarter of 2001 remained higher than at any time prior to early 2000. Even if IT investment continued to fall at the same pace in the fourth quarter, total IT investment for 2001 would still total just 3 percent less than 2000 and 16 percent more than 1999 (Figure 1.7).

The steep growth of IT investment through 2000 translated into a rapidly growing net capital stock of IT equipment and software (Figure 1.8). The net IT capital stock accelerated in the 1990s, reaching double-digit rates by 1997 and a 14 percent rate in 2000, much higher than the growth rate for the stock of non IT equipment. Even though the level of IT investment has dropped in 2001 (Figure 1.9), it has remained above any plausible amount of depreciation. As a result, the net IT capital stock continued to expand in 2001.

In sum, U.S. businesses have trimmed their spending on new IT equipment and software, but have not cut back their use of IT capital. With prices falling, the real volume of IT acquisitions has fallen much less than nominal spending. In addition, the level of spending on IT equipment had reached such a high level by late 2000 that there was considerable room to reduce spending and still add to the net IT capital stock.

Further confirmation that IT continues to play a widening role in the current U.S. economy comes from the data for employment in industries that provide IT services. Employment both in telecommunications services and in computer software and services grew vigorously until the recession began in March 2001 and have remained relatively flat since then. Over the entire 12 months of 2001, however, as employment dropped 1.4 percent in the total private sector, employment gained 0.5 percent in telecom services and 1.4 percent in computer software and services (Figure 1.10).

PROSPECTS FOR IT REBOUND IN 2002

The convergence of the lines for IT investment and depreciation in Figure 1.9 has encouraged many economic forecasters to project a rebound in IT investment (and therefore overall investment) in 2002. If IT investment were to continue declining at the 2001 rate, it would fall below the estimated rate of depreciation some time in 2002. Because many types of IT equipment tend to be replaced every three or four years, the annual depreciation rate on the IT capital stock is estimated between a quarter and a third. Economic forecasters expect that this replacement cycle will soon kick in for many companies that will want to maintain their IT capital stock. Some experts believe that businesses are finding that the IT equipment is not becoming obsolete as rapidly as a few years ago and they are stretching out their replacement cycle, say from 3 to 3-1/2 or 4 years. If, and to the extent that, the replacement cycle has been extended, the rebound in IT investment will be later and flatter.

The overall performance of the U.S. economy in the medium term hinges to a large extent on the rate at which the net IT capital stock will grow. Will it resume the double digit growth rate of the late 1990s, slip back to the 7 percent rate typical of the early 1990s, or slow to the even more modest pace typical of non-IT capital in the last decade? As Chapter 3 and 4 of this report and previous reports in the Digital Economy series have documented, IT has played an outsized role in overall U.S. economic performance, in terms of its own output and economy-wide productivity growth.

IT SUPPORTS A NEW ECONOMY OF FASTER PRODUCTIVITY GAINS

The central feature of the "new economy" has been a higher growth rate of productivity, which in turn has brought faster gains in our standards of living. The upturn of productivity in the second half of the 1990s marked the arrival of a "new economy." (See Figure 1.11.) Productivity improved by an average 2.8 percent per year from 1948 to 1973 but slowed to a 1.4 percent rate for the next 22 years. Had productivity maintained its 1947-73 pace over the next 22 years, real incomes would have been one third higher in 1995. Fortunately, productivity has accelerated to a 2.4 percent pace since 1995 and real incomes have grown faster than at any time in a generation.

The last two years of sluggish growth and recession have disproved several predictions about the "new economy." On the one hand, it has dashed some optimists' exuberant hopes that "new economy" would not only raise productivity but also eliminate the swings in business cycle and equity prices. On the other hand, recent experience has also proven wrong the pessimists who predicted the evaporation of productivity gains when the economy slowed, but much less than normal for a

Figure 1.10
CONTINUED STRENGTH IN IT SERVICE JOBS
Index, January 1999=100

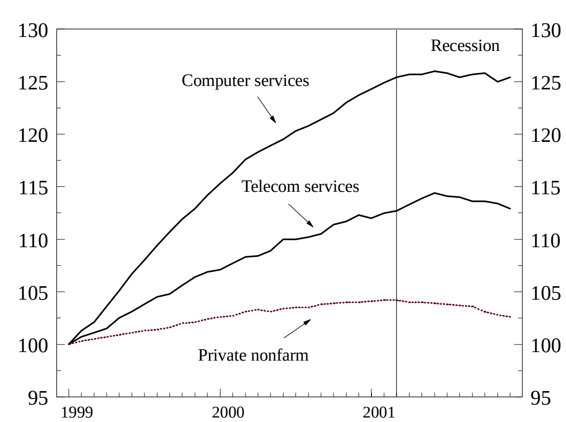
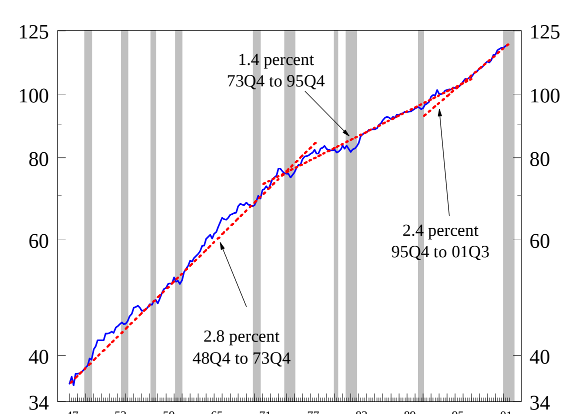


Figure 1.11
PRODUCTIVITY IN NONFARM BUSINESS SECTOR
Index, 1992=100



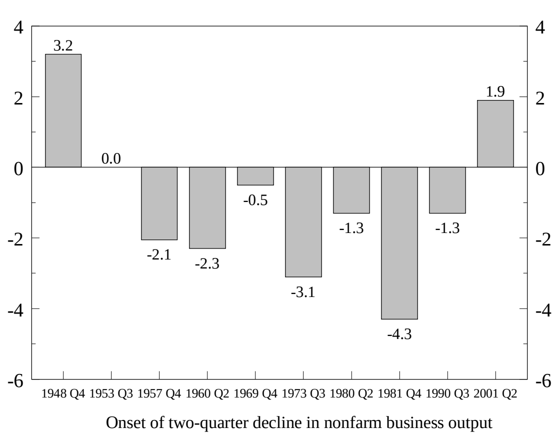
period of such economic weakness. Productivity gained 2.7 percent per year from the end of 1995 through mid-2000, but has still maintained a 1.5 percent pace in the five subsequent quarters when output grew at an average 0.7 percent pace. Output of the nonfarm business sector declined in both the second and third quarters of 2001. Those two quarters marked the first episode in more than 50 years that productivity change remained positive when non-farm business output growth first turned negative for two consecutive quarters (Figure 1.12). The productivity growth rate of +1.9 percent for the two quarters marks by far the best recessionary performance since 1948-49.

Much of the improvement in productivity gains since 1995 appears tied to greater use of information technology and associated organizational change. Several macroeconomic studies have concluded that IT contributed most of the step-up in productivity growth since 1995.[2]

Occupational employment data also show the tie of IT to productivity gains. Investment in IT with complementary organizational change can raise the productivity of many types of workers, but the most substantial effect should occur among clerical jobs. Since clerical work involves producing, storing, and distributing information, IT can directly substitute for clerical jobs. In 1989, there were 15.4 million clerical jobs[3] and 101.9 million other jobs. Over the next ten years, national output rose 34.3 percent and, because of productivity gains, total employment rose 15.3 percent. As non-clerical jobs grew 18.8 percent, clerical jobs actually declined by 8.4 percent. If clerical jobs had grown at the same rate as all other jobs, they would have grown to 18.3 million instead of shrinking to 14.1 million. As a rough approximation, if the productivity gains associated with clerical jobs had been the same as all other jobs instead of accelerated by the substitution by IT, national productivity gains over the decade would have been 0.3 percent per year lower.

Finally, productivity gains directly related to IT investment are also found at the industry level. Chapter 4 of this report presents evidence that more IT-intensive industries have contributed disproportionately to productivity gains since 1995. In addition, two recent studies using establishment level data, one on the retail industry and the other on manufacturing, both found evidence of notable productivity gains associated with IT investment.[4]

Figure 1.12
CHANGE IN PRODUCTIVITY OVER TWO QUARTERS
Percent change, Annual rate



CONCLUSION

Although 2001 has been a very difficult year for companies that produce information technology products, conditions appear to have stabilized and 2002 looks more promising. IT plays an expanding and positive role in the U.S. economy. Analysis of recent economic data for IT leads to the following more specific conclusions:

- As businesses suffered declining profits and cash flow in the last two years, they sharply

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[2] *See Chapter 3 of* Digital Economy 2000 *for an examination of those studies. Two of those studies have recently been updated and extended, both raising earlier estimates of the contribution of IT. See Dale W. Jorgenson, Mun S. Ho, Kevin J. Stiroh, "Projecting Productivity Growth: Lessons from the U.S. Growth Resurgence," dated December 31, 2000; Stephen D. Oliner and Daniel E Sichel, "Information Technology and Productivity: Where Are We Now and Where Are We Going?" mimeo dated January 7, 2002. Both documents were presented to a conference on "Technology, Growth, and the Labor Market," sponsored by the Federal Reserve Bank of Atlanta and Georgia State University, on January 7, 2002. See http://www.frbatlanta.org/news/conferen/techconference.htm.*

[3] *This category includes all occupations defined as "administrative support, including clerical" with the exception of occupations that require personal relationships such as receptionists, interviewers, insurance adjusters, and teachers' aides.*

[4] *Mark Doms, Ron Jarmin, and Shawn Klimek, "IT Investment and Firm Performance in U.S. Retail Trade," November 2000, mimeo, Center for Economic Studies, U.S. Bureau of the Census. B.K. Atrostic and Sang V. Nguyen, "Computer Networks and U.S. Manufacturing Plant Productivity: New Evidence from the CNUS Data," CES Discussion Paper In Economics, CES-WP-02-01 (January, 2002), Center for Economic Studies, U.S. Bureau of the Census.*

cut back their investment spending, including that on IT equipment and software.

- Revenues and profits of companies producing IT equipment were hit by falling prices and rising inventories in addition to shrinking real demand.
- The collapse of both exports and imports of IT equipment indicate that other countries have joined in the downturn of the U.S. IT industry.
- The most recent measures for production, shipments, new orders, exports, and imports all indicate that conditions for IT producers are stabilizing.
- U.S. businesses are nonetheless expanding their use of IT in operations: with IT investment in 2001 far surpassing every year prior to 2000, the IT capital stock continued to grow in 2001, and employment in the service industries that implement IT (telecommunications and computer and software services) grew in 2001.
- The link between IT and productivity is confirmed by employment declines in clerical occupations most readily substitutable by IT.
- The continued contribution of IT to improved productivity gains is suggested by the remarkable productivity gains of the last year despite the weakness of the economy.

Although the "new economy" continues to deliver strong productivity results, it has not created an immunity from the ups and downs of either the business cycle or the equity markets. The economy appears to be enjoying the productivity benefits of prior years' investments in IT and reorganization. Those productivity gains have buoyed remarkable real wage gains during a recession, but not profits. IT investment will probably remain subdued for a few more quarters until profits and cash flow improve. When a recovery does take hold and profits improve, IT investment should resume growth, propelled by the need to replace obsolete IT capital stock with a new generation of more powerful and less expensive hardware and software.

Chapter II

The Evolving Online Environment

By Patricia Buckley and Sabrina Montes*

Despite the current recession, migration to the online world continues. More and more individuals, businesses, and government agencies are using network technologies to connect with each other in an ever-growing number of ways for an ever-expanding number of purposes. However, as is the case with most major technological advances, progress is occurring neither smoothly nor along paths envisioned by the original developers. This past year has been marked by extreme turmoil among Internet-related businesses even as the Internet itself has continued to expand far beyond its roots as a tool for sharing research data. It has become a multipurpose, multimedia communications tool serving many different personal and business needs.

Many businesses have only begun to exploit their IT investments by moving their business processes online and the network economies associated with the Internet's growing ubiquity should continue to increase its value to users of all types. Moreover, the rapid rate of innovation in network technology witnessed over the latter half of the 1990s appears to be enduring. Taken together, this evidence suggests that major opportunities remain for networking technologies to continue to affect our economy and lifestyles.

RECENT CHANGES

The current economic environment is a difficult one for many U.S. businesses, and Internet businesses are no exception. Many online or "dot-com" companies have failed or have had to scale back operations significantly. The amount of online commercial activity conducted by both individuals and businesses remains at levels significantly below those predicted by market researchers in recent years. Investors have responded to the change in outlook: the extraordinarily high stock valuations and massive inflows of venture capital that became commonplace in the late 1990s have dissipated.

Some early observers thought that online versions of businesses would quickly replace their real-world, "bricks and mortar" counterparts. Sales outlets, in particular, were thought to be at risk from online sellers able to provide wider selections at lower prices. Traditional providers of products and services that could be delivered digitally were also thought to be in danger of competitive extinction—why buy a paper magazine if an online magazine could provide custom content on demand. Transactions between firms also were expected to be transformed as purchases and sales of even the most sophisticated products were revolutionized by instantaneous access to worldwide markets and auction pricing. Nothing approaching these degrees of transformation has yet occurred.

Like Mark Twain's famous demise, however, recent skepticism about the e-economy has been greatly exaggerated. Despite the large number of dot.com closures that occurred in 2001, this type of business is not in danger of disappearing. Rather, these businesses continue to adjust to the realities of the markets in which they operate. And, although the pace may be slower than widely predicted not very long ago, businesses of all types are still increasing their use of IT and the Internet.

Ms. Buckley is a senior policy advisor and Ms. Montes is an economist in the Office of Policy Development, Economics and Statistics Administration.

Dot-Com Shakeout

Online businesses are a very diverse group, operating in a wide variety of sectors, including retailing, publishing, wholesaling, education, health, and business services. Some of these dot-coms have only an online presence, but others are online branches of traditional companies. Although measures of dot-com activity are difficult to develop for several reasons,[1] some private groups are attempting to track the current shakeout. Webmergers.com estimates that 762 "substantial" Internet firms shut down in the two-year period between January 2000 and December 2001.[2] As shown in Figure 2.1, the number of Internet business failures was substantially higher in the later half of the period. However the figure also indicates that the pace of shutdowns slowed markedly in the later half of 2001.

Even with these shutdowns, however, a large number of online businesses remain. Webmergers claims that a conservative estimate of the total number of Internet companies that have received some formal funding from venture capitalists, angel investors or other investors to be in the range of 7,000 to 10,000. Given this base, Webmergers estimates that "at most, ten percent of significant internet companies have shutdown or declared bankruptcy."[3]

Another indication of the relative impact of the dot-com failures is the effect on jobs. Until its own demise in September 2001, the *Industry Standard* tracked layoffs stemming both from dot-com failures and staff cuts at continuing dot-coms and at the Internet divisions of primarily off-line companies and found that, as of July 26, 2001, there were 134,727 dot-com-related employees laid off since December 1999 from 902 companies.[4] Though the impact of these layoffs on affected workers is significant, the effect on the U.S. economy at large is relatively limited. The Bureau of Labor Statistics estimates that, on average, 301,800 people *per week* filed new unemployment claims in 2000.[5] Further, many laid-off dot-com employees have been successful in finding new jobs.

According to the PricewaterhouseCoopers MoneyTree Survey done in partnership with VentureOne, the amount of venture capital invested

[1] *Not every Internet address with a "dot-com" suffix is a separable business. Many are business home pages that are integrated parts of existing firms and are not viewed by their operators as separate business units. Also dot-coms are not limited to online businesses with the suffix "com". The suffix "net" and the new suffix "biz," are also used to denote commercial sites.*

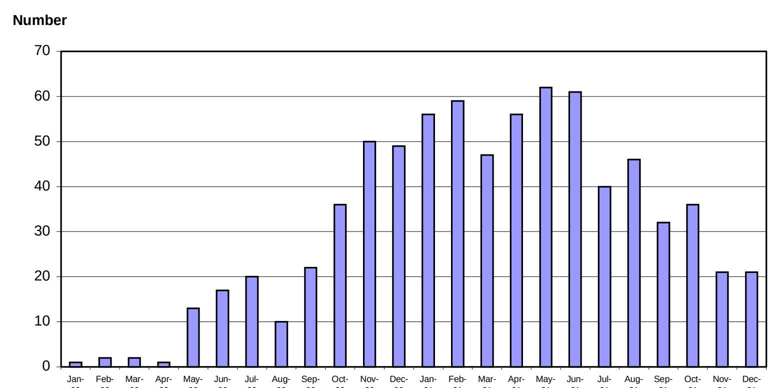
[2] *Webmergers.com counts as "substantial" all Internet companies that have received some formal outside funding from venture capitalists or other investors. Webmergers.com, "Year End Shutdowns Report: Shutdowns More than Doubled in 2001,"January 2002. (http://www.webmergers.com/editorial/article.php?id=49).*

[3] Ibid.

[4] The Industry Standard *Layoff Tracker, July 26, 2001 (http://www.thestandard.com/tracker/layoffs).*

[5] *Both the Industry Standard number and the new UI claims number can include specific individuals more than once. (http://www.bls.gov).*

Figure 2.1
MONTHLY INTERNET SHUTDOWNS
JANUARY 2000 – DECEMBER 2001

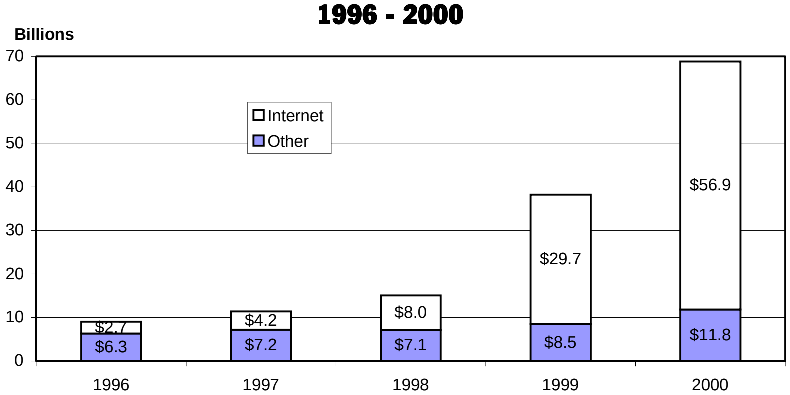


Source: Webmergers,com, January 2002.

Figure 2.2

AMOUNT RAISED BY VENTURE-BACKED COMPANIES

1996 - 2000



Source: VentureOne and PricewaterhouseCoopers.

in all types of businesses in 2000 was $68.8 billion, an 80 percent increase over investment in 1999. The year 2000 marked a high point in venture capital spending; and most of this spending went to online companies (see Figure 2.2). These Internet companies include the dot-coms, as well as new companies that produce goods and services that make e-businesses processes possible. The proportion of funds raised by these companies grew substantially after 1996. That year, Internet firms accounted for 30 percent of dollars raised by venture-backed companies; by 2000, the proportion had risen to 83 percent.[6]

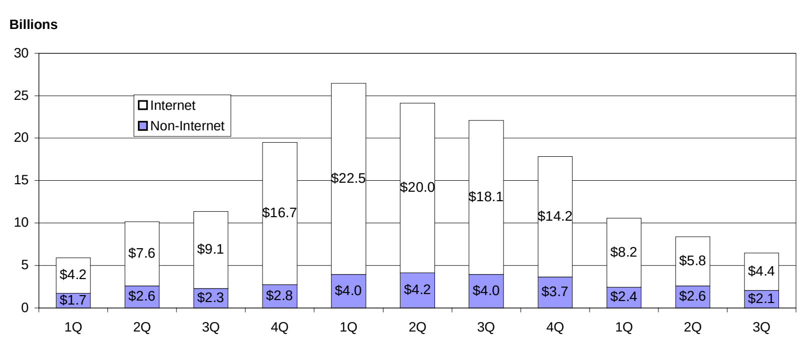
Annual numbers for 2000 were very strong. The $56.9 billion of financing raised by venture-backed Internet companies in 2000 is equivalent to over 10 percent of total business investment on IT equipment and software economy-wide in 2000. However, the first quarter of 2000 marked the beginning of a slowdown. Figure 2.3 shows that this slowdown has been sharp. According to PricewaterhouseCoopers and VentureOne, venture-

[6] *See VentureOne, "Moderate slowdown in Fourth Quarter Venture Investment Tempered by Increases in Biotechnology and Internet Infrastructure," Press Release, February 6, 2001. VentureOne's published US venture data comprises only venture-backed companies—those receiving at least one round of financing involving a US-based, professional, institutional venture capital firm, the division of an investment bank, or firm dedicated to venture financing. VentureOne does not track the investments of SBICs or angel investors. VentureOne does track the investments of corporations or corporate venture capitalists, as well as the interest of entrepreneurial companies in corporate partnerships. (http://www.v1.com/press/4QPR.pdf).*

Figure 2.3

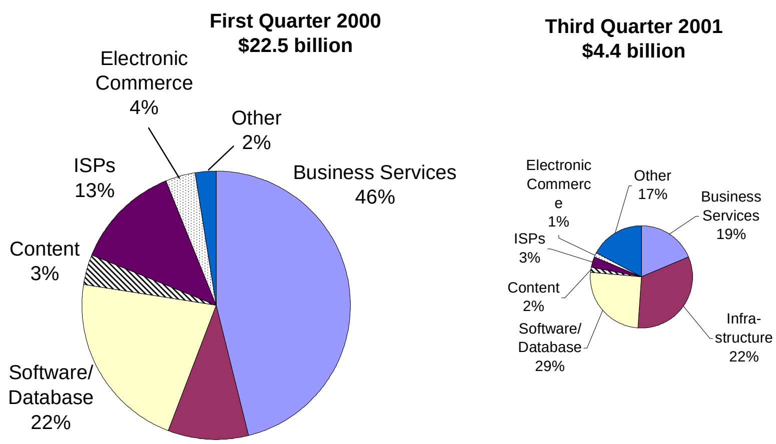
EQUITY FINANCING FOR VENTURE-BACKED COMPANIES BY INTERNET AND NON-INTERNET BUSINESSES

FIRST QUARTER 1999 TO THIRD QUARTER 2001



Source: VentureOne and PricewaterhouseCoopers.

Figure 2.4
EQUITY FINANCING FOR VENTURE-BACKED COMPANIES BY TYPE OF INTERNET BUSINESSES
FIRST QUARTER 2000 AND THIRD QUARTER 2001



Source: VentureOne and PricewaterhouseCoopers.

backed companies raised less money in the third quarter of 2001 than in any period since the first quarter of 1999 and the proportion of those funds going to Internet-related companies fell to 68 percent.[7] (It should be noted, however, that the amount of venture capital invested in 1999 was higher than the total invested in the prior three years combined, with most of that increase due to investments in Internet-related startups.)

The majority of Internet-related venture capital has not gone to the electronic commerce sites that received much of the publicity during the heyday of dot-com mania. Rather, these funds were invested in firms that provide goods and services to other firms—traditional as well as other Internet businesses. Although the sector distribution of venture financing has shifted from the peak in the first quarter of 2000 to the most recent quarter available (third quarter 2001), as shown in Figure 2.4, the fact remains that very little venture capital investment was ever made in electronic commerce firms.

Hurdles Facing Online Businesses

To date, the Internet has been far less successful as a transaction medium than many early observers thought it would be. Online sales, whether to individuals or between businesses, remain at relatively low levels in most industries. The slower than expected take-up could, and perhaps should, be viewed as an indication of the hurdles facing organizations when they attempt to incorporate a powerful new technological tool into personal, business, and government processes.

Online Sales in Perspective. Current data show that although an ever-growing number of Americans are using the Internet, their online purchases remain only a small percent of their total purchases. For the eight quarters during which the Census Bureau has been tracking the growth in e-commerce sales by retail sales establishments, the proportion of total retail sales accounted for by e-commerce has remained very small—at roughly one percent of total retail sales.[8]

These data show that online sales grew from $5.2 billion in the fourth quarter of 1999 to $8.9 billion in the fourth quarter of 2000, an increase of 67 percent. However, by the third quarter of 2001,

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[7] *VentureOne press release, "Venture Capital Continues Steady Decline in Q3 2001," October 31, 2001. (http://www.v1.com).*

[8] *E-commerce sales by retail establishments are only one part of the business-to-consumer online sales. Not included in these estimates are other types of consumer purchases made by nonretail establishments, such as airline tickets and online brokerage services. E-commerce sales are collected from the seller and not categorized by type of buyer. Retail sales estimates therefore include sales made by retail establishments to parties such as small businesses in addition to purchases by individuals.*

online sales of retail firms had declined to $7.5 billion. Since these online sales had not kept up with retail in general, the proportion of retail accounted for by online sales dropped slightly from a high of 1.1 percent during the fourth quarter 2000 to 0.9 percent in the third quarter of 2001.[9]

Although they provide a very up-to-date accounting of retail e-commerce, these quarterly statistics deal with only a portion of the economy engaged in electronic commerce. Data derived from the Census Bureau's 1999 annual surveys provide more complete coverage. Released in March 2001, the *E-Stats* report covers establishments operating in the manufacturing, merchant wholesales, retail, and selected services industries. As shown in Figure 2.5, 1999 e-commerce transactions accounted for a relatively substantial portion of total shipments by manufacturers (12.0 percent) and total sales by wholesale merchants (5.4 percent). These are industries that predominantly sell to other businesses. The sectors where individual purchasers play the larger role, retailers and selected service providers, have much lower proportions of e-commerce transactions (0.5 percent and 0.6 percent, respectively).[10] Taken together, these data provide evidence of uneven, though widespread e-commerce uptake.

Online sales to individuals remain at levels low enough to explain why some of the dot-coms' targeting individuals failed—the market is not large enough to support the number of competitors that arose. However, the relatively high percentage of e-commerce undertaken in the manufacturing and merchant wholesalers categories translates into significant dollar amounts ($486 billion and $134 billion, respectively). Why then have dot-com failures in firms targeting the business-to-business market also been widespread? Part of the reason may be that much of the volume of online business transactions does not use third-party Internet intermediaries. Rather they are transactions conducted on closed proprietary networked systems that occur between parties that have an established relationship.

E-commerce is particularly widespread among those manufacturing and merchant wholesale industries that have well-established histories of buying and selling electronically, most particularly the transportation equipment manufacturers (NAICS 336) where online shipments comprise 21 percent of total shipments, and drugs and druggists' sundries (NAICS 4222) where online sales accounted for one-third of total sales. (See http://www.census.gov/estats.) These two industries are

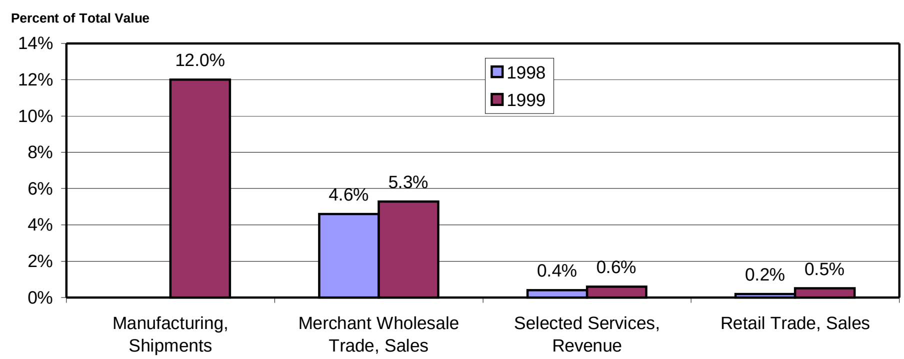
[9] U.S. Bureau of the Census, United States Department of Commerce News, November 28, 2001, http://www.census.gov/mrts/www/current.html.

[10] Data on manufacturers were collected on a special supplement to the Annual Survey of Manufactures and are only available for 1999. Data on wholesale merchants, retail establishments and services were collected for 1998 and 1999 by adding an additional question to established annual surveys for 2000. Total and e-commerce estimates from the various survey programs are not additive because they are not collected on the same basis: Estimates for manufacturing are based on shipments; estimates for wholesale merchants and retailers are based on sales; and estimates for services are based on revenues. These data, including industry detail for each of the four sectors, can be found in the March 2001 E-Stats, *a publication of the Commerce Department's Bureau of the Census. http://www.census.gov/estats.*

Figure 2.5

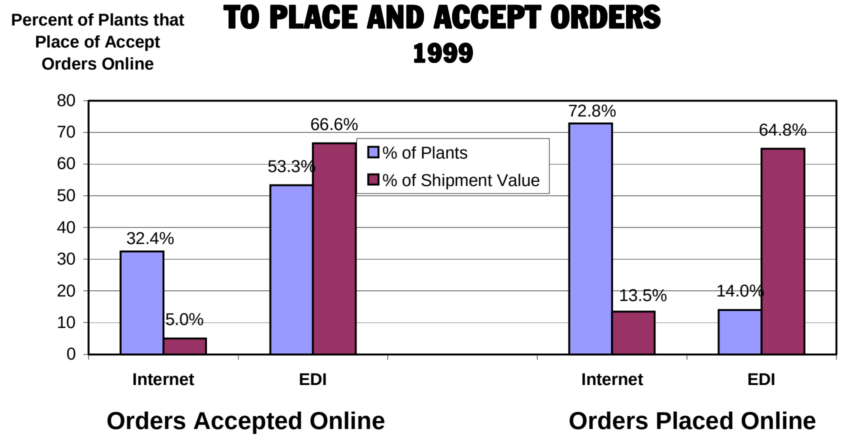
E-COMMERCE AS A PERCENT OF TOTAL VALUE

1998-1999



Source: U.S. Bureau of the Census, E-Stats, March, 2001, http://www.census.gov/estats.

Figure 2.6
MANUFACTURING PLANTS USE OF INTERNET AND EDI TO PLACE AND ACCEPT ORDERS
1999



Source: U.S. Bureau of the Census, E-Stats, June 2001, http://www.census.gov/estats.

examples of industries that have been trading online using electronic data interchange (EDI) systems over value-added networks for decades—well before the beginning of the commercialization of the Internet in 1995. And for many of the firms in these industries, EDI, not the Internet, remains the predominant e-commerce network.

Until recently, technical and cost considerations had generally limited e-commerce (particularly EDI e-commerce) to large volume trade within established supplier/customer relationships. The Internet, however, by providing a low cost, securable platform, makes e-commerce a possibility for many firms, including those in industries categorized by small sales to individuals. Figure 2.6 shows the well-established position of EDI, as well as the growing role of the Internet in manufacturing. Among those manufacturing plants that place or receive orders online, EDI accounts for the majority of the dollar value of shipments—67 percent of the dollar value of orders accepted online and 65 percent of the value of the orders placed online. However, when one considers online transactions by the percentage of plants that use a particular network, the role of the Internet becomes more prominent—32 percent of plants use the Internet to accept online orders and 73 percent of plants use the Internet to place online orders. These data are consistent with the notion of well-established, high-dollar volume EDI relationships particularly among larger plants and a growing interest among plants of all sizes in using the Internet as a sales or purchasing channel even though the dollar value of such transactions is currently small.[11]

Finding a Business Model. "Too few customers" only tells part of the story. There are reasons that individuals and businesses have not flocked to online sales sites. Some Web sites were difficult to use, had high cost, were subject to delivery delays, or made it hard to return merchandise. Some sites also failed because they could not get customers to change their behavior. For example, the model used by online grocery stores required customers to plan ahead rather than choosing and buying groceries on an as needed basis. People, however, have shown themselves reluctant to change their buying habits. Other dot-coms, such as those that hoped to support themselves through subscriptions, have found consumers very reluctant to pay fees. As a result, most non-sales sites have had to rely on advertising revenue. Online content sites (e.g., media, portal, information, and publisher sites), in particular, are dependent on advertising revenues. The most important means for generating revenue among these sites is through paid links (i.e., a button or click-through to advertiser sites) and e-commerce store hosting fees. This

[11] *U.S. Bureau of the Census*, E-Stats: Manufacturing 1999 and mid-2000, *June 8, 2001. http://www/cemsis/gov/estats. To obtain the percent of shipment values, the manufacturing plants included in the survey were asked what type of network was the primary network for making each type of transaction and the total value of all their online transactions were attributed to that network.*

type of arrangement is subject to domino effects, particularly since many of the advertisers have been other dot-com companies.

In some areas, however, the new online business models have proved to be successful, offering serious challenge to traditional providers. Online ticketing of travel, for example, is among the largest volume e-commerce segments, with e-commerce revenues of $5.3 billion or just over 20 percent of total revenues in 1999.[12] Early online entrants in this category, such as Travelocity.com, and Expedia.com, quickly gained market share from traditional travel agencies. More recently, however, these early online entrants are being challenged by the airlines themselves, both directly and through the jointly owned Orbitz.com. Estimates by Media Metrix indicate that Web sites owned by the airlines are gaining new visitors faster than online travel agencies, thereby narrowing the lead of the online travel agencies. Between February 2000 and February 2001, individual visitors to airline Web sites increased 26.1 percent, from 8.2 million to 10.4 million, while visitors to online travel agencies increased 7 percent, from 14.4 million to 15.4 million.[13] While only a portion of these site visits result in ticket sales (visitors may also be checking flight arrival and departure information or just "window shopping"), this increase indicates that the potential pool of online ticket purchasers has increased substantially.

In other industries, the ultimate impact of online businesses on the industries in which they operate is less certain. While Napster was able to attract a large audience to its music-sharing site when the service was free, it is less certain if or when a sufficient base of paying customers will emerge to support a fee-based service.

AN INCREASINGLY NETWORKED WORLD

In spite of the difficulties and uncertainties associated with technological change, individuals and businesses are continuing to move activities online. Having become nearly ubiquitous, the Internet has changed from a technological curiosity to an everyday necessity for a growing number of individuals. Firms in all industries are facing a new competitive reality—one in which the capabilities of IT, particularly network technology, either have already affected or have the potential to affect important facets of almost every business. Furthermore, available evidence suggests that the technological tools that IT users have come to rely on will continue to get better, faster, and cheaper.

Continued Growth of Internet Use by Individuals

The proportion of individuals in the United States using the Internet rose by one-third between December 1998 and August 2000, from 32.7 percent to 44.4 percent. If that trend held, over 50 percent of the U.S. population currently uses the Internet. As shown in Figure 2.7, the increase was evident across all age groups. The increase is also evident across other demographic and economic dimensions, such as race, ethnicity, income, and education.[14] Nor is the Internet a uniquely U.S. phenomenon. As shown in Figure 2.8, several countries in the European Union have higher Internet access rates than the United States.

The pervasiveness of growth in Internet use reflects the diversity of activities that can now occur over this important medium. As shown in Figure 2.9, people are engaging in a growing array of online activities. E-mail was the most prevalent online activity of individuals, and on a percentage point basis, the fastest growing. E-commerce activity played a small, albeit growing role as the proportion of the U.S. population that shops or pays bills online doubled between December 1998 and August 2000.

These data taken together with anecdotal evidence support the notion that the Internet is becoming an integral part of many people's day-today lives. Some of the activities undertaken online are timesavers. Renewing a driver's license or car registration online saves a trip to the Department of Motor Vehicles. Online banking provides a faster alternative to check writing. Others types of activities are improved qualitatively, in addition to being provided more quickly in an online world. Online travel services can provide a variety of pricing and timing options unavailable offline and users can check out destinations that they otherwise would

[12] *U.S. Bureau of the Census, United States Department of Commerce, E-Stats, March 2001.* *http://www.census.gov/eos/www/papers/estatstables.pdf.*

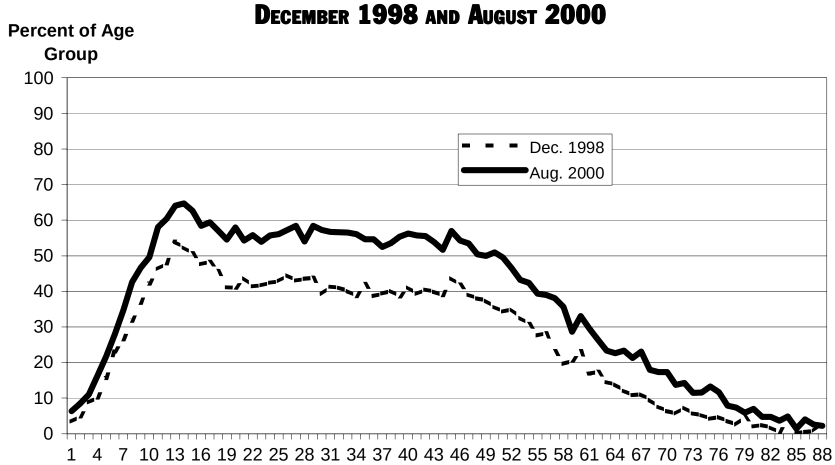
[13] *Jupiter Media Metrix, "Airline Web Sties Pose Threat to Online Travel Agencies," Press Release, April 4, 2001.* *http://www.jup.com/company/pressrelease.jsp?doc=pr010404.*

[14] *U.S. Department of Commerce,* Falling Through the Net: Toward Digital Inclusion, *October 2000.* *http://www.esa.doc.gov.*

Figure 2.7

INTERNET USE BY AGE

DECEMBER 1998 AND AUGUST 2000



Source: U.S. Department of Commerce, Falling Through the Net: Toward Digital Inclusion, October 2000. http://www.esa.doc.gov.

not have considered. Online news services can be quickly searched to find articles of interest. Wedding pictures can be circulated instantaneously to friends and family. Traffic information can be checked before starting the commute home.

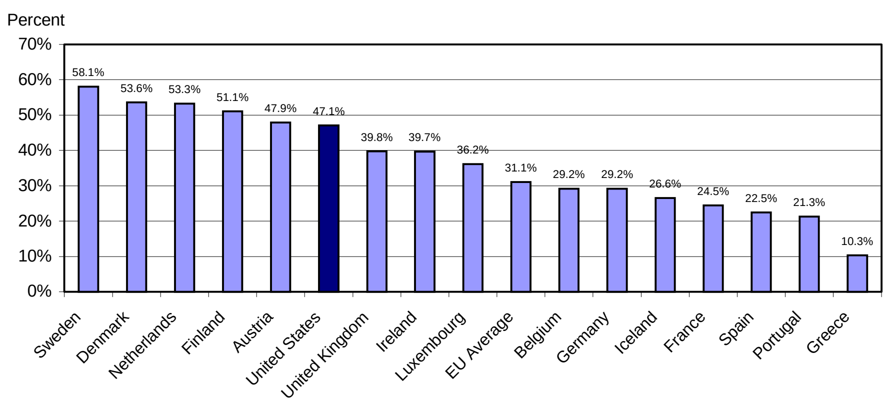
Other online activities create entirely new possibilities. The Massachusetts Institute of Technology recently launched a ten-year initiative to create public Web sites for almost all of its 2,000 courses. The school plans to post all related class materials including lecture notes, problem sets, syllabuses, exams, simulations, and even video lectures.[15] Since this program does not provide access to instructors, labs, or diplomas, it will never be the equivalent of actually attending MIT, but it will of-

[15] *Carey Goldberg, "Auditing Classes at M.I.T., on the Web and Free," The New York Times, April 4, 2001. http://www.nytimes.com. The MIT case is discussed more fully below in Chapter VII.*

Figure 2.8

INTERNET USERS AS A PERCENT OF THE POPULATION EUROPEAN UNION COUNTRIES AND THE UNITED STATES

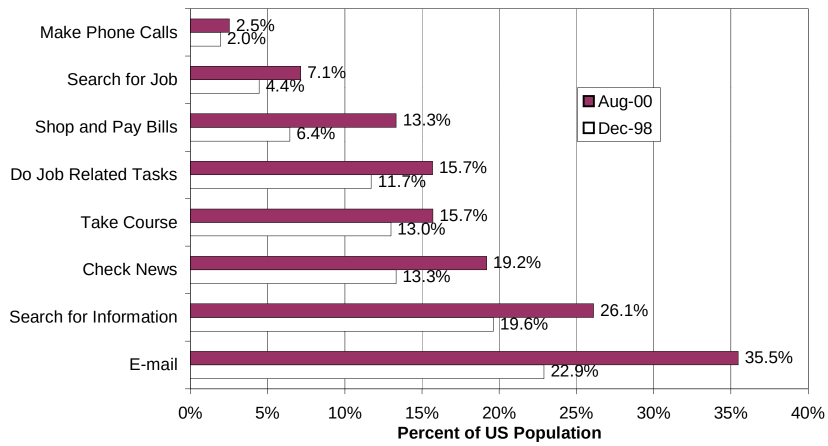
(15 YEARS AND OLDER)



Note: EU country estimates are for February 2001 and US estimates are for August 2000.

Source: European Union, http://europa.eu.int/information_society/eeurope/index_en.htm and U.S. Department of Commerce, Economic and Statistics Administration.

Figure 2.9
ONLINE ACTIVITIES AS A PERCENT OF THE U.S. POPULATION
1998 AND 2000



Source: Falling Through the Net: Toward Digital Inclusion, 2000.

fer anyone with Internet access, anywhere in the world, the opportunity to obtain the basics of a world-class education.

The Internet is even becoming integrated into everyday activities in ways that do not require all participants to be Internet users. For example, some little league baseball teams have team information officers who manage web sites that track schedules, scores, and rankings. While viewing that information requires Internet access, coaches can also use the system to place automated telephone calls to all players and track telephone responses. These and other new applications will be further supported by technology still under development.

Networked Businesses: More Than Online Sales

The Census Bureau's *E-Stats* data presented earlier painted a picture of uneven e-commerce uptake. However, the prospect of increased efficiency, lower costs, improved customer service, and global reach has caused most businesses at least to consider how networking tools, such as the Internet, could be used to increase their competitiveness.

Network technologies are not only enablers of new sales and purchasing channels; they can be used to improve a variety of business processes. Another report from the Census Bureau considered online processes in manufacturing plants.[16] This report, based on a mid-2000 survey, found that almost 90 percent of the respondent plants had some type of computer network in place at the plant and over 80 percent indicated, specifically, that they had Internet access. However, even though a large majority of plants had computer networks, only 31 percent of those plants (representing 41 percent of employment) reported accepting orders online and only 34 percent (representing 48 percent of employment), reported making online purchases. Only 16 percent of reporting plants both accepted orders and made online purchases, while 49 percent did neither.

Among plants responding to the *E-Stats* survey, the most often-reported e-business process was e-mail. Over three-fourths of reporting plants used e-mail to communicate with vendors and customers, while 70 percent used e-mail for employee communications within the plant. Smaller numbers of respondents used other e-business processes, for example, 19.2 percent reported providing online support to customers and 7.1 percent reported engaging in online bidding. Other e-business processes covered in the June 2001 *E-stats* report included, on the sales side, 11.1 percent of responding plants received online payments and 19.2 per-

[16] *U.S. Bureau of the Census*, E-Stats: Manufacturing 1999 and mid-2000*, June 8, 2001. http://www/cemsis/gov/estats.*

cent provided online sales support, and on the buying side, 8.6 percent made online payments and 7.1 percent engaged in online bidding.

The fact that e-business process use in manufacturing plants is not yet widespread suggest that firms are still in the early stages of exploiting the potential of network technologies. Several factors may help to explain why online business processes are not yet widely used in manufacturing plants. Some companies interested in purchasing online may find that their vendors are not yet online or those wishing to sell online may find that their customers are not ready to make a switch to that way of doing business. However, many corporate purchases, particularly purchases of mission critical or custom components, rely on long-standing relationships. There is a degree of trust and a record of dependability that may have been built up over a period of years that purchasing managers are reluctant to abandon.

Finally, moving even a portion of purchasing online is not costless. Purchasing activities must be integrated with the firm's other internal electronic activities. The learning curve may be steep and training cost considerable. Nonetheless, competitive pressures will likely drive greater volume to this trading channel if companies continue to see savings from online purchasing. Reported savings are considerable. For example, Raytheon Company, a manufacturer of electronics and aviation equipment, reported savings of 25 percent on $100 million worth of goods purchased at three online auctions.[17] However, not all participants in online marketplaces are as satisfied. In one recent survey, only 10 percent of companies participating in online exchanges felt that the exchanges had met their expectations. In general, participants agreed that organizational changes, such as standardizing and developing new procedures, improving and introducing new technology systems and introducing integration technology, are needed to capture benefits from exchanges.[18]

Shifting other business processes online, such as warehouse management systems, bring additional upfront costs and concerns as companies cope, not only with integrating their various systems internally, but integrating systems between companies. While technology may one day make this integration process easier and cheaper, at present interface difficulties remains a major barrier to firms realizing the full benefits of electronic business processes.[19]

Continued Technological Innovation

The foundation technologies of the digital economy—processing power, data storage, and data transmission—are dramatically more powerful now than they were only a decade ago. Furthermore, all evidence suggests that the rate of increase in the raw capabilities of these technologies will continue. However, today's online activities do not completely tap the capabilities of today's IT tools. Slow Internet connection speeds for many businesses and individuals are a particular bottleneck.

Technological Foundations. As shown in Figure 2.10, processing power has doubled roughly every 18 months. This has resulted in super computers and personal computers with processing power that is orders of magnitude greater than computers manufactured only a few decades ago. There is, however, no guarantee that this rapid growth in processing power will continue. As the number of transistor per chip grows, chip making becomes technically more difficult and more expensive. However, industry participants are working towards new chip production processes based on new lithography technologies that would keep costs down and enable the continuation of today's processing power trends.[20]

In the meantime, researchers have begun developing a techniques to get more computing power out of existing resources. For example, "grid" or "distributed" computing take advantage of unused processing power across various computer networks, such as an office computer network or even from across the Internet. In grid computing, a central computer parses a problem into discrete components and distributes the computational work over and array of networked computers. Each of

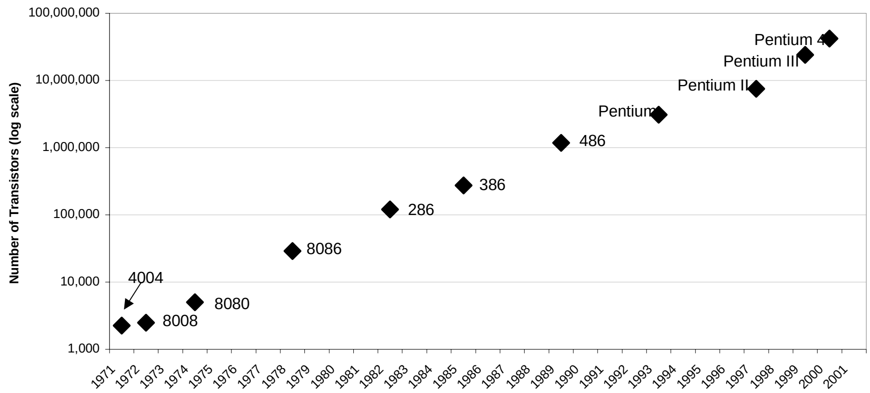
[17] *Bob Tedeschi, "E-Commerce Report: Companies in No Hurry to Buy Over the Internet,"* The New York Times*, March 5, 2001. http://www.nytimes.com.*

[18] *Giga Information Group/Booz Allen Hamilton Study: B2B Exchanges Not Yet Delivering Benefits, News Release, November 19, 2001. http://www.Gigaweb.com.*

[19] *James Aaron Cooke, "Making the Right Connections,"* Logistics Management & Distribution Report *from Logistics Online, February 2001. http://www.manufacturing.net/magazine/logistic/archives/2001/lm0201.01/lm0201system.htm.*

[20] *Gary Stix, "Getting More for Moore's Law," Scientific American, April 2001 (www.sciam.com/2001/0401issue/0401innovations.html)*

Figure 2.10
GROWTH IN PROCESSING POWER
1971 - 2001



Source: Intel (http://www.intel.com/research/silicon/mooreslaw.htm).

the networked computers computes its portion of the project and sends the completed work back to the main computer. The result is massive total processing power achieved not through better hardware, but through software coordination of existing hardware. The Departments of Defense and Energy, the National Science Foundation (NSF), and the National Aeronautics and Space Administration are each financing grid projects.[21] The NSF granted $53 million to fund TerraGrid, a "grid" computing project that will link four U.S. supercomputer sites.[22]

In the longer term, quantum computing—using circuits created out of individual molecules—has the potential to yield advances in processing power that dramatically exceeds what is possible today. If realized these molecular-scale processors would enable the development of computers capable of addressing computational problems that are, for all practical purposes, unsolvable using current technologies.[23] Even in today's environment where investors are skeptical of technology investments, quantum computing and other nanotechnology research appears to be drawing investment money.[24]

Transmission speeds are also on the rise. Transmission speeds over fiber optical cable have been doubling every 12 months. French and Japanese companies have each announced experimental results in which they transmitted more than 10 trillion bits per second through a single optical fiber.[25] Researchers are also working on developing all-optical networks, which would even further increase transmission speeds by eliminating the current requirement of converting optical signals to electronic signals to route them.[26]

Advances in digital data storage technologies have taken place concurrently with those in data processing and communications technologies. Disk capacities have been doubling every nine months.[27] As in the case of processing power, these advances have also come at decreasing costs. The price per megabyte for hard-disk drives fell from $11.54 in 1988 to $0.04 in 1998, and an estimated $0.01 in 2000.[28] (Figure 2.11) There also has been a proliferation of inexpensive and portable consumer-oriented digital data storage technologies. [29]

Overcoming the Broadband Bottleneck. While the transmission speed of communications technologies, such as fiber optics, is increasing, these high-

[21] *Steve Lohr, "I.B.M. Making a Commitment to Next Phase of the Internet," New York Times, August 2, 2001.*

[22] *Jeffrey Benner, "A Grid of Supercomputers,* Wired News*, August 9, 2001 (www.wired.com/news/business/0,1367,45977,00.html?tw=wn20010810).*

[23] *"Quantum Dreams,"* The Economist*, March 7, 2001 (www.economist.com).*

[24] *"The Smaller the Better,"* The Economist*, June 21, 2001 (www.economist.com/science/tq/displayStory.cfm?Story_ID=662220).*

[25] *Jeff Hecht, "Fiber Crosses the 10-Trillion-Bit Barrier,"* Technology Review*, March 27, 2001 (http://www.technologyreview.com/articles/hecht032701.asp).*

[26] *Peter Heywood, "Optical Networking In Five Easy Pieces,* Business Communications Review*, May 2000.*

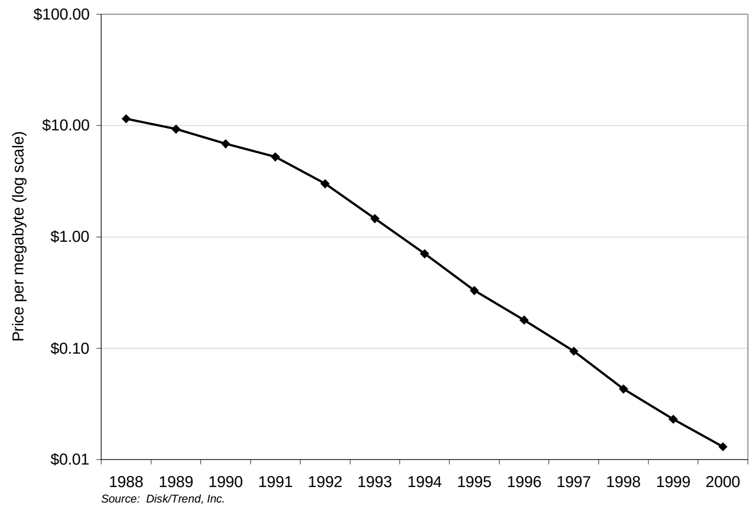
[27] *Jon William Toigo,* Avoiding a Data Crunch*, Scientific American, May 2000, (http://www.sciam.com/2000/0500issue/0500toig.html).*

[28] *Correspondence with James N. Porter, Disk Trend, on October 1, 2001.*

[29] *Michael Marriott, "In the Storage Race, Will Consumers Win?"* The New York Times*, April, 5, 2001.*

Figure 2.11

DRAMATIC DECLINES IN THE COST OF DIGITAL DATA STORAGE
ILLUSTRATED BY FALLING AVERAGE COST PER MEGABYTE IN HARD DISK DRIVES



speed technologies are not distributed throughout the networking infrastructure. This creates transmission bottlenecks.

The most dramatic advances in transmission capacity can be seen in long-haul infrastructure, which is largely constructed using fiber optic cable. Because of the costs associated with installation, however, fiber is generally not used in the “last-mile” connections to homes and businesses.[30] In time, fiber may be used to bridge the last-mile. Today, however, communications companies are trying to provide higher bandwidth communications by upgrading existing infrastructure.[31] Most home and businesses already have at least one communications line that can be upgraded to provided high-speed Internet access. At the close of 2000, there were 5.2 million residential and small business subscribers to high-speed communications lines in the United States.[32]

In addition, broadband wireless communications—e.g. satellite and “fixed-wireless” technologies, such as LMDS (Local Multipoint Distribution Service) and MMDS (Multipoint Microwave Distribution System)—can substitute for broadband home access. Communications companies are also developing broader bandwidth wireless networks for mobile use.

Wireless communications networks, however, have bottleneck problems of their own. At present, wireless data applications are relatively rudimentary because most wireless networks still operated at low bandwidths. Today’s fastest wireless (“second generation wireless”) data transfer rates are about 14 Kb/sec or four times slower that the average dial-up connection.[33]

Although there have been many press reports about the “third generation” (3G) wireless, promising speeds as much as 150 times faster than current data rates, the combination of a slow economy and the technological complexity of 3G has caused many communications companies to delay their 3G deployment plans. Faster wireless bandwidth will ultimately be deployed, but 3G has been temporarily set aside for interim technologies that exploit the existing wireless infrastructure.

[30] A few communications companies have instituted trials of “fiber to the curb” and “fiber to the home” in new housing developments.

[31] The diffusion of broadband depends largely on the communications section—a sector that is fundamental to the Internet and the IT-driven changes that are underway and a sector that is being wracked by both these new forces and the current economic slowdown.

[32] Federal Communications Commission, “Federal Communications Commission Releases Data on High-Speed Services for Internet Access,” Press Release, August 9, 2001 (http://www.fcc.gov/Bureaus/Common_Carrier/News_Releases/2001/nrcc0133.txt).

[33] “Sprint Leads Evolution to 3G with Nation’s Clearest, Fastest, Most Economical Migration Strategy, “PR Newswire, *March 20, 2001.*

Outstanding Policy Issues

Adopting network technologies has proved more challenging then many observers originally thought. Not only have businesses, governments, and individuals had to cope with rapidly changing technology, uncertain business models, and shifting economic conditions, but a variety of public policy concerns have proved difficult to address.

One of these is privacy. In order to provide service to customers, online businesses must be able track the customer at least from the point at which the customer signals they want to make a purchase. Privacy concerns focus on the uses of that customer information beyond the point of that immediate need.

Businesses operating online also face specialized variants of consumer concerns in the area of security, authentication, and fraud. Security (*e.g.*, protecting credit card numbers from misuse) and authentication (*e.g*. verification of a seller's identity) are concerns that are being addressed by a combination of encryption technologies and legislation, such as the consumer consent provision of the Electronic Signatures in Global and National Commerce Act (ESIGN). Fraud, in particular, remains a source of concern—particularly Internet auction fraud, which has accounted for 64 percent of all Internet fraud reported to the Internet Fraud Complaint Center (IFCC).[34]

CONCLUSION

As the 1990s closed, the marketplace was littered with failed ideas related to the provision of some good or service over the Internet. Some were unsustainable business plans—there was no way to generate enough revenue to cover costs, much less make a profit. Others did not pass the test of the market—business and consumers simply did not want or need the products and services at the price offered. Today, the environment is much more cautious and there is a great deal of uncertainty about what businesses and consumers do on the Internet, what products and services they want, and what they will be willing to pay for them. The continual barrage of reports on Internet use and opinion surveys attests to the effort underway to divine the Internet's future.

The digital technology revolution has not ended, but the costs of change are easier to see. The uptake of technologies has been slower and more uneven than expected as businesses sift through a myriad of options to find IT solutions suited to their needs. Numbers of dot.com companies have closed their doors; but many more remain.

If we consider the history of other technological revolutions, none of this should be a surprise. Of nearly 1,000 U.S. companies that tried to build and sell gas-powered automobiles before 1927, only 200 survived long enough to bring a commercially suitable vehicle to market.[35] Of these, fewer than a handful operate today, but they account for a substantial share of a much larger economy. The lesson is that technological revolutions take time, and the digital technology revolution has barely begun. Throughout the current economic slowdown and retrenchment in the dot.com sector, U.S. companies have expanded their use of IT and networking technologies in a continuing search for competitive advantage. More slowly than we might have predicted, but no less relentlessly, these efforts are transforming our economy and our lives.

[34] The Internet Fraud Complaint Center "Internet Auction Fraud," May 2001. The IFCC is a partnership between the Federal Bureau of Investigation (FBI) and the National White Collar Crime Center (NW3C). (http://www.ifccfbi.gov/strategy/pressroom.asp).

[35] Lawrence H. Seltzer, A Financial History of the American Autoas cited in General Motors, "Competition and the Motor Vehicle Industry," a Study submitted to Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary of the United States, April 10, 1974.

Chapter III

Information Technology Industries in the New Economy

*by David Henry and Donald Dalton**

The second half of 2000 marked a turning point in recent U.S. economic experience. GDP growth decelerated sharply from 4 percent (annualized) in the first half of 2000, to 1-1/2 percent in the second half of that year. In the third quarter of 2001, for the first time since 1992, the U.S. economy began to decline.

Though the speed of these events was surprising, economists had long anticipated a slowdown and suggested that its arrival would test broadly held notions about the long-term strength of the digital economy. In March 2000, Nobel Laureate Robert Solow observed that he would "feel better about the endurance of the productivity improvement after it [had survived] its first recession."[1]

This chapter is written during, rather than after a recession, and in the wake of an event that has deeply clouded the nation's near-term economic future. In the midst of uncertainty, the chapter's method is to seek clues about the way ahead by looking carefully at the way we have come. Simply put, its question is what can the last seven quarters of economic experience tell us about effects of IT on America's long-term economic strength?

The chapter looks particularly at recent changes in industry contributions to U.S. economic growth, recent developments in the composition of investment, and changing patterns of private sector R&D. It finds that IT-producing industries continued in 2000, as in prior years, to contribute disproportionately to overall economic growth. At the same time, sharply declining business demand for IT capital equipment and software accounted for much of the slowdown in overall growth that began in mid 2000.

Strength in IT-producing industries, however, is only one indicator of a new economy.[2] A second measure is the diffusion and increasingly productive use of IT goods and services both inside and outside the IT producing sector. Here, events of the last 2 years give reasons for optimism. While the rate of IT investment has fallen sharply, American businesses are still adding to the nation's IT capital stock. Moreover, businesses are continuing to deploy more products and services (*e.g.*, software and computer services) that can facilitate productive use of the IT hardware that has already been installed.

Together with the analyses in other chapters (especially Chapter IV on the contributions of non-IT producing industries to accelerated productivity growth), these findings suggest that even in this period of cyclical slowdown, U.S. industries

Mr. Henry is a senior industry analyst and Mr. Dalton is an economist in the Office of Business and Industrial Analysis, Office of Policy Development, Economics and Statistics Administration.

[1] *Louis Uchitelle quotes Solow in "Productivity Finally Shows the Impact of Computers,"* New York Times, *New York, March 12, 2000.*

[2] *We define the "new economy" as an economy in which IT and related investments drive higher rates of productivity growth. U.S. experience in the late-1990s suggests that new economies are capable of long periods of rapid growth with low inflation and low unemployment. Events since July 2000 indicate that IT-related changes in the organization of production and the composition of employment also support atypically high rates of productivity growth in periods of economic slowdown.*

are continuing to discover and exploit IT's productive potential and to create the foundations of a structurally stronger economy.

In this chapter and throughout the report, IT-producing industries are defined as producers of goods and services that support IT-enabled business practices and processes across the economy, as well as the Internet and e-commerce. (The Appendix to Chapter 3 includes a more complete discussion of this definition.) The industries meeting these criteria are listed below. (Box 3.1.)

The chapter is divided into three major sections—the first examines output growth in the IT-producing sector during 2000 and its relation to the performance of the rest of the economy; the second looks at categories of demand for IT goods and services for the seven quarters ending in September 2001 (*i.e.*, patterns of business investment, but also consumer and government purchases of IT goods and services); and the third considers recent changes in the composition of corporate R&D.

OUTPUT GROWTH IN IT PRODUCING INDUSTRIES AND IT'S RELATIONSHIP TO THE ECONOMY AT LARGE 1996-2000

IT Industries' Contribution to Economic Growth—1996-2000

In nominal and real (inflation adjusted) dollars, output[3] from IT-producing industries as a group continued to grow at double-digit rates in 2000. (Tables 3.1 and 3.2) Growth was particularly strong in software and services, and communications equipment.

[3] *Output as measured by its Gross Product Originating (GPO). GPO equals an industry's total output less the cost of goods and services used to produce it. See the Appendix for a more detailed explanation of GPO and why it is used here.*

Box 3.1

INFORMATION TECHNOLOGY PRODUCING INDUSTRIES

Hardware Industries

Computers and equipment
Wholesale trade of computers and equipment
Retail trade of computers and equipment
Calculating and office machines
Magnetic and optical recording media
Electron tubes
Printed circuit boards
Semiconductors
Passive electronic components
Industrial instruments for measurement
Instruments for measuring electricity
Laboratory analytical instruments

Software/Services Industries

Computer programming services
Prepackaged software
Wholesale trade of software
Retail trade of software
Computer-integrated system design
Computer processing, data preparation
Information retrieval services
Computer services management
Computer rental and leasing
Computer maintenance and repair
Computer related services, nec

Communications Equipment Industries

Household audio and video equipment
Telephone and telegraph equipment
Radio and TV communications equipment

Communications Services Industries

Telephone and telegraph communications
Cable and other TV services

** Although Radio and TV broadcasting industries were included as IT-producing industries in prior Digital Economy publications, they are not included in this report because they are now considered "content" providers, not IT infrastructure producing sectors.*

Adjusted for inflation, output growth in IT-producing industries in 2000 was nearly 20 percent—roughly the same rate as in the previous four years. (Table 3.2) Growth in communications equipment jumped to almost 29 percent—near its 1997 peak. Growth in IT hardware, though down from its peak in 1998, remained exceptionally strong (28 percent).

During 2000, despite the overall economic slowdown, businesses continued to build real net capital stocks[4] of information processing equipment and software at about the same rate as in the prior four years. (Table 3.3) However, this aggregate stability masked a considerable shift in the composition of investment. Growth in the net stock of computer capital slowed dramatically, while additions to the net stock of software continued at about the same rate as in 1999, and additions to the net stock of communications equipment sharply accelerated. (Analysis in Chapter I indicates that U.S. businesses continued to add to net IT capital stocks in 2001, though at a much slower rate.)

In 2000, IT-producing industries continued as in 1996-99 to play an important role in economic growth. During 1996-99, when the economy grew by an average 4 percent, the IT-producing sector, which accounted for an average annual 7 percent of GDP, grew by an average 22 percent per year (in inflation adjusted dollars), and was responsible for an average 29 percent of the

[4] Real net capital stock equals the value of installed capital, plus new investment, minus depreciation.

TABLE 3.1: IT-PRODUCING INDUSTRIES, BY SECTOR: GROSS PRODUCT ORIGINATING (GPO)

	1996	1997	1998	1999	2000
			($Billions)		
Total	**522.0**	**588.4**	**646.9**	**718.2**	**796.6**
Hardware	171.1	197.5	210.9	225.4	251.7
Software and services	131.5	153.9	185.6	214.0	245.7
Communications equipment	32.4	43.9	46.7	51.4	61.5
Communications services	186.9	193.2	203.7	227.4	237.8
			(Annual Change – Percent)		
Total	**10.8**	**12.7**	**9.9**	**11.0**	**10.9**
Hardware	10.1	15.4	6.7	6.9	11.7
Software and services	18.1	17.0	20.6	15.3	14.8
Communications equipment	5.4	35.3	6.4	10.1	19.6
Communications services	7.8	3.4	5.4	11.6	4.6

Source: ESA estimates derived from BEA and Census data.

TABLE 3.2: IT-PRODUCING INDUSTRIES, BY SECTOR: REAL GPO GROWTH

	1996	1997	1998	1999	2000
			(percent)		
Total IT-producing	**22.7**	**20.0**	**24.7**	**20.7**	**18.5**
Hardware	46.9	43.4	50.4	32.4	28.1
Software and services	13.6	6.1	24.2	12.0	13.5
Communications equipment	24.0	35.3	23.2	19.7	28.8
Communications services	9.4	2.6	9.4	18.0	11.9

Source: ESA estimates derived from BEA and Census data.

TABLE 3.3: NET STOCKS OF INFORMATION PROCESSING EQUIPMENT AND SOFTWARE

	1996	1997	1998	1999	2000
Information processing equipment	(Billions of chained (1996) dollars)				
and software	**906.0**	**1,010.8**	**1,141.7**	**1,287.2**	**1,464.8**
Computers and equipment	101.5	144.5	204.4	284.7	307.0
Software	173.7	201.9	238.1	275.2	315.2
Communication equipment	363.8	393.0	430.2	478.5	549.4
Instruments	175.0	182.1	191.4	200.7	209.8
Information processing equipment	(percent change)				
and software	**10**	**12**	**13**	**13**	**14**
Computers and equipment	39	42	41	39	8
Software	12	16	18	16	15
Communication equipment	7	8	10	11	15
Instruments	5	4	5	5	5

Source: Bureau of Economic Analysis

country's overall real economic growth. In 2000, when the economy also grew rapidly, the IT-producing sector, now 8 percent of GDP, grew by 19 percent and accounted for 26 percent of real economic growth. (Table 3.4)

IT Investment Spending in the Current Economic Slowdown

Experience since the beginning of 2001 suggests that the dynamism of IT-producing industries is double-edged. Just as the extraordinary growth in these industries made their share of overall growth much larger than their share of the economy in the period before December 2000, so rapidly slowing demand for IT capital goods has contributed substantially to economic weakness in 2001. (Table 3.5) During the first three quarters of 2001, for the first time in a decade, reductions in business spending on information processing equipment and software had a negative effect on economic growth.[5] Because real information processing (IP) business spending was essentially unchanged between the third and fourth quarter of 2001, it made no contribution up or down to growth in the fourth quarter.

DEMAND FOR IT GOODS AND SERVICES THROUGH THE THIRD QUARTER OF 2001

Business Investment

Despite slowing output growth and slower growth in business investment overall, business spending on information processing equipment and software continued to grow at double-digit rates through end of 2000. In the first quarter of 2001, however, demand for IT equipment and software turned sharply negative, declining by 14 percent (at an annual rate). This was the first decline in business spending for IT equipment since mid-1990 when such spending declined at a 4 percent annual rate and quickly recovered. Business investment for IT equipment and software continued to decline at double-digit annual rates in the second and third quarters of 2001, before flattening in the fourth quarter. (Table 3.6)

Nonetheless, because IT spending remained strong through the end of 2000, unlike other investment, IT investment contributed more than four-fifths of the 11-percent growth in total real U.S. equipment and software spending for 2000 as a whole. (Table 3.7)

The decline in business investment in the first three quarters of 2001 was led by a precipitous drop in IP business investment. (Table 3.8) The stabilization of real IP business investment in the

[5] This chapter's analysis of annual data through 2000 has used total U.S. IT industry output sold to business, government, consumers, and export markets. To examine 2001, however, because industry output data are not yet available, we must turn to current quarterly data on U.S. business investment spending. These data are the best available proxy for current trends in the U.S. IT industry, but have important limitations: they not only exclude government and consumers, but also business spending on intermediate IT inputs; they also include imports for business investment and exclude exports. Nonetheless, because U.S. business spending for investment represents the largest single market for IT producers' output, it provides a useful indication of the importance of IT in 2001.

TABLE 3.4: CONTRIBUTION TO REAL ECONOMIC GROWTH

	1996	1997	1998	1999	2000
(1) Changes in Real			(Percent)		
Gross Domestic Income*	3.5	4.5	5.0	4.5	4.7
			(Percentage Points)		
(2) IT Contribution	1.1	1.1	1.5	1.2	1.2
(3) All Other Industries	2.4	3.4	3.5	3.3	3.5
(4) IT Share of			(Percentage Share)		
GDI change (2)/(1)	32	25	29	28	26

**GDI is equal to the income that originates from the production of goods and services in the U.S.*

Sources: ESA estimates derived from BEA and Census data.

TABLE 3.5: BUSINESS SPENDING ON INFORMATION PROCESSING EQUIPMENT AND SOFTWARE: CONTRIBUTION TO GDP GROWTH

(Annualized rates)

	2000				2001			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
(1) Change in real				(Percent Change)				
Gross Domestic Product	2.3	5.7	1.3	1.9	1.3	0.3	-1.3	0.2
				(Percentage Points)				
(2) Business spending on information								
processing equipment and software (IPE&S	1.2	0.9	0.6	0.6	-0.6	-1.0	-0.5	0.0
(3) All other spending in the economy	1.1	4.8	0.7	1.3	1.9	1.2	-0.8	0.2
(4) IPE&S share of				(Percentage Share)				
GDP change (2)/(1)	52	16	46	32	-46	-333	38	0

Source: ESA calculations using BEA data.

TABLE 3.6: REAL BUSINESS SPENDING ON EQUIPMENT AND SOFTWARE

(2000-2001, by Quarter)

	2000				2001			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
				(Billions of chained (1996) dollars)				
Total Equipment and software	**1,058.3**	**1,089.6**	**1,102.3**	**1,099.3**	**1,087.7**	**1,043.2**	**1,019.4**	**1,005.9**
IT Equipment and Software	573.6	601.5	621.0	641.8	620.9	588.1	572.1	572.9
Industrial Equipment	159.0	160.5	165.1	165.6	170.7	161.2	151.3	146.7
Transportation Equipment	200.6	200.8	193.2	176.2	177.4	174.4	174.0	171.8
Other	141.8	146.7	146.1	144.1	143.3	141.1	142.3	137.1
				(percent annualized change from previous quarter)				
Total Equipment and software	**18.1**	**12.4**	**4.7**	**-1.1**	**-4.2**	**-15.4**	**-9.1**	**-5.3**
IT Equipment and Software	31.3	20.9	13.6	14.1	-12.4	-19.5	-10.9	0.6
Industrial Equipment	28.3	3.8	12.0	1.2	12.9	-20.5	-22.4	-12.2
Transportation Equipment	-4.3	0.4	-14.3	-30.8	2.8	-6.6	-0.9	-0.2
Other	5.5	14.6	-1.6	-5.4	-2.2	-6.0	3.4	-14.6

Source: Bureau of Economic Analysis

fourth quarter resulted from a hefty rebound in computers offset by continued weakness in communications equipment.

Demand for IT Other Than Business Investment

In assessing demand for IT, it is important to note that data for business spending for information processing equipment and software capture only expenditures counted as investment. They do not encompass business spending for intermediate IT goods and services (e.g., communications services), consumer spending, government consumption, and international trade. These other sources of demand for IT goods and services are substantial.

In 2000, business investment in IT equipment and software totaled $467 billion. In addition, we estimate that businesses spent a further $258 billion on communications services, which are not counted as investments. (Table 3.9) Consumers spent another $165 billion on computers and communication services and government spent about $20 billion. Imports of IT goods and services exceeded exports by about $76 billion. (See Chapter VI.)

Moreover, in contrast to business investment, personal and government consumption of IT-goods and services tend to be relatively constant. During the first three quarters of 2001, while business expenditures for information processing equipment and software declined, personal

TABLE 3.7: CONTRIBUTION OF IT EQUIPMENT AND SOFTWARE* TO GROWTH IN CAPITAL EQUIPMENT AND SOFTWARE SPENDING

	1996	1997	1998	1999	2000	2001
			(Percent)			
(1) Change in real spending for capital equipment	11.0	13.3	14.6	11.8	11.7	-14.0
			(Percentage Points)			
(2) Contribution of real spending on IT equipment	7.6	9.1	9.7	7.8	9.5	-4.9
(3) Contribution from all other types of capital equipment	3.4	4.2	4.9	4.0	2.2	-9.1
			(Percent)			
(4) IT contribution to the change in real capital equipment spending	68.7	68.4	66.6	66.4	81.4	34.7

**Defined by BEA as information processing and related equipment*

Source: Bureau of Economic Analysis

TABLE 3.8: REAL BUSINESS SPENDING ON INFORMATION PROCESSING EQUIPMENT AND SOFTWARE, BY TYPE

	2000				2001			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
				(Billions of chained (1996) dollars)				
Total IT Equipment and Software	**573.6**	**601.5**	**621.0**	**641.8**	**620.9**	**588.1**	**572.1**	**572.9**
Computers/peripheral equipment	253.9	284.5	305.2	317.6	314.4	287.3	265.7	289.2
Software	181.0	183.5	189.7	196.0	192.9	191.1	193.1	191.3
Communication equipment	124.2	131.5	132.2	137.7	122.6	107.4	99.7	94.6
				(percent annualized change from previous quarter)				
Total IT Equipment and Software	**31.3**	**20.9**	**13.6**	**14.1**	**-12.4**	**-19.5**	**-11.8**	**0.5**
Computers/peripheral equipment	43.9	57.6	32.4	17.3	-4.0	-30.3	-30.1	35.4
Software	14.4	5.6	14.2	14.0	-6.2	-3.7	4.2	-3.7
Communication equipment		25.7	2.1	17.7	-37.2	-41.1	-25.7	-18.9

Source: Bureau of Economic Analysis

demand and government consumption of IT goods and services remained quite stable, increasing in each case by 1 to 2 percent. In addition, while data on business spending for expensed IT goods and services (*e.g.*, communications and computer services other than software) are not available, this spending tends to be less discretionary and, therefore, also more stable than investment

TABLE 3.9: SPENDING FOR IT GOODS AND SERVICES*, 2000

Major Activity	2000
	($billions)
Business Investment	466
Business spending on communications	258**
Personal consumption	165
Government consumption	20
Exports	166
Imports	242

* *Other than business investment and trade, spending by the other major activities do not encompass all spending on IT, but are provided here to give a sense of the importance of other sources of IT demand.*

** *Intermediate industry demand is not counted as final demand in GDP and therefore, it cannot be added to other major activities in this table.*

Sources: ESA estimates using BEA data and University of Maryland INFORUM model results.

TABLE 3.10: COMPANY FUNDED R&D SPENDING

	1997	1998	1999	2000	1997-2000
		($billions)			(AA %*)
Total R&D, including Federal	**212.4**	**226.9**	**244.1**	**264.2**	**7.5**
All Industries	**133.6**	**145.0**	**160.3**	**180.4**	**10.5**
Manufacturing	101.2	102.2	99.9	110.8	3.2
Non-manufacturing	32.4	42.8	60.4	69.7	29.5
IT-Producing**	**37.3**	**40.4**	**37.6**	**48.0**	**9.7**
IT-Hardware	25.0	26.4	21.3	29.5	8.3
Computers	7.7	8.3	4.1	5.2	-5.3
Communication equipment	2.8	8.4	5.8	11.2	87.4
Semiconductors and electronic components	14.0	9.1	10.6	12.8	0.7
Other electronics	0.5	0.6	0.8	0.3	-3.1
IT-Services**	12.3	13.9	16.3	18.5	14.6
Software publishing	7.2	9.2	10.9	12.6	20.6
Computer systems design	3.0	2.9	4.0	4.9	19.0
Telecommunications***	2.1	1.8	1.4	1.0	-21.7
			(percent)		
IT-Producing Share of Industry R&D	28.0	28.0	23.4	26.6	

* *Average annual percent change*
** *Data collected using NAICS categories*
*** *Includes broadcasting*

Source: National Science Foundation

spending. (See Employment chapter that shows IT service employment is much more stable than IT goods employment.)

R&D SPENDING IN THE NEW ECONOMY

During the 1990s, the surge in business investment in capital equipment was accompanied by sharp increases in R&D investment in the economy as a whole and IT-producing industries in particular. Between 1994 and 2000[6], total U.S. R&D investment grew at an annual average inflation-adjusted rate of 6 percent, in contrast to roughly 0.3 percent between 1988 and 1994. Patents, another indicator of innovation, grew at an annual rate of 8.6 percent after 1994, compared with a sluggish growth rate of 1.2 percent between 1988 and 1994.

Between 1997 and 2000, R&D spending by IT-producing industries increased rapidly, accounting for an average 26 percent share of overall private R&D spending. (Table 3.10) IT-related R&D accounted for an indeterminate amount of public R&D spending. Within the IT-sector, R&D spending in IT hardware and IT services industries grew by 8.3 percent and 14.6 percent, respectively.[7] This pattern mirrored changes in total private R&D. During 1997-2000, total industrial R&D surged at an annual rate of 10 percent, with robust growth in non-manufacturing R&D (29.5 percent) and slower growth (3.2 percent) in manufacturing R&D.

Particularly strong growth in R&D occurred in three IT-producing industries: communications equipment, software publishing, and computer systems design. Companies in both the computer industry and the telecommunications services industry scaled back their R&D over this period.

NEAR-TERM PROSPECTS CLOUDED, LONG-TERM PROSPECTS ENCOURAGING

In view of recent uncertainty, this chapter makes no estimates of likely levels of output of IT-producing industries for 2001 and beyond. Even before the human tragedy and economic shock of September 2001, the Administration, the Congressional Budget Office, and a host of respected private economic forecasters had been revising downward their forecasts of GDP for 2001. The events of September have made it more difficult to see the way ahead and to anticipate with any confidence the timing and strength of a rebound in IT investment and production.

Nonetheless, preceding analysis shows that despite the economic slowdown, U.S. industries have continued to build the nation's stock of IT capital, to spend heavily on IT goods and services that can make the installed base of IT hardware increasingly productive, and to create as a result the enduring foundation of a stronger economy.

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[6] R&D expenditures for 2000 are based on projections published by the National Science Foundation. Actual data for total R&D and industry are available only through 1999. Industry has accounted for nearly all the growth in R&D since 1988, while the Federal share has been declining, reaching a low point of 26 percent in 1999.

[7] Part of the decline in R&D in the computer industry was due to consolidation in the PC industry, with commodity-type producers gaining market share from integrated companies serving all industry segments.

Chapter IV

Industry-Level Effects of Information Technology Use on Productivity and Inflation

*by Jesus Dumagan and Gurmukh Gill**

In recent years, economists have carefully considered the productivity effects of massive U.S. investments in information technology (IT). Positive IT impacts on productivity growth are now well established at the macroeconomic and firm levels of analysis.[1] However, evidence from the industry level remains ambiguous.

This chapter examines the role of IT in reviving and spreading productivity growth and in restraining inflation in the U.S. economy. "New economy" skeptics continue to argue that strong productivity growth over the past decade reflects highly concentrated gains in manufacturing durables—especially industries that produce computers and semiconductors—but not in industries that have invested heavily in IT use.[2] In contrast, this chapter shows that only 18 percent of the acceleration in productivity growth in the U.S. nonfarm business sector from 1989-1995 to 1995-2000 came from manufacturing durables. It shows, moreover, that the IT-intensive industries that helped accelerate productivity growth also helped hold down inflation.

The widespread dispersion of productivity growth across major sectors of the economy suggests that massive IT investments by U.S. industries are producing positive and likely lasting changes in the nation's economic potential. These conclusions are consistent with recent findings by other economists concerning the widespread and lasting impacts of IT on the revival of U.S. productivity growth.[3]

DATA AND METHODS

Decomposing Overall Productivity Growth into Individual Industry Contributions

Studies of IT's impacts on productivity at the macroeconomic level generally use the growth accounting framework. They first decompose aggregate productivity growth into the contribution due to capital deepening (growth in the capital-labor ratio), the contribution due to multifactor productivity growth (technological advance not embedded in the growth of capital and labor inputs), and the

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Mr. Dumagan is an economist in the Office of Business and Industrial Analysis (OBIA), Office of Policy Development, Economics and Statistics Administration. Mr. Gill is Director of OBIA.

[1] *See U.S. Department of Commerce,* Digital Economy 2000 *(June 2000), Chapter 4, for an analysis of the macroeconomic, industry-level, and firm-level impacts of IT on productivity. Also, see Chapter 3 for an analysis of the contributions of IT-producing industries.*

[2] *See the comments by Robert J. Gordon on Martin N. Baily and Robert Z. Lawrence, "Do We Have a New E-conomy," presented at the American Economic Association Meetings, New Orleans, LA (January 5, 2001). Gordon's written comments were handed out at the meetings and Baily and Lawrence's paper appeared in "Papers and Proceedings of the One Hundred Thirteenth Annual Meeting of the American Economic Association,"* American Economic Review *(May*

[3] *The findings in this chapter are consistent with those of recent studies by Baily and Lawrence,* ibid.*; Kevin J. Stiroh, "Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?," Federal Reserve Bank of New York,* Staff Reports*, no. 115 (January 2001); and Kevin J. Stiroh, "Investing in Information Technology: Productivity Payoffs for U.S. Industries," Federal Reserve Bank of New York,* Current Issues in Economics and Finance*, vol. 7, no. 6 (June 2001), pp. 1-6. Moreover, the methodology and empirical findings in this chapter are similar to those in the recent study by McKinsey Global Institute,* US Productivity Growth, 1995-2000*, Washington, DC (October 2001).*

Box 4.1

COMPUTING AN INDIVIDUAL INDUSTRY'S CONTRIBUTION TO OVERALL PRODUCTIVITY GROWTH

In this analysis, the economy's overall productivity is the ratio of aggregate GDP to total FTE. Therefore, overall productivity growth equals aggregate GDP growth minus total FTE growth. To illustrate an industry's contribution to this overall growth, suppose for simplicity there are only two industries (A and B) in the economy for which we have the information shown in columns (1) to (4) of the following table:

	Own Real GDP Growth (Pct.) (1)	Share of Nominal Aggregate GDP (2)	Own FTE Growth (Pct.) (3)	Share of Total FTE (4)	Contribution to Aggregate GDP Growth (Pct. Pt.) (1) x (2)	Contribution to Total FTE Growth (Pct. Pt.) (3) x (4)	Contribution to Overall Prod. Growth (Pct. Pt.) [(1) x (2)] - [(3) x (4)]
Industry A	3.0	0.4	5.0	0.2	1.2	1.0	0.2
Industry B	4.0	0.6	3.5	0.8	2.4	2.8	-0.4
Sum		1.0		1.0	3.6	3.8	-0.2

In the above example, an industry's percentage point (Pct. Pt.) contribution to aggregate GDP growth is the percent (Pct.) growth of the industry's own real GDP, column (1), multiplied by the industry's share (decimal) of nominal GDP, column (2). Similarly, an industry's percentage point contribution to total FTE growth is the percent growth of the industry's own FTE, column (3), multiplied by the industry's share of total FTE, column (4).

In turn, an industry's percentage point contribution to overall productivity growth equals its contribution to the aggregate GDP growth, (1)x(2), minus its contribution to total FTE growth, (3)x(4). The percentage point contribution is 0.2 by industry A and -0.4 by industry B, yielding a sum of -0.2 percent overall productivity growth.

If each industry is looked at in isolation, productivity growth equals the industry's own GDP growth, column (1), minus the industry's own FTE growth, column (3). Thus, A's individual productivity growth equals 3.0 - 5.0 = -2.0 percent, a negative number which is opposite to its positive 0.2 percentage points contribution to overall productivity growth. On the other hand, industry B's individual productivity growth equals 4.0 - 3.5 =0.5 percent, a positive number which is opposite to its negative 0.4 percentage points contribution to overall productivity growth.

It appears from the example that productivity trends in individual industries looked at in isolation are misleading indicators of the direction of industry contributions to the trend in overall productivity. For this reason, this chapter proposes a decomposition of overall productivity growth into exact contributions by individual industries as a more rigorous and accurate procedure for determining industry-level sources of economy-wide productivity growth.

The above example conveys the essence of industry decomposition of overall productivity growth. What varies from case to case is the determination of industry shares of aggregate GDP and of total FTE because this depends on the specific formula for determining aggregate GDP and total FTE. In this analysis, aggregate GDP is computed using BEA's chain-type quantity index (based on the Fisher ideal quantity index) and total FTE is the arithmetic sum of the FTE of each industry. The mathematical procedure for exact decomposition of overall productivity growth into industry contributions is presented in detail in the appendix to this chapter. This decomposition ensures that the sum of industry contributions exactly equals the overall growth. Contributions are, therefore, additive so that any industry group's contribution is the sum of individual contributions of the industries belonging to the group.

contribution due to growth in labor quality. Then they determine IT's impacts by decomposing the contribution of capital deepening into contributions of IT capital and non-IT capital.[4]

The present analysis also adopts a growth accounting framework. But in contrast to the above macroeconomic studies where the focus is on the contributions of technological advance and of the growth in specific inputs (labor, IT capital, and non-IT capital) to productivity growth, this study examines the contributions of individual industries to a broad set of economic variables at the aggregate level. Specifically, this study decomposes the growth of aggregate gross domestic product (GDP), total full time equivalent (FTE) workers, overall productivity (GDP/FTE), and inflation into contributions by individual industries. This industry-by-industry approach provides building blocks for reviewing the performance of individual industries, sectors or selected groups of industries across time and across industries.

We use BEA annual data for the period 1989-2000 for 55 industries (2-digit SIC) in the U.S. pri-

[4]The percentage point contribution of IT capital deepening to productivity growth is the product of the income share of IT capital and the percent growth of the IT capital-labor ratio. Although the income share of IT capital is still rather small, IT capital's productivity growth contribution has been significant because IT capital deepening accounts for most of overall capital deepening during the last decade. For more details and a summary of findings from recent major growth accounting studies on the productivity impacts of IT, see U.S. Department of Commerce, op.cit.*, Chapter 4.*

Box 4.2

COMPARING THIS STUDY WITH OTHER RECENT STUDIES ON IT'S ROLE IN U.S. PRODUCTIVITY GROWTH ACCELERATION

This study decomposes overall productivity (aggregate GDP over total FTE) growth into the percentage point contributions of individual industries (as illustrated in Box 1) for each year during 1989-2000. This entire period is then broken into two sub-periods, 1989-1995 and 1995-2000, and the simple averages of each industry's annual percentage point contributions are computed for each sub-period. The difference between the 1995-2000 average and the 1989-1995 average is the industry's contribution to the acceleration (i.e., average overall growth during 1995-2000 less the average overall growth during 1989-1995) in overall productivity growth. IT's role in this acceleration is assessed by classifying the industries into two groups, the more IT-intensive sub-group and the less IT-intensive sub-group (see the next section in the main text for the IT-intensiveness criteria). Because the percentage point contributions above are additive across industries, the sum of the contributions of the industries in each sub-group can be obtained and compared as a basis for gauging IT's role in productivity growth acceleration.

Kevin J. Stiroh, op. cit., provides alternative methods for determining IT's productivity impacts both at the aggregate level (employing separately a growth accounting framework, regression analysis, as well as production function estimation) and at the industry level, implementing a decomposition of overall productivity growth into percentage point contributions of individual industries. Stiroh's decomposition is conceptually similar to the decomposition framework of this chapter but for some differences. One is that he defines productivity as output per hour where output is a value-added measure, as it should be, for aggregate productivity but is either gross output (his preferred definition) or value-added at the industry level. In contrast, in this chapter, productivity is defined as output per FTE where output is a value-added (e.g., GDP) measure for both aggregate and industry level productivity. Our use of value-added is based on the fact that value-added is, by definition, the industry's contribution to aggregate output. Moreover, the use of value-added at the industry level makes the decomposition simpler because it does not involve intermediate inputs (which are included in industry gross output) that cancel out anyway at the aggregate level.

Moreover, Stiroh assumes for simplicity a Tornqvist index underlying aggregate real output since this index enables a straightforward decomposition of aggregate growth into individual industry contributions. This, however, leads to approximation errors because the actual aggregate real (chained dollar) output is based on the Fisher index. Though small, these errors are completely avoidable by using BEA's exact formula for a component's (e.g., an industry's) contribution to aggregate growth. This exact formula (see appendix) is used in this study.

To assess IT's growth impacts in his decomposition framework, Stiroh classifies industries into IT-producing, IT-using, and others. IT-using industries are those that have an "above-median value for the preferred IT-intensity indicator, the 1995 nominal IT share of capital services." In contrast, IT-producing industries are not separated in this chapter but are part of the more IT-intensive group defined above. On the whole, Stiroh's IT-producing and IT-using groups correspond to this chapter's more IT-intensive group and his "other industries" correspond to the less IT-intensive group. Finally, he employs a similar framework for analyzing contributions to productivity growth acceleration comparing average growth during 1987-1995 to that during 1995-2000.

Martin Neil Baily and Robert Z. Lawrence, op. cit., also assess at the industry level the role of IT in aggregate productivity growth. However, they do not decompose aggregate productivity growth into industry-level contributions. Instead, they determine the acceleration in productivity (an income-side measure of value-added per FTE) growth for each industry by the difference between an industry's average productivity growth during 1995-2000 and the average during 1989-1995. Then they compare each industry's productivity growth acceleration to the overall (for all private industries) average productivity growth acceleration from 1989-1995 to 1995-2000. The role of IT is then assessed by showing that those industries that are "intense IT users" (based on "IT spending relative to value added") generally have higher individual productivity growth acceleration compared to the overall acceleration.

McKinsey Global Institute (MGI), op. cit., implemented a procedure similar to this chapter's framework for decomposing aggregate productivity growth into industry contributions, albeit with some differences. One difference is that this chapter uses BEA's FTE for employment while MGI uses BEA's "persons engaged in production." The other difference is that, as part of the decomposition of aggregate productivity growth, this chapter uses BEA's exact formula for an industry's contribution to the growth of aggregate chained dollar GDP while MGI uses an approximate formula (MGI, op. cit., Exhibit A4, "Objectives & Approach"). Overall, this chapter's and MGI's empirical findings are quantitatively similar. Where this chapter and MGI diverge is on the interpretation of the results.

vate nonfarm business sector.[5] Because peak-to-peak comparisons over business cycles help reduce distortions associated with cyclical factors, we choose 1989 as the starting year and 2000 as the end year for our analysis. Both 1989 and 2000 are pre-peak years.

In this chapter, overall productivity is defined as GDP/FTE, the ratio of aggregate GDP to total FTE. Thus, the overall productivity growth rate is the difference between the growth rate of aggregate GDP and the growth rate of total FTE. And an industry's contribution to the overall productivity growth rate is the difference between its contribution to the aggregate GDP growth rate and its contribution to the total FTE growth rate.[6] Box 4.1 illustrates the

[5] *In this chapter, nonfarm business sector industries include those classified under* mining, construction, manufacturing durables, manufacturing nondurables, transportation & public utilities, wholesale trade, retail trade, finance and insurance, *and* services. *Real estate in the usual FIRE group of industries (consisting of finance, insurance, and real estate) is excluded in the analysis because BEA data on real estate GDP and FTE do not match each other. The reason is that real estate GDP includes value-added from owner-occupied housing for which there is no corresponding employment.*

[6] *Ordinarily, "aggregate" and "total" are interpreted to mean the same thing, an arithmetic sum. However, in this chapter, they are*

method used in this chapter to estimate each industry's contribution to the economy's productivity growth.

Box 4.2 briefly compares the methods used in this study with those used by Baily and Lawrence, Stiroh, and McKinsey Global Institute (see footnote 3).

Determining the Role of IT in Productivity Growth

To determine IT's impacts on productivity growth, we ranked all industries based on the intensity in their use of IT equipment (ITEQ), covering computers and peripheral equipment, software, and other information processing equipment, per FTE. Then, we computed the *ratio* between ITEQ per FTE in each industry (industry ITEQ/industry FTE) and the *average* ITEQ per FTE for all industries (total ITEQ/ total FTE).

In this analysis, an industry with a ratio exceeding 1 is *more* IT-intensive than the overall average—has above average ITEQ per FTE. Conversely, an industry with a ratio below 1 is *less* IT-intensive than the overall average—has below average ITEQ per FTE.[7]

We ranked all industries in *descending* order of IT intensity and divided them into a *top-half* group (i.e., those relatively more IT-intensive industries accounting for 50 percent of aggregate GDP) and a *bottom-half* group (i.e., those relatively less IT-intensive industries accounting for the remaining 50 percent of GDP). Industry rankings are presented in Table 4.1.

Computing Growth Contributions by Industry Groups

Because of the additivity of individual industry contributions to productivity growth (see Box 1), we were able to determine contributions by industry groups by summing the contributions of the industries in each group. We were also able to compare productivity performance between groups.

Dividing industries into a *top half* and *bottom half*—each half comprising a 50 percent share of aggregate GDP—allows a comparison of more IT-intensive to less IT-intensive industries, with regard to the impacts of IT on productivity growth. This approach also permits us to assess top-half and bottom-half industries' contributions to the *acceleration* in productivity growth after 1995.

Another grouping is based on BEA's major industry groups: *mining*, *construction*, *manufacturing durables*, *manufacturing nondurables*, *transportation and public utilities*, *wholesale trade*, *retail trade*, *finance and insurance*, and *services*. This grouping permits analysis of how widespread productivity growth and growth acceleration have been.

MAJOR FINDINGS

IT-intensive Industries Account for all U.S. Productivity (GDP/FTE) Growth Over the Period 1989-2000

Between 1989 and 2000, the relatively more IT-intensive group (top-half industries) far outperformed the less IT-intensive group (bottom half) in terms of productivity growth. Productivity growth of top-half industries averaged 2.95 percent annually during 1989-2000 compared to only 0.58 percent among bottom-half industries. The relatively strong productivity performance by top-half industries is largely responsible for the 1.68 percent average productivity growth in all private nonfarm business industries during the period.

In general, an industry's productivity growth is larger, the larger its output (GDP) growth and the smaller its employment (FTE) growth. Output growth for the more IT-intensive group averaged 4.75 percent between 1989 and 2000—2 percentage points more than the less IT-intensive group average of 2.74. (Figure 4.1 and Appendix Table A-4.1)

By contrast, except for 1997 and 1998, FTE growth in the more IT-intensive group remained well below that in the less IT-intensive group. (Figure 4.2 and Appendix Table A-4.2) In general, less IT-

intended to convey different meanings because GDP is measured in chained dollars *and, thus, "aggregate" GDP is* not *arrived at by arithmetic summation of the components, the chained dollar GDP of individual industries. BEA's special procedure for aggregating chained dollar components is described in Eugene P. Seskin and Robert P. Parker, "A Guide to the NIPA's,"* Survey of Current Business*, vol. 78 (March 1998), pp. 26-68. In contrast, "total" FTE is the arithmetic sum of the FTE of the individual industries*

[7]*Total net stocks of capital (Total K) may be broken down into IT equipment (ITEQ), non-IT equipment (Non-ITEQ), and Structures. From these categories, alternative capital intensity criteria similar to the above ratio of* industry *ITEQ/FTE to* overall *ITEQ/FTE were calculated using Non-ITEQ/FTE, Structures/FTE, Non-IT K/FTE (where Non-IT K = Non-ITEQ + Structures), and Total K/FTE. The results show that industries with ratios exceeding 1 based on any of the above capital intensity criteria* as a group contributed a larger share to productivity growth than their share in the economy. *However, the ranking based on ITEQ/FTE resulted in the* largest *contribution share to productivity growth than the share in the economy.*

Table 4.1

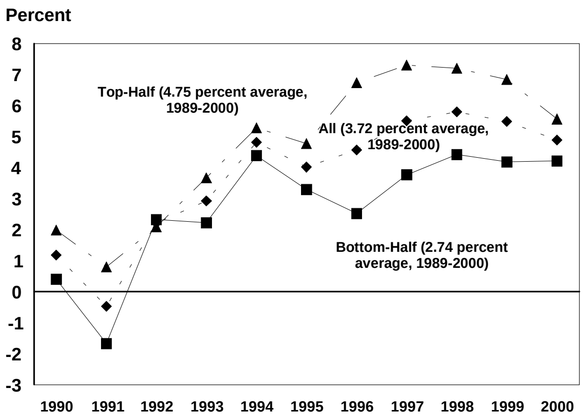
IT-INTENSITY RANKING BY RATIO OF INDIVIDUAL INDUSTRY ITEQ/FTE TO OVERALL ITEQ/FTE, 1996 AND CUMULATIVE SUM OF AVERAGE SHARES OF NOMINAL GDP, 1989-2000

Industry	SIC	Industry ITEQ/FTE over Overall ITEQ/FTE	Cumulative Sum of Average Shares of Nominal GDP (%)
Top Half Industries with 50% GDP Share			
Telephone and telegraph	481,482,489	22.98	2.82
Pipelines, except natural gas	46	14.25	2.93
Nondepository institutions	61	12.39	3.60
Radio and television	483,484	10.07	4.43
Petroleum and coal products	29	7.57	5.01
Electric, gas, and sanitary services	49	6.40	8.67
Oil and gas extraction	13	4.02	10.11
Chemicals and allied products	28	3.72	12.73
Metal mining	10	2.96	12.84
Tobacco products	21	2.44	13.11
Transportation services	47	2.38	13.55
Motion pictures	78	2.28	13.98
Security and commodity brokers	62	2.10	15.52
Depository institutions	60	2.07	19.87
Insurance carriers	63	1.94	21.90
Railroad transportation	40	1.73	22.33
Holding and other investment offices	67	1.65	22.49
Instruments and related products	38	1.59	23.47
Wholesale trade	50,51	1.50	32.62
Transportation by air	45	1.45	33.82
Electronic and other electric equipment	36	1.27	36.37
Paper and allied products	26	1.00	37.34
Printing and publishing	27	0.84	38.93
Coal mining	12	0.81	39.15
Industrial machinery and equipment	35	0.76	41.61
Other transportation equipment	37exc371	0.74	42.70
Nonmetallic minerals, except fuels	14	0.64	42.87
Business services	73	0.64	48.64
Miscellaneous repair services	76	0.63	49.02
Bottom Half Industries with 50% GDP Share Share			
Food and kindred products	20	0.59	51.15
Primary metal industries	33	0.57	52.05
Motor vehicles and equipment	371	0.56	53.57
Legal services	81	0.49	55.43
Personal services	72	0.43	56.30
Health services	80	0.42	64.05
Stone, clay, and glass products	32	0.42	64.64
Water transportation	44	0.42	64.86
Insurance agents, brokers, and service	64	0.41	65.74
Trucking and warehousing	42	0.36	67.41
Other services, n.e.c.	83,84,86,87,89	0.34	72.75
Fabricated metal products	34	0.32	74.34
Miscellaneous manufacturing industries	39	0.29	74.76
Local and interurban passenger transit	41	0.28	75.00
Textile mill products	22	0.26	75.47
Rubber and miscellaneous plastics products	30	0.26	76.31
Auto repair, services, and parking	75	0.20	77.51
Lumber and wood products	24	0.20	78.22
Retail trade	52-59	0.17	90.29
Hotels and other lodging places	70	0.16	91.41
Leather and leather products	31	0.16	91.50
Furniture and fixtures	25	0.16	91.87
Apparel and other textile products	23	0.13	92.37
Construction	15,16,17	0.11	98.01
Amusement and recreation services	79	0.10	98.99
Educational services	82	0.06	100.00

Note: BEA's industry GDP at the 2-digit SIC level is too broad or lumpy for our purposes. IT intensity within a 2-digit industry varies a great deal because some component 3-digit or 4-digit industries are IT-intensive while others are not. However, because of data constraints, we had to apply our IT intensity criterion at the 2-digit level. Thus, IT intensive and non-IT intensive industries within a 2-digit level are assigned the same 2-digit ranking. For example, SIC 35 and SIC 36 include the IT-producing industries in this report (see Chapter III) that are IT-intensive. However, the IT intensity ranking of SIC 35 and SIC 36 puts them near the bottom of the Top-Half group above because these 2-digit categories include 3-digit and 4-digit industries that are non-IT intensive.

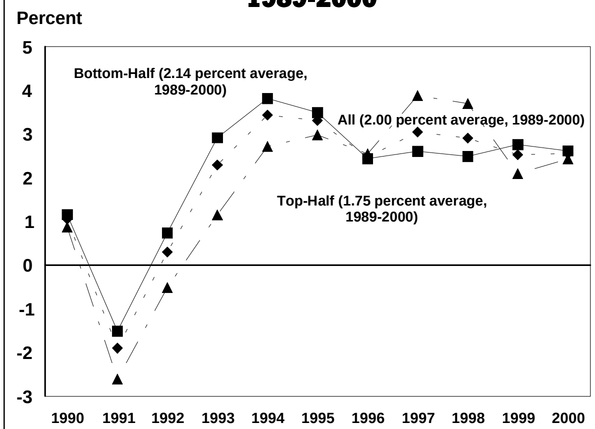
Source: ESA estimates derived from BEA data.

Figure 4.1
GDP GROWTH IN TOP-HALF AND BOTTOM-HALF INDUSTRIES AND IN ALL INDUSTRIES OF THE U.S. NONFARM BUSINESS SECTOR 1989-2000



Source: ESA estimates derived from BEA data.

Figure 4.2
FTE GROWTH IN TOP-HALF AND BOTTOM-HALF INDUSTRIES AND IN ALL INDUSTRIES OF THE U.S. NONFARM BUSINESS SECTOR 1989-2000



Source: ESA estimates derived from BEA data.

intensive industries are more worker-intensive than more IT-intensive industries.[8]

As a result of stronger output growth and weaker employment growth, more IT-intensive industries achieved higher productivity growth than less IT-intensive industries for the period 1989-2000 as a whole (2.95 percent on average compared with 0.58 percent) and in every year of the period. (Figure 4.3 and Appendix Table A-4.3)

As noted above, ESA analysts also decomposed overall productivity growth into contributions by the top-half IT-intensive industries and the bottom-half less IT-intensive industries. Top-half industries contributed 1.68 percentage points or practically 100 percent of the overall average productivity growth of 1.68 percent per year during 1989 to 2000. Year by year comparisons of contributions between the two groups also show that the contribution of the IT-intensive top half far exceeded that of the less IT-intensive bottom half. (Figure 4.4 and Appendix Table A-4.4)

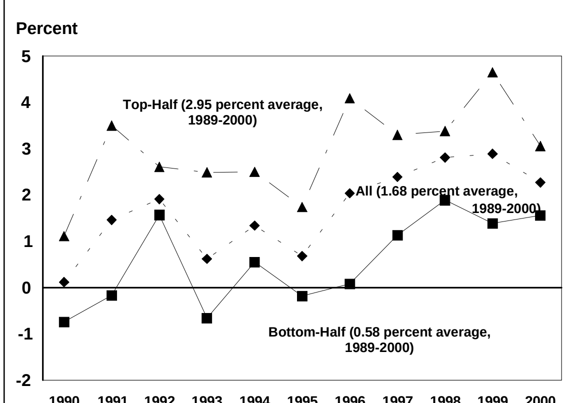
In the more IT-intensive top-half industries, productivity growth accelerated 1.38 percentage points from an average 2.32 percent during 1989-1995 to 3.70 percent average during 1995-2000. In contrast, in the less IT-intensive bottom-half industries, growth accelerated at a slower 1.15 percentage points from 0.06 percent average (1989-1995) to 1.21 percent average (1995-2000). For all industries, overall productivity growth accelerated 1.46 percentage points. (Figure 4.5 and Appendix Table A-4.5).

Our analysis indicates that the bulk of productivity growth acceleration after 1995 was generated by IT-intensive industries.[9] Figure 4.6 (also, see Appendix Table A-4.6) shows that 1.01 percentage points—69 percent of 1.46 percentage points over-

[8]*Sixty-five percent of U.S. workers in the nonfarm business sector work in less IT-intensive industries.*

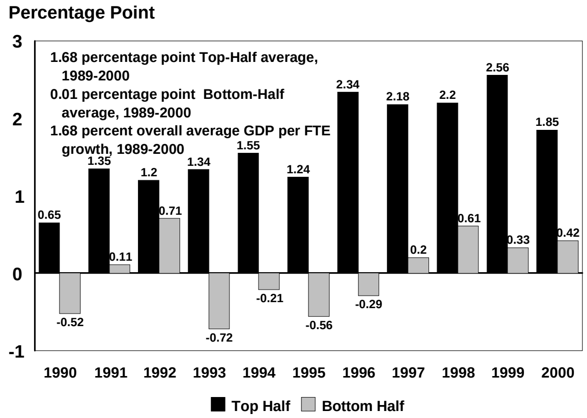
[9]*For the significant contributions of IT capital deepening to the acceleration in labor productivity from the first to the second halves of the 1990s, see Stephen D. Oliner and Daniel E. Sichel, "The Re-*

Figure 4.3
GDP PER FTE GROWTH IN TOP-HALF AND BOTTOM-HALF INDUSTRIES AND IN ALL INDUSTRIES OF THE U.S. NONFARM BUSINESS SECTOR 1989-2000



Source: ESA estimates derived from BEA data.

Figure 4.4
CONTRIBUTIONS TO OVERALL GDP PER FTE GROWTH BY TOP-HALF AND BOTTOM-HALF INDUSTRIES OF THE U.S. NONFARM BUSINESS SECTOR 1989-2000

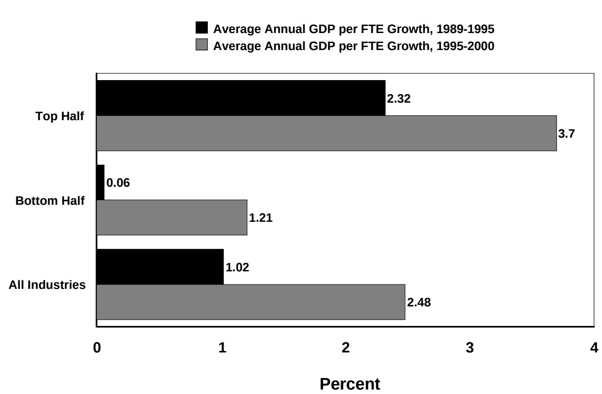


Source: ESA estimates derived from BEA data.

all growth acceleration—was provided by the more IT-intensive top-half industries. In contrast, the

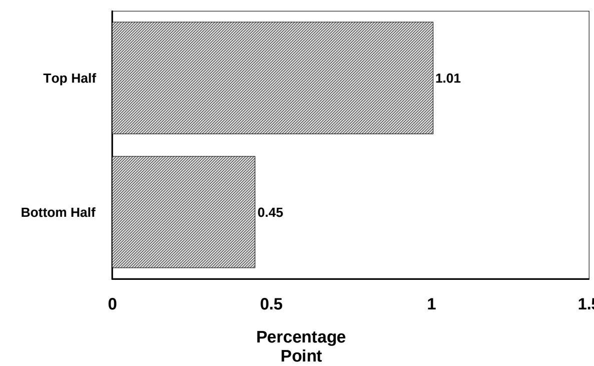
surgence of Growth in the Late 1990s: Is Information Technology the Story?," Washington, DC: Federal Reserve Board (May 2000), Table 5, p. 28; Congressional Budget Office, The Budget and Economic Outlook: Fiscal Years 2001-2010 *(January 2000), Appendix A;* Economic Report of the President *(February 2000), Table 2-3, p. 83; Dale W. Jorgenson and Kevin J. Stiroh, "Raising the Speed Limit: U. S. Economic Growth in the Information Age" (May 1, 2000), available from kevin.stiroh@ny.frb.org; and Karl Whelan, "Computers, Obsolescence, and Productivity" (February 2000), Table 4, p. 34, available from kwhelan@frb.org. These contributions to productivity acceleration are summarized in U.S. Department of Commerce,* op. cit.*, Figure 4.1, p. 38.*

Figure 4.5
GDP PER FTE GROWTH IN TOP-HALF AND BOTTOM-HALF INDUSTRIES AND IN ALL INDUSTRIES OF THE U.S. NONFARM BUSINESS SECTOR 1989-1995 AND 1995-2000



Source: ESA estimates derived from BEA data.

Figure 4.6
CONTRIBUTIONS TO OVERALL GDP PER FTE GROWTH ACCELERATION BY TOP-HALF AND BOTTOM-HALF INDUSTRIES OF THE U.S. NONFARM BUSINESS SECTOR 1995-2000 OVER 1989-1995



Source: ESA estimates derived from BEA data.

bottom-half industries that use IT less intensively contributed only 0.45 percentage points or 31 percent of the acceleration in overall productivity growth. Our estimates show that productivity acceleration was spread across 17 industries in the top-half group.[10]

Productivity Growth Widespread Across Major Industrial Sectors

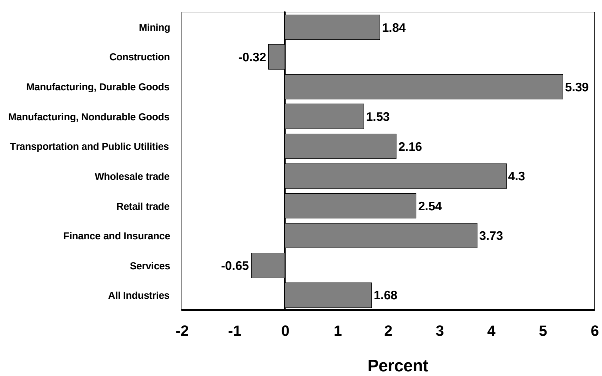
Some economists have asserted that strong productivity growth is narrowly concentrated in manufacturing durables, and, within that sector, in the computer and semiconductor producing industries. In contrast, this study shows that productivity growth during 1989-2000 has been widespread across many sectors of the economy in addition to manufacturing durables.

Figure 4.7 (also, see Appendix Table A-4.7) shows average productivity growth for all major industry groups during 1989-2000. Manufacturing durables led all sectors with an average productivity growth of 5.39 percent, followed by wholesale trade (4.30 percent), finance and insurance (3.73 percent), retail trade (2.54 percent), transportation and public utilities (2.16 percent), and mining (1.84 percent).

ESA analysts also decomposed overall productivity growth into percentage point contributions by

[10]A total of 30 industries had positive contributions to growth acceleration, including 13 industries in the bottom-half group.

Figure 4.7
GDP PER FTE GROWTH IN U.S. NONFARM BUSINESS SECTOR BY MAJOR INDUSTRY GROUPS 1989-2000



Source: ESA estimates derived from BEA data.

the major sectors. Manufacturing durables made the largest contribution—0.68 percentage points or over 40 percent of annual average 1.68 percent growth of productivity in the nonfarm private business sector.[11] (Figure 4.8 and Appendix Table A-4.8) But sectors outside manufacturing durables also made significant contributions. Finance and insurance contributed 0.41 percentage points (24.3 percent), wholesale trade 0.41 percentage points (24.2 percent), transportation and public utilities 0.35 percentage points (20.5 percent), retail trade 0.15 percentage points (9.1 percent), manufacturing nondurables 0.14 percentage points (8.1 percent), and mining 0.01 percentage points (0.3 percent).

Sources of Productivity Growth Acceleration Also Widely Dispersed

Overall productivity growth accelerated to 2.48 percent average during 1995-2000 from an average 1.02 percent during 1989-1995. Productivity growth accelerated not only in manufacturing durables but also in wholesale trade, retail trade, finance and insurance, and services. (Figure 4.9 and Appendix Table A-4.9).

Manufacturing durables contributed 0.27 percentage points (18 percent) to the overall 1.46 percent productivity growth acceleration.[12] (Figure 4.10 and Appendix Table A-4.10). The remaining 1.19 percentage points (or 82 percent) of nonfarm business productivity growth acceleration came from outside of manufacturing durables.

The largest contribution to this acceleration came from finance and insurance, which accounted for 0.54 percentage points (37 percent), followed by retail trade 0.41 percentage points (28.3 percent), wholesale trade 0.30 percentage points (20.8 percent), and services 0.23 percentage points (15.8 percent).

IT-intensive Industries Help Hold Down Inflation

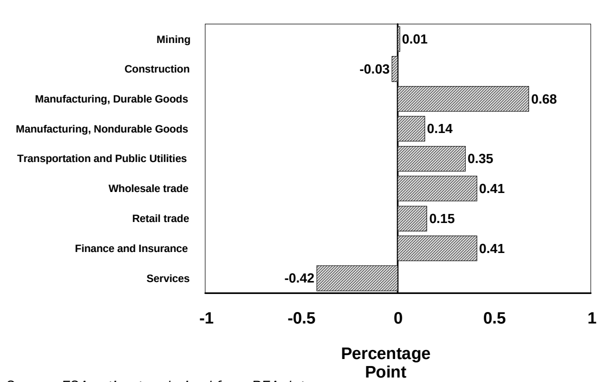
Between 1989 and 2000, IT production and use contributed substantially to restraining inflation.[13] Figure 4.11 (also, see Appendix Table A-4.11) shows

[11]Within manufacturing durables, 85 percent of productivity growth of durables was contributed by the two industries that produce IT equipment: industrial machinery and equipment (SIC 35) and electronic and other electric equipment (SIC 36).

[12]Manufacturing durables' contribution to overall productivity growth was 0.56 percentage points during 1989-1995 and 0.83 percentage points during 1995-2000.

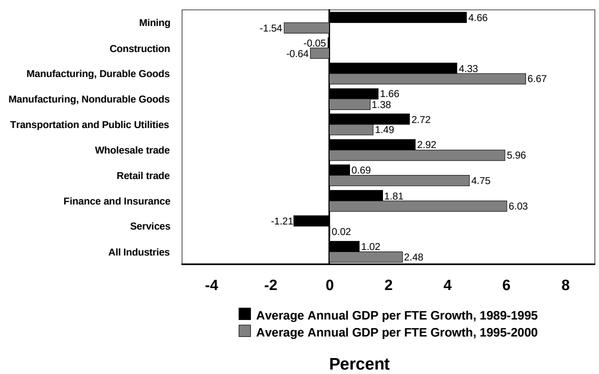
[13]To examine this issue, we looked at price growth separately within the more IT-intensive top-half group of industries and within the less IT-intensive bottom-half group, after excluding energy and food producing and processing industries consistent with the "core inflation" concept. Core inflation, as measured by the official CPI, excludes the price effects of volatile food and energy sectors. Consistent with this concept, we excluded from our inflation analysis four more industries (in addition to the previously excluded real estate industry): (1) oil and gas extraction, (2) electric, gas, and sanitary services, (3) petroleum and coal products, and (4) food and kindred products. We then examined the contributions of these two groups to the overall price growth in the U.S. nonfarm business sector.

Figure 4.8
CONTRIBUTIONS TO GDP PER FTE GROWTH IN U.S. NONFARM BUSINESS SECTOR BY MAJOR INDUSTRY GROUPS 1989-2000



Source: ESA estimates derived from BEA data.

Figure 4.9
GDP PER FTE GROWTH IN U.S. NONFARM BUSINESS SECTOR BY MAJOR INDUSTRY GROUPS 1989-1995 AND 1995-2000

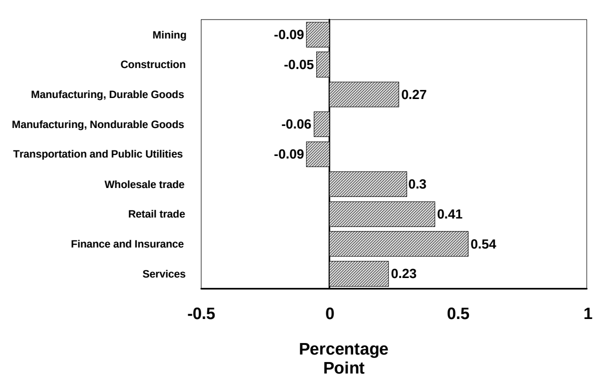


Source: ESA estimates derived from BEA data.

that each year during 1989-2000, except in 1995, price growth was higher within the less IT-intensive bottom-half group (3.01 percent average) compared to the overall price growth for all industries (2.13 percent average). In contrast, except in 1995, price growth within the more IT-intensive top-half group (1.26 percent on average) was lower than the overall price growth.

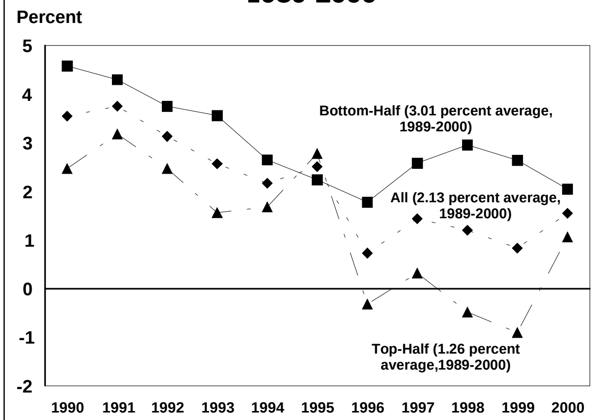
Because the roles of prices and quantities are symmetric in the definition of Fisher indexes—the index formulas that underlie BEA's chained dollar framework—switching quantities to prices and vice versa converts the quantity index to a price index. Thus, BEA's formula (Moulton and Seskin, op. cit.*) for contributions to overall* quantity *growth switches to one that measures contributions to overall* price *growth or inflation. The appendix contains a more detailed discussion of the method.*

Figure 4.10
CONTRIBUTIONS TO GDP PER FTE GROWTH ACCELERATION IN U.S. NONFARM BUSINESS SECTOR BY MAJOR INDUSTRY GROUPS 1995-2000 OVER 1989-1995



Source: ESA estimates derived from BEA data.

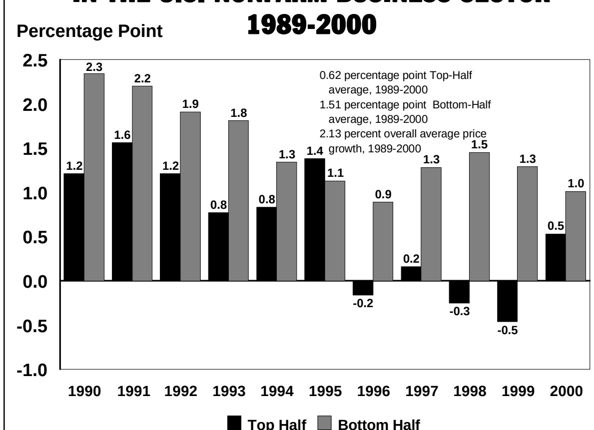
Figure 4.11
PRICE GROWTH IN TOP-HALF AND BOTTOM-HALF INDUSTRIES AND IN ALL INDUSTRIES OF THE U.S. NONFARM BUSINESS SECTOR 1989-2000



Source: ESA estimates derived from BEA data.

The above result is buttressed by decomposing the overall price growth into the contributions of more IT-intensive top-half and less IT-intensive bottom-half industries. Each year from 1989 to 2000, except in 1995, the top-half group contributed less to overall price growth than the bottom-half group. (Figure 4.12 and Appendix Table A-4.12). Top-half

Figure 4.12
CONTRIBUTIONS TO OVERALL PRICE GROWTH BY TOP-HALF AND BOTTOM-HALF INDUSTRIES IN THE U.S. NONFARM BUSINESS SECTOR 1989-2000



Source: ESA estimates derived from BEA data.

industries together contributed 0.62 percentage points or 29 percent to the average annual overall inflation rate of 2.13 percent. In contrast, bottom-half industries contributed a much larger 71 percent of the overall inflation rate.

CONCLUSION

The analysis in this chapter shows that the more IT-intensive top-half industries perform much better in terms of their contribution to productivity (GDP/FTE) growth than the less IT-intensive bottom-half industries. During the period 1989-2000, the more IT-intensive industries that contribute a 50 percent share of nominal GDP accounted for practically 100 percent share of the overall productivity growth. In contrast, the less IT-intensive bottom-half industries together made a negligible contribution.

During the period 1989-2000, manufacturing durables accounted for over 40 percent of the productivity growth in U.S. nonfarm business sector. However, almost 60 percent of aggregate growth was widely dispersed across many major industry groups, including manufacturing nondurables, transportation and public utilities, finance and insurance, wholesale trade, retail trade, and mining.

Nonfarm business productivity growth accelerated by an annual average 1.46 percentage points from 1989-1995 to 1995-2000. Manufacturing durables contributed 0.27 percentage points to this acceleration, an 18 percent share. A full 82 percent of nonfarm business productivity growth acceleration came from outside of manufacturing durables.

In addition, the IT- intensive top-half industries together contributed a 29 percent share of the average annual inflation rate during 1989-2000 while the relatively less IT-intensive bottom-half industries contributed 71 percent of the overall inflation rate.

The analysis in this chapter shows that the sources of productivity growth acceleration are well dispersed across major sectors of the economy and that decades of IT investment by U.S. industries are producing positive and lasting changes in the nation’s economic potential.

Chapter V

Jobs in the New Economy

*by Sandra D. Cooke**

Despite reports of mounting layoffs, IT workers are still in demand, especially in industries that provide IT services and occupations related to IT security, networking, and e-commerce. As the economy has slowed, so has the demand for many types of IT equipment, but demand remains strong for many IT-related services.

For IT workers, the new economy offers both opportunity and risk. The highest skilled IT workers enjoy strong demand for their services and above average compensation packages. At the same time, less skilled IT workers and some non-IT workers face a greater chance of being displaced by rapidly evolving technologies.

Even for workers in non-IT jobs, basic IT skills are becoming a requirement. IT skill requirements are ever changing and workers are finding that life-long training is needed for long-run economic security. Educators, too, recognize the growing need for skilled workers and are designing curricula to include basic IT skills training especially at the secondary school level.

This chapter discusses implications of the IT revolution for both IT and non-IT workers. The first half of the chapter focuses on IT workers—employment demand, compensation, skill requirements and related supply issues. The second half discusses IT's role in labor markets — how IT is changing the nature of work, the way workers find work, and where they work.

Highlights

- After growing much faster than average during the late 1990s, IT industry employment growth has slowed in recent months in response to a slowing economy. Some IT service industries, however, are still adding jobs.
- In 2000, there were 5.6 million workers employed in IT industries.
- Average wages per worker in IT industries are twice the national average. IT industry workers earn $73,800 compared with $35,000 for all workers engaged in private nonfarm industries.
- In 2000, 6.6 million workers were employed in IT occupations in all industries.
- More than half of IT jobs are "high skilled" and require at least an associate degree. High skilled IT jobs pay considerably more than low skilled IT jobs.
- Business, government, and educational institutions are working to prepare students and workers for the job demands of the information age.
- IT has contributed to rising skill requirements across a number of occupations.
- In the new economy, workers are less constrained by geographical barriers as IT allows some types of work to be done from virtually any location.
- IT plays an important role in the efficient operation of labor markets through matching employers with job seekers and allowing contingent workers to quickly respond to changing market conditions.

*Ms. Cooke is an economist in the Office of Business and Industrial Analysis, Office of Policy Development, Economics and Statistics Administration.

IT WORKERS: DEMAND AND SUPPLY

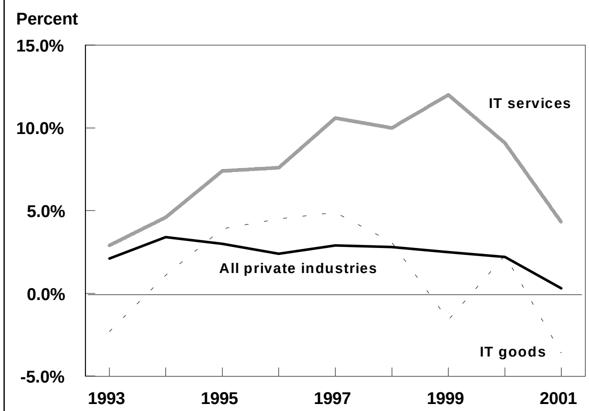
IT workers design, manufacture, operate, repair, and maintain the IT infrastructure that facilitates e-commerce and other Internet or network-related activities. For the purpose of this analysis, the IT workforce is divided into two partially overlapping groups—workers in IT-producing industries and workers in IT occupations. Workers in IT-producing industries include all occupations, e.g., sales, marketing, and financial services, in addition to workers in IT occupations. IT-producing industries consist of four major segments: hardware, software and related computer services, communications equipment, and communications services. (See Chapter 3, Table 3.1) Workers in IT occupations work across all industries, e.g., a computer programmer might work in financial services or retail trade as well as in IT-producing industries. IT occupations are listed in Box 5.1 and duties are described in Appendix Table A-5.5.

Employment in IT-Producing Industries: IT Services Adding Jobs, IT Goods Losing Jobs

From 1992 to 2000, jobs in IT-producing industries grew twice as fast as the national average, driven by growth in IT services industries. (Appendix Table A-5.1) The number of IT workers grew from 3.6 million in 1992 to 5.6 million in 2000, or from about 4 percent to 5 percent of total private nonfarm employment.[1] Since the beginning of 2001, however, as the economy has weakened, employment growth of IT industries has slowed considerably.

The overall growth in IT-producing industry employment represents a churning in IT jobs, with significant increases in some areas and declines in others. This trend is evident when we examine IT services and IT goods industries separately.[2] As shown in Figures 5.1 and 5.2, since 1992, IT services industries have enjoyed higher than average rates of employment growth, even into 2001. Industries that manufacture IT equipment, however, have seen little job growth over the period and in recent months, have even lost jobs. This trend also reflects the aggregate trend of much stronger employment growth in the services sector than in the manufacturing sector. Despite overall IT job growth during much of the 1990s,

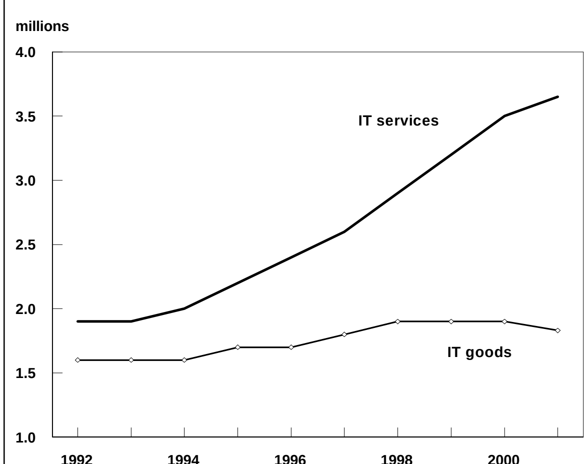
Figure 5.1
EMPLOYMENT GROWTH:*
IT GOODS, IT SERVICES, AND ALL PRIVATE INDUSTRIES
(year to year rates of change)



** 2001 - January to November 11-month average.*
IT services: computer software/related services & communications services
IT goods: computer hardware & telecommunications equipment

Source: ESA estimates based on BLS data.

Figure 5.2
EMPLOYMENT LEVELS:*
IT GOODS AND IT SERVICES



** 2001 - January to November 11-month average.*
IT services: computer software/related services & communications services
IT goods: computer hardware & telecommunications equipment

Source: ESA estimates based on BLS data.

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[1] *Because of definitional changes, these estimates are not comparable to those reported in earlier Digital Economy reports. See Appendix Table A-5.1 for a complete historical revision.*

[2] *Churning is even more evident at the 4-digit SIC level as shown in Appendix Table A-5.1. Average annual rates of change in employment from 1992 to 2000 range from -5.4 percent for the optical recording media industry to 23.4 percent for the information retrieval services industry.*

some workers in IT-producing industries have been replaced by new technologies, either directly or as productivity improvements reduced the need for some workers. Also, several IT-producing industries faced import competition during the 1990s.

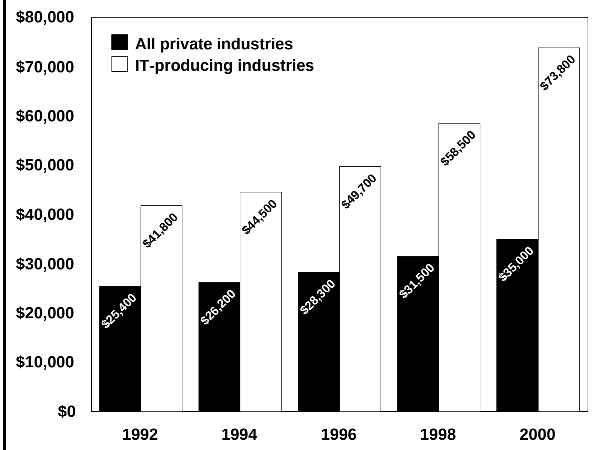
By sector, we find that software and computer services, the largest IT sector, recorded the fastest employment growth from 1992 to 2000. Jobs in this area more than doubled, from 854,000 in 1992 to more than 2.1 million in 2000 (a 12 percent annual growth rate). (Appendix Table A-5.1) Information retrieval services and computer programming services were also among the fastest growing industries in this IT sector. Employment in communications services grew slightly faster than average over the period, led by cable and other pay television service providers. By the end of 2001, however, employment in several IT services industries showed slight declines as the economy continued to weaken.

Employment in hardware industries grew more slowly than average from 1992 to 2000, at about 2.5 percent per year; and some sub-industries experienced significant employment declines, e.g., manufacturers of computers and electron tubes. Communications equipment manufacturers also lost jobs over the period. Employment demand in these IT goods-producing industries thus far in 2001 either has declined or grown very slowly, consistent with trends of the past decade.

IT Industries Consistently Pay Higher Than Average Wages

In 2000, the average annual wage for workers in IT-producing industries was $73,800—more than twice as high as the average annual wage for all private workers, $35,000.[3] (Figure 5.3) Since 1992, wages paid by IT-producing industries have grown by 7.4 percent per year, compared with private-industry average wage growth of 4.1 percent. (Appendix Table A-5.2)

Figure 5.3
ANNUAL WAGES PER WORKER:
IT-PRODUCING AND ALL PRIVATE INDUSTRIES



Source: ESA estimates based on BLS data.

Among workers in IT-producing industries in 2000, those in software and computer services industries, including computer programming services and software development, earned the highest average wage, $80,900. The wages of these workers grew at an average annual rate of 7.8 percent per year during the 1992 to 2000 period.

Although all IT-producing industries paid wages that were higher than the total private industry average in 2000, and almost all of them had higher than average annual wage growth from 1992 to 2000, some IT jobs are low-skilled and low-paying, as discussed in the next two sections.

Skill Requirements Vary Across IT Occupations

Workers in IT occupations design, manufacture, operate, maintain, and repair IT products and provide related services across all industries, not just in IT-producing industries. In general, occupations change gradually as technology creates new job categories and eliminates some old ones. For some IT jobs, however, changes have been rapid and pronounced. Technology tools and platforms used by IT workers can become obsolete

[3] Because of definitional changes, wage estimates in this report are not comparable to those reported in previous Digital Economy reports. See Appendix Table A-5.2 for a complete historical revision.

very quickly. This may require workers to retrain, seek recertification, or even change occupations. BLS revises the Standard Occupational Classification (SOC) system periodically to reflect such changes. Occupations noted in Box 5.1 reflect the most recent BLS revisions and additions to the list of IT-related job categories.[4]

Because of changes to the occupational classification system, historical analysis of IT occupations is not possible. However, historical analysis of IT occupations defined under the previous SOC system shows that over time, the IT workforce has become more highly skilled. Moreover, projected future demand for IT workers will favor the highest skilled workers.[5]

IT occupations included 6.65 million workers in 2000, about 4.6 percent of all U.S. workers. More than half (3.8 million) of the workers with IT occupations were in jobs that generally need at least an associate degree. By contrast, in the U.S. economy as a whole, only about one in four workers is employed in a high-skilled occupation. (Figure 5.4) Computer engineers, electrical engineers, and computer programmers are among the highest skilled IT occupations. (See Appendix Table A-5.4 for a complete list of IT occupational employment for 2000.) In 2000, about a quarter of all IT workers (1.6 million) were employed in moderately skilled occupations—jobs requiring long-term on-the-job training, related work experience, or post secondary vocational training. Such jobs include data entry keyers and telecommunications line installers and repairers. In addition, slightly less than one-fifth of IT workers were employed in low-skilled IT occupations such as switchboard

BOX 5.1

IT-RELATED JOBS

Skill Level: High

Engineering managers
Computer and information systems managers
Computer and information scientists, research
Computer programmers
Computer software engineers, applications
Computer software engineers, systems software
Computer support specialists
Computer systems analysts
Database administrators
Network and computer systems administrators
Network systems and data communications analysts
Computer hardware engineers
Electrical engineers
Electronics engineers, except computer
Electrical and electronic engineering technicians

Skill Level: Moderate

Data entry keyers
Computer, ATM, and office machine repairers
Telecommunications equipment installers and repairers, except line installers
Electrical and electronics repairers, commercial and industrial equipment
Electrical power-line installers and repairers
Telecommunications line installers and repairers
Electrical and electronic equipment assemblers
Electromechanical equipment assemblers
Semiconductor processors

Skill Level: Low

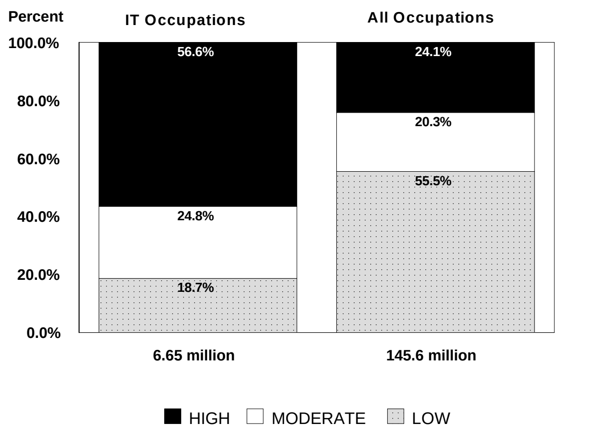
Switchboard operators, including answering service
Telephone operators
Billing and posting clerks and machine operators
Computer operators
Mail clerks and mail machine operators, except postal service
Other office machine operators

Source: ESA in consultation with BLS.

[4] *BLS recently revised its SOC classification expanding several IT-related occupations, adding new occupations, and combining others. For example, the 2000 SOC divided the computer engineer occupation into three new categories: computer software engineers - applications; computer software engineers - systems software; and computer hardware engineers. New IT occupations include network systems and data communications analysts. Because of changes in the SOC categories, the numbers reported in this chapter are not directly comparable with those reported in previous Digital Economy publications.*

[5] *Sandra Cooke, "The IT Workforce,"* iMP: The Magazine on Information Impacts, *April 2000, (http://www.cisp.org/imp) and* Digital Economy 2000, Chapter 5, *June 2000.*

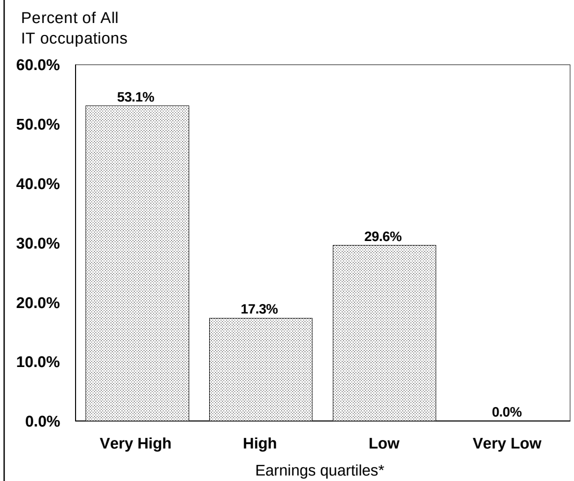
Figure 5.4
EMPLOYMENT AND TRAINING REQUIREMENTS OF IT OCCUPATIONS, 2000



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

Source: ESA estimates based on BLS data.

Figure 5.5
EARNINGS DISTRIBUTION AMONG IT OCCUPATIONS, 2000



** Very High: > $39,700 High: $25,760-$39,660*
Low: $18,500-$25,760 Very Low: < $18,490

Source: ESA estimates based on BLS 2000 occupational employment and earnings.

operators and billing and posting machine operators —jobs that require little on-the-job training.

Skilled IT Jobs Pay Highest Wages

The earnings of IT workers vary greatly, based on their skills and educational levels. IT worker earnings are higher than average and IT jobs requiring high levels of education and training pay more than those requiring little formal education and training. A ranking of IT jobs according to BLS average earnings quartiles, reveals that in 2000, more than two-thirds of IT jobs paid "high" or "very high" earnings (greater than $25,760). (Figure 5.5)

In 2000, most high skilled IT jobs (86 percent) paid "very high" wages (more than $39,660), while 17 percent of moderately skilled IT jobs ranked among the highest paid. (Table 5.1) Though one quarter of all jobs rank in the "very low" earnings quartile (less than $18,500), none of them are IT jobs. Almost 60 percent of moderately-skilled IT workers earned low wages. This is because data entry keyers, an occupation that includes a large number of workers, requires a moderate amount of training but is among the lowest paid IT occupations.

For specific occupations, we find that in 2000, median earnings ranged from $84,070 for highly skilled engineering managers, who typically require a bachelors degree plus experience, to $19,840 for mail clerks and mail machine operators, a position that requires little work experience. (See Appendix Table A-5.4 for a complete list of IT occupations and median earnings.)

Private surveys provide more timely earnings estimates and include the newest IT occupations. Computerworld conducts an annual salary survey as does RHI Consulting, Inc., a major job placement firm.[6] RHI's most recent survey suggests that starting salaries will increase very little for most IT jobs during 2002. However, jobs related to corporate security and e-commerce will see large rises in base compensation. RHI forecasts that the strongest demand for IT workers will be in health care, finance, and real estate industries.

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[6] See Computerworld's 15th Annual Salary Survey: "More for the Money," September 3, 2001 for a list of earnings by occupation, industry, and region. (http://www.computerworld.com/cwi/story/0,1199,NAV63_STO63423,00.htm) RHI Consulting, 2002 Salary Guide.(http://www.rhic.com/FreeResources), December 2001.

TABLE 5.1: IT OCCUPATIONAL EMPLOYMENT, BY EARNINGS AND SKILL LEVELS, 2000

	SKILL LEVELS 1/			
EARNINGS QUARTILES	High	Moderate	Low	Total
Very High >$39,700	3,240,440	288,670	0	3,529,110
High $25,760-$39,660	522,570	392,630	238,610	1,153,810
Low $18,500-$25,760	0	965,420	1,003,980	1,969,400
Very Low < $18,490	0	0	0	0
TOTAL	**3,763,010**	**1,646,720**	**1,242,590**	**6,652,320**
Skill shares	**56.6%**	**24.8%**	**18.7%**	
	Earnings Percent Distribution			
Very High >$39,700	86.1%	17.5%	0.0%	53.1%
High $25,760-$39,660	13.9%	23.8%	19.2%	17.3%
Low $18,500-$25,760	0.0%	58.6%	80.8%	29.6%
Very Low < $18,490	0.0%	0.0%	0.0%	0.0%
TOTAL	100.0%	100.0%	100.0%	100.0%

1/ High: Associate degree, bachelor's degree or work experience plus a bachelor's degree or higher
Moderate: long-term on-the-job training, work experience in a related occupation or post secondary vocational training
Low: short to moderate-term on-the-job training

Source: ESA estimates based on Bureau of Labor Statistics data.

In addition to base pay, many IT workers in the past negotiated lucrative compensation packages that included stock options and profit sharing. However, the demise of many dot-coms has erased the lure of stock options as a form of compensation. Computerworld reports that in the current economic climate, job seekers are more interested in job security and less interested in extraordinary compensation packages. Employers now offer bonuses to reward workers for good work rather than as a recruiting incentive.[7]

IT Worker Supply Initiatives

In response to the IT worker supply debate that emerged during the 1990s, hundreds of programs have been implemented to increase the supply of IT workers and raise overall IT literacy. Public and private institutions are working both independently and in partnerships to promote IT literacy across all occupations, age groups, ethnic and economic categories. (See Box 5.2 for a sample of initiatives.) One response to the IT worker supply debate was the temporary increase in the number of foreign workers allowed in the United States under the H-1B visa program.[8] In addition, fees from H-1B visa applications are being used to fund IT programs to train Americans for these jobs. Another response has been the emergence of IT certification and other short-term IT training programs that have produced skilled IT workers.

In recent months, however, the slowing of the economy and the failure of some Internet firms has helped to ease supply pressures in IT labor markets. Challenger, Gray, and Christmas report that during 2001, dot-com layoff announcements totalled 100,925 and telecommunications and

[7] Computerworld,"Hiring Gets Sane," April 2, 2001. (http://www.computerworld.com/cwi/stories/0,1199,NAV47-81_STO59071,00.html); "More for the Money," September 3, 2001 (http://www.computerworld.com/storyba/0,4125,NAV47STO63423,00.html)

[8] The H-1B visa program allows foreign workers to enter the country for the specific purpose of temporarily filling skilled jobs (a large share of which are IT jobs) and last year, Congress passed legislation that raised the cap on H-1B visas from 65,000 to 195,000 in FY2001, FY2002, and FY2003, after which the cap will revert to 65,000. (http://www.ins.usdoj.gov/graphics/publicaffairs/statements/018H1BCapState.htm)

[9] Challenger, Gray, and Christmas, Inc., press release, December 31, 2001. (http://www.challengergray.com)

Box 5.2

SPECIFIC EXAMPLES OF CURRENT AND PLANNED IT TRAINING INITIATIVES:

POSTSECONDARY TRAINING

NCR donated $1.2 million to the University of Dayton to create two endowed professorships along with hardware and software needed to provided specialized coursework in data warehousing.

EMC^2, a leader in networked information storage systems, is partnering with the Massachusetts Bay Community College and New England Institute of Technology to sponsor an accelerated associate's degree program in technology skills.

PREPARING TEACHERS AND STUDENTS

Intel's "Teach to the Future" program will provide technology training for over 400,000 teachers by 2002.

Microsoft's "Classroom Teacher Network" is a free online training and professional development tool for K-12 teachers. Teachers from 80 different countries use this resource.

TECHNOLOGY GRANTS AND SCHOLARSHIPS

The Department of Labor administers the H-1B Technical Skills Training Grant Program which is authorized to use 55 percent of the $1,000 per H-1B visa application fee to fund training programs that will assist American workers in acquiring skills in occupations that are in demand, e.g., information technology.

Nortel Networks Scholars Program provides scholarships to university level students studying engineering and computer science. Over the next decade, more than 7,000 students will become Nortel Networks Scholars.

The National Science Foundation sponsors the Computer Science, Engineering, and Mathematics Scholarships (CSEMS) program which awards $2,500 per student per year for up to two years to low income and minority students.

DIVERSITY INITIATIVES

Hewlett Packard has committed $5 million over 5 years to their Diversity in Education Initiative which promotes study of engineering by minorities and women.

3com and the YWCA have established a new training program to encourage high school age females who are graduates of the YWCA's TechGYRLS program (ages 9-13) to continue their IT training in computer networking.

IT CAREER INFORMATION AND TRAINING SOURCES

The Information Technology Association of America provides information on IT careers, jobs and training. (http://www.itaa.org/workforce/resources/partner.htm)

The Department of Labor maintains America's Career Kit consisting of America's Career InfoNet (http://www.acinet.org), America's Job Bank (http://www.ajb.dni.us) and America's Learning Exchange (http://www.alx.org), which provides the public with training sources and job search information.

computer firms announced 486,172 job cuts.[9] Nonetheless, companies continue to hire for specific types of IT jobs including, networking, IT security, and e-commerce and some industries that provide IT services are still adding workers.[10]

Growth in demand for high quality digital products and electronically delivered services is expected to fuel the demand for skilled IT workers well into the future. BLS projects that seven of the ten fastest growing occupations over the next decade will be IT occupations and IT services will be among the fastest growing industries.[11]

INFORMATION TECHNOLOGY'S IMPACT ON LABOR MARKETS

The diffusion of information technology is affecting the way our labor markets operate. Widespread use of IT has reduced the importance of geographical boundaries and allowed some types of labor services to be provided from practically any location. IT has also raised education and skill requirements across the board, causing many workers and employers to commit to continuous training and skills upgrading. In addition, use of the Internet and related technologies has facilitated the matching of workers with employers, especially contingent workers who can more quickly and efficiently move among employers as needed.

IT and Job Location

The Internet and other networking technologies now allow some workers to work from virtually any location. Companies are no longer limited to local or regional job pools when competing for talent. This is especially true when the output is information and requires little person-to-person contact. In addition, businesses can leverage the Internet to subdivide work and have tasks performed at different geographical locations. They can also lower their costs by redistributing work to regions or even countries where labor costs are relatively lower. IT also gives employers access to a more diverse pool of workers including the disabled, older workers, parents with small children, and others who prefer to work from home.

E-mail, teleconferencing, video-conferencing, and the ability to reach people via cellular phones and two-way pagers help employers keep in touch with workers from all locations. This provides greater flexibility to the worker while increasing productivity, reducing costs and avoiding duplication of effort. At the same time, 24-hour access can blur the line between work and leisure, resulting in longer work hours and reduced job satisfaction. Some employers practice teleworking—an arrangement that allows employees to work from home one or more days per week. An estimated 13 to 19 million workers were involved in some form of teleworking in 2000.[12] This option is being used increasingly as a way to attract and retain high-quality workers. In addition, local governments, especially in urban areas are encouraging employers to use teleworking as a way to alleviate traffic congestion, reduce pollution, and promote energy conservation. The Federal government also favors flexibility in the workplace and has set goals for increasing teleworking by all federal agencies.[13]

IT and Rising Skill Requirements

One measure of the pervasiveness of IT is the growth in on-the-job computer use. According to

[10] *David Foote, "As 2002 Dawns, Job Market has some Bright Signs,"* Computerworld, *January 7, 2002. (http://www.computerworld.com); RHI Consulting , January 4, 2002 press release. (http://www.rhic.com/PressRoom?); Information retrieval services and cable and pay television services industries are two IT industries that continued to add jobs in 2001.*

[11] *Daniel Hecker, "Occupational Employment Projections to 2010,"* and *Jay M. Berman, "Industry Output and Employment Projections to 2010,"* Monthly Labor Review, *November 2001.*

[12] *"Telework and the Workplace of the 21st Century," Conference sponsored by the Department of Labor and Xavier University, October 2000. (http://www.dol.gov/dol/asp/public/telework/main.htm) Conference presenters cite several studies that provide evidence of the positive benefits of teleworking; U.S. Department of Labor,* Futurework: Trends and Challenges for Work in the 21st Century, *1999. (http://www.dol.gov/dol/asp/public/futurework/report.htm)*

[13] *Public Law 106-346, Section 359, 10/23/2000, as interpreted by OPM memorandum to agencies (2/9/2001), instructs federal agencies (1) to review telework barriers, act to remove them and increase actual participation, (2) to establish eligibility criteria, and (3) that subject to any applicable agency policies or bargaining obligations, employees who meet the criteria and want to participate must be allowed that opportunity if they are satisfactory performers. The law provides that its requirements must be applied, within four years, to 100 percent of the federal workforce. (http://policyworks.gov/telework)*

estimates from the Census Bureau, the number of workers using computers at work increased from 24.2 million in 1984 to almost 64 million in 1997, an average annual increase of 7.8 percent per year.[14] This growth in computer usage is widely believed to be a major contributor to the increased demand for skilled workers and the wage premium associated with using a computer.[15] Researchers have found that workers who use a computer at work can earn 17 to 22 percent more than other workers.[16]

Growth in computer use is not limited to workers in IT producing industries and IT occupations. Workers in a variety of non-IT occupations find themselves using computers and computerized devices to perform their jobs and more often than not, this requires some upgrading of skills. For example, in many financial services occupations, workers use computers for routine accounting and billing as well as more complex financial modeling. Records processing has become automated with records being maintained and transmitted electronically. Real estate agents maintain listings electronically and auto mechanics use computerized diagnostic devices. Almost any occupation that requires research involves the use of IT to search in-house or online databases.

Increased competition and rapid change in the new economy, along with rising skill requirements means workers must be able to adapt quickly to changing technologies and organizational structures. This will require technical skills as well as "soft" skills, e.g., interpersonal, management, and problem solving skills. Long-term prosperity for many workers will depend on their flexibility and willingness to upgrade their skills.

Although employer-sponsored training is offered by an estimated 80 percent of employers,[17] some skilled IT workers report spending up to 20 percent of their own time training to keep current in their field.[18] Many workers interested in upgrading their skills on their own, can take advantage of the lifetime learning tax credit.[19] Educational enrollment trends show that more workers are returning to school for job/career-related training. Between 1995 and 1999, participation in adult education programs increased across almost all age groups. For students enrolled in classes that were job related, enrollment grew fastest for the 55-59 age group.

IT and the Contingent Workforce

The contingent workforce includes workers who are part-time, temporary, self-employed, on-call, or independent contractors. Depending on how many of these groups are included in the definition, the size of the contingent workforce in 1999 ranged from 5 to almost 30 percent of all workers. BLS provides three measures of contingent workers, defined according to the worker's expected length of tenure. According to the broadest measure, the number of contingent workers has not changed much over time.[20] In 1995, the first year of the survey, there were slightly more than 6 million contingent workers; the number declined to 5.57 million in 1997 and 5.64 million in 1999. In contrast, employment in the help supply (temporary staffing) industry has grown dramatically—12 percent per year between 1992 and 2000, and BLS projects that it will be among the fastest growing industries over the next decade. Nonetheless, during the recent economic slowdown, employees in the help supply industry

[14] *Robert Kominski and Eric Newburger, "Access Denied: Changes in Computer Ownership and Use: 1984-1997," August 1999.(http://www.census.gov/population/www/socdemo/computer.html)*

[15] *David Autor, Lawrence Katz, and Alan Krueger, "Computing Inequality: Have Computers Changed the Labor Market?" NBER Working Paper 5956, March 1997; Lawrence Katz, "Technological Change, Computerization, and the Wage Structure," May 1999 (unpublished); Michael Handel, "Computers and the Wage Structure," Jerome Levy Economics Institute, Working Paper No. 285, October 1999; David Autor, Frank Levy, and Richard J. Murnane, "The Skill Content of Recent Technological Change: An Empirical Exploration," NBER Working Paper 8337, June 2001. (http://www.nber.org/papers/w8337)*

[16] *Using Current Population Survey (CPS) data, Autor, Katz, and Krueger estimated wage premiums of 18.5 percent for 1984, 20.7 percent for 1989 and 22.5 percent for 1993. McKittrick finds a wage premium of 17.6 for 1997 using CPS data and 21.9 percent for 1999 using the Survey of Income and Program Participation (SIPP) dataset. Source: George McKittrick, Department of Commerce, ESA, unpublished analysis, July 2001.*

[17] *Lisa Lynch and Sandra Black, "Beyond the Incidence of Employer-Provided Training,"* Industrial and Labor Relations Review, *Vol. 52, No. 1, October 1998.*

[18] *Based on National Research Council interviews with IT placement specialists.* Building a Workforce for the Information Economy, *National Academy Press, 2001, p. 254-255.(http://www.nap.edu/catalog/9830.html)*

[19] *Internal Revenue Service, "Tax Benefits for Higher Education," Publication 970. (http://www.irs.gov)*

[20] *Steven Hipple, "Contingent Work in the Late-1990s,"* Monthly Labor Review, *March 2001.*

have been the first to suffer layoffs. Employment (seasonally adjusted) in that industry declined by 6 percent during the first half of 2001.

More generally, information technologies have allowed the help supply industry to more efficiently and quickly match contingent workers with employers requiring these types of workers.[21] In addition, some researchers contend that increased use of temporary workers helped maintain a low rate of unemployment throughout the 1990s by helping restrain wage pressures that ordinarily accompany tight labor markets. IT also gives self-employed and independent contractors the flexibility and mobility to work outside of a traditional organization. Though temporary workers often lag behind in wages and benefits and run a greater risk of job loss, some workers prefer these types of flexible, nontraditional arrangements.[22]

IT and Job Search/Placement Outcomes

Information technologies are also changing the way we find work. From 1998 to 2000, the proportion of unemployed workers who reported regularly using the Internet to search for jobs, increased from 15 to 26 percent.[23] Companies not only post job openings on their web sites, but accept applications online. In 2000, there were over 3000 Internet job boards. Monster.com, one of the major Internet job search boards, saw the number of job seekers double in less than a year from 7 million in April 2000 to 14 million in March 2001. The number of job postings increased from 360,000 to over 500,000 during the same period. Many government agencies now allow potential employees to search and apply for jobs online.

Online job searching and advertising enable more efficient matching of workers and employers.[24] Efficiencies arise because potential employers can provide more information to job seekers more conveniently, on a more timely basis, and at a lower cost via an Internet job board or an online database. In contrast, space is limited (because of cost) in a traditional print classified advertisement. Also, employers can screen a larger number of applicants at a lower cost by scanning large volumes of information for keywords that indicate specific skills or work experience. Improved quality of matching between employers and job seekers should translate to higher productivity, output, and profitability for the employer. Moreover, access to so many job search options makes it easier for workers move between jobs.

CONCLUSION

Labor markets in the new economy provide workers with both opportunities and challenges. For higher skilled workers, the new economy offers strong demand and high wages. Lower skilled workers, on the other hand, are seeing skill requirements rise across a broad range of occupations. IT allows greater flexibility in working arrangements and lets employers quickly hire and release workers in response to changing market conditions. IT also makes the job search process easier for job seekers, and gives employers access to a wider and more diverse labor pool.

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[21] *Lawrence Katz and Alan Krueger, "The High Pressure U.S. Labor Market of the 1990s,"* Brookings Papers on Economic Activity, *1999.*

[22] *GAO report, "Contingent Workers– Incomes and Benefits Lag Behind Those of Rest of Workforce," GAO/HEHS-00-76, June 2000.*

[23] *Peter Kuhn and Mikal Skuterud, "Job search methods: Internet vs traditional,"* Monthly Labor Review, *October 2000. Kukh and Skuterud unpublished estimates, December 2001.*

[24] *David H. Autor, "Wiring the Labor Market," NBER Working Paper 7959, October 2000. (http://www.nber.org/papers/w7959)*

Chapter VI

International Sales of Information Technology Goods and Services

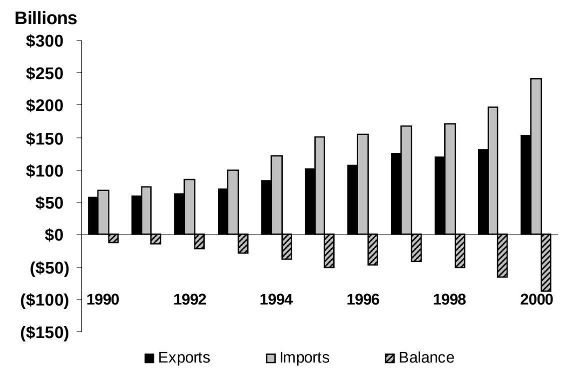
by Dennis G. Pastore[*]

In the midst of a global economic slowdown, U.S. IT goods trade slowed substantially in 2001. With imports down $28 billion and exports down $19 billion through the third quarter, the annual deficit in IT goods may shrink for the first time in five years.

Deficits are a chronic feature of U.S. IT goods trade (Figure 6.1). Moreover, except for 2001 and a brief period in the mid-1990s, our position has steadily worsened. In 2000 (the last year for which we have annual data), the U.S. trade deficit in IT goods was a record $88 billion (Figure 6.1). Deficits appeared in all major subcategories of goods trade except software and instruments. On the services side, 2000 data indicate a positive balance ($6.4 billion), with net receipts for computer and information services and software royalties and license fees ($8.0 billion) comfortably exceeding the nation's long-standing deficit in payments for telecommunications services.

Large and persistent IT trade deficits may seem to be clear evidence of competitive weakness and a telling refutation of the general perception that U.S. IT producers are leaders in the world market. In an increasingly integrated global economy, however, trade balances are incomplete and even misleading indicators of competitive success. Assessments of U.S. competitiveness must also take account of evolving patterns of global production and distribution.

Figure 6.1
U.S. TRADE IN IT GOODS



Source: OBIA calculations based on Census data obtained from the Trade Policy Information System (TPIS), International Trade Administration (ITA), U.S. Department of Commerce.

In addition to analyzing U.S. trade in IT goods and services, this chapter examines two factors that help to explain the apparent inconsistency between IT trade deficits and the perceived competitive strength of U.S. producers: (i) the tendency of U.S. IT companies to rely on overseas affiliates rather than exports to service foreign clients; and (ii) global deployment of production by multinational companies resulting in large negative intra-firm trade balances for the United States. Among the chapter's most important findings are:

- In 1998 (the last year for which data on the operations of U.S. multinationals are avail-

[*] *Mr. Pastore is an economist in the Office of Business and Industrial Analysis, Office of Policy Development, Economics and Statistics Administration.*

able), foreign sales of goods and services by majority-owned overseas affiliates of U.S. IT companies exceeded $202 billion—almost twice the value of comparable exports ($113 billion) that year from the United States.[1]

- The United States remains the world's largest exporter of IT goods, supplying 18 percent of the IT goods traded in world markets in 1999. Sales of goods produced abroad by foreign affiliates of U.S. companies to unaffiliated foreigners increase the global trade share of U.S. IT goods.
- In 2000, the U.S. deficit in IT goods trade between related parties (*i.e.*, U.S. parents and their foreign affiliates or foreign companies and their U.S. affiliates) totaled $104 billion—more than the entire U.S. IT trade deficit in 2000.
- While globalizing production, however, U.S. companies have kept high value-added functions at home. Plants located in the United States still produce, on average, more than three-quarters of the combined value added of companies in the United States and their foreign affiliates in the computer and office equipment, household audio and video and communications equipment, and electronic components and accessories industries. U.S. workers employed in these industries earn on average more than twice as much as employees of U.S. foreign affiliates in the same industries.

U.S. IT trade deficits also reflect cyclical, macroeconomic trends. Rapid economic growth in the United States through mid-2000 and the rush by U.S. businesses to adopt the latest in IT hardware and software were potent forces drawing in imports. The economic slowdown since mid-2000 is having the opposite effect.

I. TRADE IN IT-MANUFACTURED GOODS

The $88-billion overall deficit in U.S. IT goods trade in 2000, reflected deficits in all major segments of the IT goods market except instruments and software. Table 6.1 shows that the largest deficits in absolute terms were for components and accessories ($32.5 billion), computer and office equipment ($25.5 billion), and household audio and video equipment ($24.1 billion). The main contributors to the overall ($22 billion) increase in the deficit from 1999 to 2000, however, were telecommunications equipment, with a deficit increase of $9.8 billion, and electronic components and accessories, with an increase of $6.8 billion. Of the two surplus-generating IT goods categories, only instruments registered an increase. The surplus in software products declined 3.4 percent.

Closer inspection of the trade flows reveals a mixed pattern. The $13 billion improvement in the U.S. balance from 1995 to 2000 on sales of semiconductors and related devices and parts – driven to a large extent by increasing surplus sales of "unmounted" chips and wafers – is almost the mirror image of a $12.3 billion increase in the deficit on electronic components, n.e.c., a category dominated by imports of *assembled* printed circuits.[2] The two measures taken together provide a ready-made example of the international division of labor that now characterizes the global IT industry. Leading technology producers retain control of capital and knowledge intensive operations while transferring the more labor intensive manufacturing and assembly overseas. The year 2000 also marked the second time in a row that U.S. imports of computers exceeded exports. As in 1999, the negative balance on portable computers, dominated by deficits with Taiwan ($3.8 billion) and Mexico ($1.6 billion), more than accounted for the overall imbalance in computers.

The deficit in communications equipment trade rose substantially in 2000, jumping to $12.7 billion from $2.9 billion in 1999. This increase reflected import growth of nearly 60 percent compared with 12 percent for exports. Imports of radiotelephones (predominantly cell phones) accounted for about half of the rise.

II. TRADE IN IT SERVICES

IT services trade falls in two major categories—computer-related services and telecommunications services. Between 1990 and 2000, the United States enjoyed growing surpluses in cross-border sales of computer-related services, including infor-

[1]Citations for this and other findings reported in this summary introduction are included in later sections of the chapter.

[2] This observation is based on analysis of commodity trade flows from 1996 through 2000 based on harmonized trade classification system. Data source: TPIS database, International Trade Administration, U.S. Department of Commerce.

TABLE 6.1: U.S. TRADE IN IT MANUFACTURED GOODS

(Billions of dollars)

Product Description	1990	1995	1996	1997	1998	1999	2000
Exports							
All IT Goods	**57.6**	**100.8**	**107.5**	**124.7**	**120.6**	**130.6**	**153.9**
Computer and office equipment	**24.0**	**35.5**	**39.0**	**42.9**	**39.7**	**39.8**	**45.7**
Electronic computers	7.6	9.2	9.4	10.1	8.4	8.3	9.6
Computer storage devices	2.7	3.8	3.3	3.5	3.4	3.4	3.0
Computer peripheral equipment and parts	12.7	21.3	24.9	27.9	26.4	26.8	31.7
Calculating and accounting equipment and parts	0.5	0.5	0.6	0.7	0.7	0.7	0.8
Office machines and parts, nec	0.5	0.7	0.8	0.8	0.8	0.7	0.7
Electronic components and accessories	**17.4**	**34.7**	**36.4**	**44.2**	**43.5**	**52.1**	**64.3**
Electron tubes	0.6	1.5	1.7	2.3	2.5	2.4	2.6
Printed circuit boards	1.8	1.7	1.7	2.0	2.2	2.4	2.9
Semiconductors and related devices and parts	10.7	22.7	24.0	29.0	29.0	36.6	44.7
Electronic capacitors and resistors	0.7	1.5	1.8	2.1	2.0	2.3	3.3
Electronic coils, transformers, and connectors	1.2	2.0	2.2	2.7	2.6	2.8	3.8
Electronic components, nec	2.3	5.4	5.0	6.1	5.3	5.6	7.0
Household audio and video equipment	**2.1**	**3.3**	**3.5**	**4.1**	**4.5**	**3.8**	**4.1**
Communications equipment	**5.2**	**12.6**	**13.0**	**16.0**	**16.0**	**17.3**	**19.4**
Telephone and telegraph apparatus	2.4	5.8	6.6	7.3	7.9	9.1	11.8
Radio and TV communications equipment	2.8	6.8	6.4	8.6	8.2	8.2	7.7
Instruments	**6.0**	**9.5**	**10.1**	**11.7**	**11.6**	**12.7**	**15.7**
Magnetic and optical recording media	**1.7**	**2.0**	**2.7**	**2.6**	**2.0**	**1.7**	**1.4**
Prepackaged software	**1.2**	**3.2**	**2.8**	**3.3**	**3.2**	**3.3**	**3.3**
Imports							
Product Description	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
All IT Goods	**69.0**	**151.2**	**154.1**	**167.1**	**171.5**	**196.4**	**241.7**
Computer and office equipment	**16.7**	**43.2**	**50.0**	**58.1**	**57.4**	**63.6**	**71.2**
Electronic computers	2.6	4.9	6.4	7.3	7.2	10.1	13.6
Computer storage devices	6.0	14.2	16.4	19.5	18.1	16.9	16.3
Computer peripheral equipment and parts	6.3	21.4	24.6	28.6	29.2	33.9	38.4
Calculating and accounting equipment and parts	1.0	1.2	1.3	1.4	1.5	1.4	1.6
Office machines and parts, nec	0.9	1.5	1.4	1.3	1.4	1.3	1.3
Electronic components and accessories	**28.4**	**69.3**	**65.4**	**67.8**	**68.1**	**77.8**	**96.7**
Electron tubes	0.8	1.4	1.2	1.1	1.0	0.9	0.8
Printed circuit boards	1.9	1.9	1.9	2.1	2.0	2.2	3.0
Semiconductors and related devices and parts	12.1	39.2	37.0	37.0	33.7	37.8	48.2
Electronic capacitors and resistors	0.8	1.8	1.6	1.9	1.9	2.3	3.8
Electronic coils, transformers, and connectors	1.7	3.0	3.0	3.4	3.3	3.7	4.9
Electronic components, nec	11.1	22.1	20.7	22.3	26.2	30.9	36.0
Household audio and video equipment	**10.9**	**18.0**	**16.9**	**18.5**	**21.2**	**23.8**	**28.2**
Communications equipment	**8.5**	**12.5**	**13.1**	**13.2**	**14.5**	**20.2**	**32.1**
Telephone and telegraph apparatus	4.1	5.9	6.3	7.2	7.8	9.7	15.1
Radio and TV communications equipment	4.4	6.6	6.8	6.1	6.7	10.5	17.0
Instruments	**3.0**	**5.8**	**6.0**	**6.8**	**7.5**	**8.3**	**10.5**
Magnetic and optical recording media	**1.5**	**1.9**	**2.1**	**2.1**	**2.1**	**2.2**	**2.4**
Prepackaged software	**0.2**	**0.6**	**0.5**	**0.6**	**0.6**	**0.5**	**0.5**
Balance (X-M)							
Product Description	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
All IT Goods	**-11.5**	**-50.4**	**-46.6**	**-42.5**	**-50.9**	**-65.9**	**-87.8**
Computer and office equipment	**7.3**	**-7.7**	**-11.1**	**-15.2**	**-17.7**	**-23.8**	**-25.5**
Electronic computers	5.0	4.3	3.0	2.8	1.1	-1.8	-4.0
Computer storage devices	-3.3	-10.4	-13.1	-16.0	-14.7	-13.5	-13.3
Computer peripheral equipment and parts	6.4	-0.1	0.3	-0.7	-2.7	-7.1	-6.8
Calculating and accounting equipment and parts	-0.4	-0.7	-0.7	-0.7	-0.7	-0.8	-0.8
Office machines and parts, nec	-0.4	-0.8	-0.6	-0.5	-0.6	-0.6	-0.6
Electronic components and accessories	**-11.0**	**-34.6**	**-29.0**	**-23.6**	**-24.7**	**-25.7**	**-32.5**
Electron tubes	-0.1	0.2	0.5	1.1	1.5	1.5	1.8
Printed circuit boards	0.0	-0.2	-0.2	-0.1	0.1	0.2	-0.1
Semiconductors and related devices and parts	-1.4	-16.5	-13.0	-8.1	-4.8	-1.2	-3.5
Electronic capacitors and resistors	-0.1	-0.3	0.1	0.3	0.1	0.0	-0.5
Electronic coils, transformers, and connectors	-0.5	-1.0	-0.8	-0.7	-0.7	-0.9	-1.1
Electronic components, nec	-8.8	-16.7	-15.7	-16.2	-20.9	-25.3	-29.0
Household audio and video equipment	**-8.8**	**-14.6**	**-13.4**	**-14.4**	**-16.7**	**-20.1**	**-24.1**
Communications equipment	**-3.3**	**0.1**	**-0.1**	**2.7**	**1.5**	**-2.9**	**-12.7**
Telephone and telegraph apparatus	-1.7	-0.1	0.3	0.2	0.1	-0.6	-3.3
Radio and TV communications equipment	-1.5	0.2	-0.4	2.6	1.5	-2.3	-9.4
Instruments	**3.0**	**3.7**	**4.0**	**4.9**	**4.1**	**4.4**	**5.2**
Magnetic and optical recording media	**0.2**	**0.1**	**0.6**	**0.5**	**-0.1**	**-0.5**	**-1.0**
Prepackaged software	**1.0**	**2.6**	**2.3**	**2.7**	**2.6**	**2.8**	**2.7**

Sources:

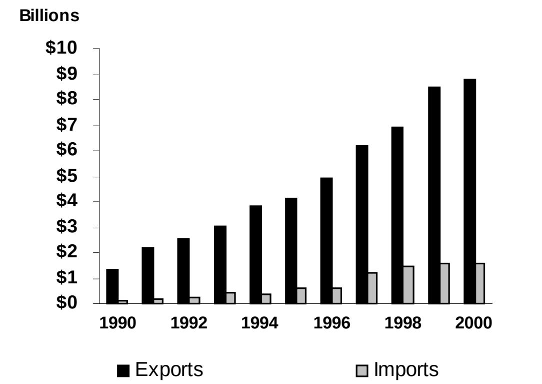
OBIA tabulations based on Census data from the Trade Policy Information System (TPIS) database, International Trade Administration, U.S. Department of Commerce.

Data on software trade from Bureau of Economic Analysis, Balance of Payments Division.

mation services and royalty income from software sales (Figure 6.2). Imports (purchases of services from overseas) over the period grew at 32 percent per year, while exports (receipts for U.S. services provided to overseas customers) grew at 21 percent. Though imports grew more rapidly than exports, the value of exports of computer-related services in 2000 ($8.8 billion) was still almost six times the value of imports. Receipts from royalties and license fees accounted for close to half (44 percent) of computer services exports.[3]

In contrast, deficits in telecommunications services trade are a fixture in the U.S. IT service sector, averaging more than $3 billion a year between 1990 and 2000. A number of factors contribute to the imbalance, including the relatively higher incomes in the United States and the wide array of cultural and business ties that exist between U.S. and foreign residents. In recent years, however, several developments worked to lower international rates and, along with them, the U.S. deficit. One of these was the FCC Benchmarks Order, which requires U.S. carriers to negotiate more cost-based settlement rates with foreign carriers for terminating calls from the United States. Another was the WTO Agreement on Basic Telecommunications, which accelerated the global trend of opening domestic telecommunications markets to competition. The WTO agreement obligated signatories to reduce their settlement rates by predetermined amounts each year over a five-year period beginning in 1997. Table 6.2 shows U.S. trade involving the major IT services between 1990 and 2000.

Figure 6.2
U.S. TRADE IN COMPUTER-RELATED SERVICES[1]



services, data base and other information services, and receipts of software royalties and license fees.
Source: OBIA calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis, "U.S. International Services: Cross-Border Trade in 2000 and Sales through Affiliates in 1999," Survey of Current Business 81 *(November 2001) and data provided by BEA, Balance of Payments Division.*

III. TRADE EFFECTS OF THE GLOBALIZATION OF PRODUCTION AND DISTRIBUTION OF IT GOODS AND SERVICES

Driven perhaps by the desire to increase foreign sales or to raise the level of support provided to overseas clients or by pressure to reduce costs, U.S. IT companies have established a significant operational presence abroad. The global deployment of production and distribution has strengthened U.S. companies in a highly competitive sector of the world economy.

Foreign sales of majority-owned foreign affiliates of U.S. IT companies in the five industries for which data are reported (*i.e.*, computer and office equipment, electronic components and accessories, household audio and video and communications equipment, computer and data processing services, and communications services)[4] substantially exceed U.S. exports of comparable goods and services (Figure 6.3).[5] In 1998 (the most recent year for which data are available)[6], estimated sales by foreign affiliates of U.S. firms in these industries totaled about $202 billion—almost twice the value of comparable IT goods and services exported by all U.S. companies that year ($113 billion).[7] Foreign affiliates of U.S. firms in the computer and office equipment industry accounted for more than half of these sales.

To reduce costs, U.S. firms reportedly have transferred production of many lower value-added, commoditized components and parts to foreign af-

[3] *Does not include royalties and license fees received from foreign affiliates*

[4] *Defined as sales to unaffiliated foreigners of goods and services by majority-owned foreign affiliates of U.S. IT companies net of the apportioned value of U.S. exports going to these affiliates. Source: U.S. Department of Commerce, Bureau of Economic Analysis,* U.S. Direct Investment Abroad: Operations of U.S. Parent Companies and Their Foreign Affiliates, Preliminary 1998 Estimates *(Washington, D.C.: U.S. Department of Commerce, 2000), Tables III.F 9 and II.T 1.*

[5] *In this regard, the IT sector is no different from other U.S. industries with a global presence. See also Joseph Quinlan and Marc Chandler, "The U.S. Trade Deficit: A Dangerous Obsession,"* Foreign Affairs*, Vol. 80, No. 3 (May/June 2001), 87-97.*

[6] *Data from the 1999 survey are expected to be published in the spring of 2002.*

[7] *The $113 billion figure does not include the value of U.S. exports of IT instruments (measuring and controlling devices), magnetic and optical recording media, prepackaged software, or receipts from overseas clients of software royalties and license fees.*

TABLE 6.2: U.S. TRADE IN IT SERVICES

(Billions of dollars)

Exports (Receipts)								
Description	**1990**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
IT Services Exports					**11.7**	**13.8**	**13.6**	**14.0**
To Unaffiliated Parties	**4.0**	**6.7**	**7.4**	**8.2**	**10.1**	**12.5**	**12.2**	**12.6**
Telecommunications services	2.7	2.9	3.2	3.3	3.9	5.6	3.7	3.8
Computer-related services	1.3	3.8	4.1	4.9	6.2	6.9	8.5	8.8
Software royalties and license fees	(1)	1.5	1.7	2.1	2.7	3.2	3.7	3.9
Computer and data processing services	1.0	1.3	1.3	1.6	2.0	1.9	2.7	2.5
Data base and other information services	0.3	1.0	1.1	1.2	1.5	1.8	2.1	2.4
To Affiliated Parties(2)					**1.6**	**1.3**	**1.4**	**1.4**
Computer and information services(3)								
U.S. parents to foreign affiliates					1.4	1.3	1.3	1.4
U.S. affiliates to foreign parent group					0.2	(*)	0.1	(*)

Imports (Payments)								
Description	**1990**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
IT Services Imports					**10.4**	**10.1**	**9.0**	**7.6**
From Unaffiliated Parties	**5.7**	**7.3**	**7.9**	**8.9**	**9.6**	**9.2**	**8.2**	**6.9**
Telecommunications services	5.6	6.9	7.3	8.3	8.3	7.7	6.6	5.4
Computer-related services	0.1	0.4	0.6	0.6	1.2	1.5	1.6	1.6
Software royalties and license fees	(1)	0.2	0.3	0.2	0.5	0.5	0.5	0.5
Computer and data processing services	0.0	0.1	0.1	0.3	0.6	0.8	0.9	0.8
Data base and other information services	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2
From Affiliated Parties(2)					**0.8**	**0.9**	**0.8**	**0.7**
Computer and information services(3)								
U.S. parents from foreign affiliates					0.5	0.6	0.6	0.6
U.S. affiliates from foreign parent group					0.3	0.3	0.2	0.1

Balance (X-M)								
Description	**1990**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
IT Services Trade Balance					**1.3**	**3.7**	**4.6**	**6.4**
Between Unaffiliated Parties	**-1.6**	**-0.6**	**-0.5**	**-0.7**	**0.5**	**3.3**	**4.0**	**5.7**
Telecommunications services	-2.8	-4.1	-4.1	-5.0	-4.4	-2.1	-2.9	-1.5
Computer-related services	1.2	3.4	3.6	4.3	4.9	5.4	6.9	7.2
Software royalties and license fees	(1)	1.3	1.4	2.0	2.2	2.7	3.2	3.3
Computer and data processing services	1.0	1.2	1.2	1.3	1.4	1.1	1.8	1.6
Data base and other information services	0.2	0.9	0.9	1.0	1.4	1.6	1.9	2.2
Between Affiliated Parties(2)					**0.8**	**0.4**	**0.6**	**0.7**
Computer and information services(3)								
U.S. parents from foreign affiliates					0.9	0.7	0.7	0.8
U.S. affiliates from foreign parent group					-0.1	-0.3	-0.1	-0.1

**Less than $50 million. Treated as zero when used in calculations.*
1Included in computer and data processing prior to 1992.
2Trade between affiliated parties reported on an industry basis. For accounting purposes, BEA considers all intrafirm payments for telecommunications services as transactions between unaffiliated parties. BEA does not separately identify intrafirm payments involving software royalties and license fees. However, unpublished data indicate that net payments to U.S. companies are substantial and could add a few billion dollars a year to the trade surplus.
3Includes both computer and data processing services and data base and other information services.
Sources:
U.S. Department of Commerce, Bureau of Economic Analysis, "U.S. International Services: Cross-Border Trade in 2000 and Sales through Affiliates in 1999," Survey of Current Business *81 (November 2001).*
Unpublished data on software royalties from 1994 through 1996 obtained from BEA, Balance of Payments Division.

filiates, while focusing in the United States on more profitable higher-end manufacturing activities and on the provision of computer and information services. Census Bureau estimates of industry-level value-added support this contention. Between 1995 and 1998, American manufacturing workers in the computer and office equipment, household audio and video and communications equipment, and electronic components and accessories (IT3) industries generated more than three-quarters of the combined value-added produced at IT3 firms located in the United States and at majority-owned

TABLE 6.3: U.S. IT GOODS TRADE BETWEEN RELATED PARTIES 2000

(Billions of dollars)

Product Description	Exports		Imports		Balance (X-M)	
	To Related Parties	Other[1]	From Related Parties	Other[1]	Between Related Parties	Other[1]
Total[2]	150.6		241.1		-90.6	
All IT	**56.5**	**94.1**	**160.4**	**80.8**	**-103.9**	**13.3**
Computer and office equipment	17.9	27.8	47.9	23.3	-30.0	4.5
Household audio, video and communication eq	6.8	16.7	42.4	18.0	-35.5	-1.3
Electronic components and accessories	25.5	38.7	62.2	34.5	-36.7	4.2
Other IT goods (excluding software)	6.3	10.8	7.9	5.0	-1.6	5.9

[1]Consists of trade between unrelated parties or parties who fail to specify whether a relationship exists.
[2]Total does not reflect trade in software. Values may differ from those in Table 5.1 because of rounding.
Source:
OBIA tabulations derived from data provided by the Foreign Trade Division, U.S. Census Bureau, U.S. Department of Commerce.

TABLE 6.4: WORLD TRADE IN IT GOODS[1] 1996 AND 1999

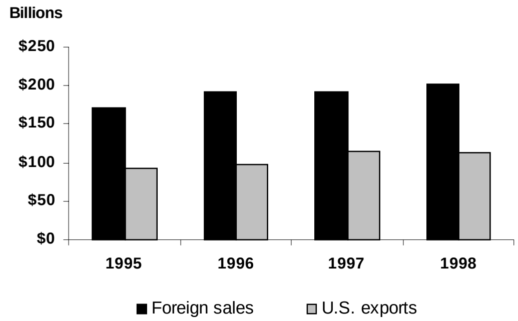
(Billions of dollars)

Country of Origin	Exports		Rate of Growth	Share of World Exports	Rank	
	1996	1999	1996-1999	1999	1999	1996
Total	**769**	**970**	**8.1%**			
United States	146	170	5.3%	18%	1	1
Japan	115	121	1.9%	13%	2	2
Taiwan	15	60	57.6%	6%	3	11
Germany	53	58	2.8%	6%	4	3
Malaysia	39	52	10.0%	5%	5	6
United Kingdom	40	49	7.1%	5%	6	5
Singapore	48	48	-0.1%	5%	7	4
Korea	32	46	12.6%	5%	8	7
Mexico	18	32	21.4%	3%	9	10
France	26	29	4.7%	3%	10	8
Netherlands	22	29	9.4%	3%	11	9
Philippines	11	23	29.1%	2%	12	16
Ireland	11	19	20.3%	2%	13	15
Thailand	14	19	9.0%	2%	14	13
Canada	15	18	5.9%	2%	15	12
Hong Kong	13	15	3.7%	2%	16	14
Hungary	2	7	59.3%	1%	17	17
Rest of World	150	177	5.6%	18%		

[1]Harmonized trade system (HTS) categories grouped to reflect 1987 SIC-based IT goods trade, not including software. Imports (c.I.f). reported by trading partners used as the measure of a country's exports. Calculated totals are estimates of the value of IT goods based on the first six digits of 10-digit HTS commondity codes for IT goods. The resulting inclusion of some non-IT goods and the different sources and valuation of the reported data cause the value of IT trade for the United States (and most likely for other countries as well) to be overstated.
Source:
OBIA tabulations based on United Nations trade data obtained from the TPIS database, ITA, U.S. Department of Commerce.

Figure 6.3

FOREIGN SALES[1] OF MAJORITY-OWNED FOREIGN AFFILIATES OF U.S. IT COMPANIES COMPARED TO U.S. IT EXPORTS[2]



[1]*Sales of goods and services to unaffiliated foreign parties by foreign affiliates of U.S. companies in IT3, computer and data processing services, and telecommunications services industries net of the apportioned value of affiliate purchases of goods from the United States. Values withheld to avoid disclosure were estimated for purposes of aggregation.*

[2]*U.S. exports of IT3 products and receipts for exports of computer-related services (excluding software royalties and licensing fees) and telecommunications services. Exports do not include receipts from intrafirm sales of computer-related services.*

Sources: OBIA calculations based on data derived from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), U.S. Direct Investment Abroad: Operations of U.S. Parent Companies and Their Foreign Affiliates, Revised 1995, 1996, and 1997 Estimates and Preliminary 1998 Estimates *(Washington, D.C.: U.S. Department of Commerce: 1998-2000); Census trade data in TPIS, ITA, U.S. Department of Commerce; and U.S. Department of Commerce, Bureau of Economic Analysis, "U.S. International Services: Cross-Border Trade in 2000 and Sales through Affiliates in 1999,"* Survey of Current Business *81 (November 2001).*

foreign IT3 affiliates of U.S. companies. An OBIA estimate places the total value added by these firms in 1998 at about $172 billion.[8]

Reflecting their higher per capita value-added, U.S. domestic workers in IT3 industries are better paid than their U.S. foreign affiliate counterparts. Average annual compensation per U.S. domestic worker in the IT3 industries was $51,787 in 1998 versus $24,727 for employees of majority U.S.-owned foreign affiliates.[9]

As a result of the globalization of production, internal transfers between accounting units of a single firm may become international transactions affecting national trade balances. A case in point: shipments of goods between firms producing in the United States and related companies located on foreign soil have a large negative impact on America's IT trade balance. Census data for the year 2000 show that two-thirds ($160 billion) of U.S. imports of IT goods and a little over a third ($57 billion) of U.S. IT exports involved shipments between related parties—*i.e.*, U.S. parents and their foreign affiliates or foreign parents and their U.S. affiliates (Table 6.3).[10] The resulting U.S. deficit in related party IT goods trade ($104 billion) in 2000 more than accounted for the nation's total IT trade deficit.

Finally, despite large and increasing deficits in U.S. IT trade and intense competition from producers in foreign countries, the United States remains the world's largest exporter of IT goods (Table 6.4). According to U.N. trade data,[11] companies located in the United States supplied about $170 billion, or 18 percent, of all IT goods traded in 1999. Exports to third countries of goods produced by foreign IT affiliates of U.S. companies ($88 billion in 1998) increase the contribution of U.S. companies to world trade in IT goods.[12]

[8] *OBIA estimates are based on data on value added obtained from the* Annual Survey of Manufacturing (1999), *Table 2, and* USDIA Operations (1998), *Table III G.4. We arrive at this figure by combining NAICS-based estimates of value added from the Census Bureau's* Annual Survey of Manufacturing *(for companies located in the United States) and SIC-based estimates from BEA of the gross product of majority-owned foreign affiliates. The measure is an approximation because the two concepts,while similar, are not identical. Value added is derived from a measure of total inputs that includes the cost of purchased services. BEA does not include the value of purchased services in its input measure when calculating gross product. While the method for calculating affiliate gross product is conceptually similar to the one used by BEA in its gross domestic product by industry data series, the industry-level estimates are only available at the two-digit SIC level, which makes them inadequate for our purposes here. A comparison of the ASM estimate of value added for all manufacturing industries in 1998 ($1,956 billion after adjusting the published NAICS-based $1,899 billion figure to reflect SIC-based accounting conventions) with the corresponding BEA estimate of gross product by (SIC) industry for all manufacturing industries ($1,432 billion) shows that the value added measure was about 27 percent higher than the corresponding gross product estimate. Reducing the value added by U.S.-based firms accordingly lowers the average U.S. share for the period 1995-1998 from 82 to 77 percent.*

[9] *OBIA estimates are based on data on compensation of employees obtained from* Annual Survey of Manufacturing (1999), *Table 3, and* USDIA Operations (1998), *Table III H.7.*

[10] *Tabulations are based on data provided by the Foreign Trade Division, Bureau of the Census, U.S. Department of Commerce.*

[11] *United Nations trade data were obtained from the Trade Policy Information System (TPIS), International Trade Administration, U.S. Department of Commerce. Imports, c.i.f., were used as the measure of world trade.*

[12] *Exports of goods by majority-owned foreign IT3 affiliates of U.S. companies (*i.e., *non-local foreign sales of majority-owned foreign affiliates net of the apportioned value of goods they imported from the United States). See* USDIA Operations (1998), *Tables III F.14 and II T.1. The industry-based foreign affiliate trade figures from BEA are not strictly comparable to the product-based UN trade numbers, but they provide a rough basis for gauging the relative magnitudes of the flows involved.*

Chapter VII

e-Learning: Impacts of IT on Education

Jacqueline L. Savukinas*

Understanding IT's role in the economy can be facilitated by a careful examination of varied industry-level effects. The effects of IT in health care, for example, are quite different from the effects of IT in manufacturing. This year's report begins an analytical approach we hope to continue in future reports—examination of important industry cases. The current chapter assesses the role of IT in the education industry, the relative importance of this industry, and the current and potential effects of IT on the way we learn.

The use of information technology in education is not new and it has not always been successful. From the integration of audio and visual equipment, such as educational filmstrips and audiotapes of 50 years ago, to the more recent use of videocassettes and computers, we see examples of past attempts to improve education delivery through IT. The latest generation of technology, including better Internet connections, education-related web sites, and sophisticated teaching software, promises also to have an impact on teaching. The latest software can be used as a teaching aid in conjunction with classroom instruction. And Web-based learning has the potential to allow students to receive education without ever setting foot inside a classroom.

Many observers expect IT to have a profound impact on the delivery and quality of education at every level, from preschool and elementary school to higher education and corporate training. At the primary and secondary levels, they point out, computers can be powerful teaching tools, allowing instructors to be more effective in reaching students if discipline and motivation issues can be addressed. At the postsecondary and corporate training levels, the Internet and the World Wide Web provide students with access to countless resources, including remote instructors and electronic libraries that can enhance learning in ways never before possible. More skeptical observers, however, argue that technology can be a distraction, adding an unnecessary cost to education and even impeding the learning process.

This chapter looks at the current applications of IT in each level of education—primary and secondary, higher education, and corporate learning. In each case, the chapter finds exciting developments but also problems. It is too early to say where the final balance between traditional and technology-based education is likely to be. However, IT's greatest impact so far is as a complement rather than a substitute for traditional education.

THE EDUCATION INDUSTRY

The education sector (i.e. total U.S. expenditure for schools and universities) accounts for 7 percent of GDP[1] and roughly 20 percent of all government expenditures.[2] For school year 1999-2000, estimated public school expenditures were $389 billion and higher education expenditures $258 billion.

In the fall of 2000, education employed 8.4 million people, including elementary and secondary school teachers, college faculty, and other profes-

*Ms. Savukinas is an economist in the Office of Business and Industrial Analysis, Office of Policy Development, Economics and Statistics Administration.

[1] *U.S. Department of Education, National Center for Education Statistics,* Digest of Education Statistics 2000, *NCES 2001-034, January 2001.*

[2] *U.S. Department of Commerce, Bureau of the Census, unpublished data.*

sional, administrative, and support staff. Of these, 3.3 million (18 percent more than a decade earlier) were elementary and secondary schoolteachers. In addition, in 1997[3] there were nearly a million full- and part-time faculty members in degree-granting institutions.

In the fall of 1998,[4] approximately 52.5 million students were enrolled in elementary and secondary schools, continuing a steady upward trend in U.S. school enrollment that began in 1985. According to the U.S. Department of Education's National Center for Education Statistics, enrollment will continue to rise each year for the next several years before gradually declining later in the decade.

In 1998, college enrollment also hit a record level (14.5 million), with expectations of a continued rise in the current decade. This growth in enrollment reflects an increase in the number of college age students, a greater incidence of high school graduates, a higher share of these graduates going on to college, and a higher enrollment rate for older women. Collectively, these changes more than offset the drop in traditional college-age enrollment that occurred during the 1980s and early 1990s. Between 1990 and 1998, while the enrollment rate of part-time students held steady, college enrollment of full-time students grew by 10 percent.

Employee training is also a factor in the growth of the education sector. U.S. corporations spent an estimated $60 billion on employee training in 2000,[5] including job-specific training, general education, and skills upgrading. Workforce training has become particularly important as employees update their skills in order to keep pace with rapidly changing technologies. Although estimates of skill obsolescence vary, one study estimates that half of all employees' skills become outdated within 3 to 5 years.[6] This ongoing skill decay may help explain why corporate training budgets increased by an estimated 24 percent between 1994 and 1999.[7]

IMPACTS OF IT ON EDUCATION

Primary and Secondary Education

The Federal Government now spends an estimated $1.5 billion[8] per year on technology investment in schools, directly through targeted programs for technology (such as the Technology Literacy Challenge Fund and Technology Innovation Challenge Grants) and indirectly through general federal education programs. The remainder of a school's technology budget comes from state and local governments and private institutions, including parents' groups and private and corporate donors. According to a 1998 survey[9], schools in 29 large urban school districts spent an average of $120 to $130 per student on technology during the 1998-99 school year. However, the amount that individual schools spent on technology and Internet access varied widely—from $22 to $584 per student.

Aided by lower connectivity cost and government assistance, schools have been improving the quality and speed of their Internet connections. In 1996, nearly three-quarters of public schools with Internet connections used dial-up network connections. By 1999, however, 86 percent were using faster and better dedicated lines or other (non dial-up) network connection approaches, such as ISDN, cable modem, and wireless connections.[10]

According to the U.S. Department of Education, 98 percent of all public schools had an Internet connection in 2000, up from 35 percent in 1994. Classroom connectivity, considered more important for instructional purposes, has increased from 3 percent in 1994 to 77 percent in 2000. Differences remain among schools with regard to classroom connectivity. Only 60 percent of the classrooms in schools with high concentrations of poverty (as measured by the percentage of students eligible for free and reduced lunch programs) are connected to the Internet, compared with 82 percent of classrooms in schools with the lowest concentrations of poverty. Similarly, the ratio of students

[3] *Latest year for which data are available.*

[4] *Latest year for which data are available.*

[5] *Rob Eure, "On the Job,"* The Wall Street Journal*, March 12, 2001.*

[6] *Michael Moe and Henry Blodgett,* The Knowledge Web*, Merrill Lynch & Co., Global Services Research & Economics Group, Global Foundation Equity Research Department, 2000, p. 229.*

[7] *Gregory Cappelli, Scott Wilson, and Michael Husman,* e-Learning: Power for the Knowledge Economy*, Credit* Suisse *First Boston Corporation, 2000, p.127.*

[8] The Power of the Internet for Learning, *Report of the Web-based Education Commission to the President and the Congress of the United States, December 2000, p. 117.*

[9] *Consortium for School Networking,* Taking TCO to the Classroom: A School Administrator's Guide to Planning or the Total Cost of New Technology*, Washington, D.C., 1999.*

[10] *U.S. Department of Education, National Center for Education Statistics,* Internet Access in U.S. Public Schools and Classrooms: 1994-2000*, NCES 2001-071, May 2001.*

to Internet-linked computers is 6 to 1 in schools with the lowest percentage of students in poverty, while the ratio is 9 to 1 in higher poverty schools.[11]

It is difficult to identify or measure the level of improvement in student achievement resulting from the use of web-based and other IT-enhanced learning. While educators and policymakers acknowledge that more research is needed to understand IT's impact on education, however, there is broad agreement that computers *alone* do not teach children. Two problems frequently identified by educators are the scarcity of applicable instructional technology, including software and online content material, and the lack of sufficient technical support and teacher training.

Instructional technology. Today, only a fraction of the $4 billion educational content market, including textbooks as well as instructional technology such as software and online course material, is comprised of online content material.[12]

The educational software market is highly fragmented. Products and services must be targeted according to grade and subject matter, and then marketed to over 15,000 school districts. Demand is limited to the number of students taking any given class at any given time.[13] Since the average cost of supplying product in these specialized sub-markets is high, many producers have reacted by generalizing their products and services into less-specific content, geared toward a wider audience, such as K-6.

Limited availability of online content is a particular problem in specialized areas of the curriculum, including foreign language studies and higher-level math and science courses. Moreover, producers of online content are not yet addressing the interests of cultural or ethnic groups. One survey reports that only 2 percent of Web sites target Americans who speak English as a second language.[14]

Technical support and training. Computers and the Internet can do little to enhance the quality of education without sufficient technical support. Technology expenditures must balance the need for investments in infrastructure, such as hardware, networking, and software, and the training and technical support required to maintain systems. In addition, teachers must be trained in the pedagogical uses of computers and the Internet. Simply knowing how to surf the Web is not enough. A 1999 study found that two-thirds of all teachers felt that they were not at all or only somewhat prepared to use technology in their teaching.[15] Another study found that even younger teachers with experience using computers felt unprepared to integrate their skills into their teaching because training in educational technology is not part of the curriculum in most schools of education.[16] Some universities have begun to address this deficiency. The University of Texas System offers a Master of Education in Educational Technology.

Higher Education

In higher education, IT's greatest impact has been to increase the flexibility of the learning experience, affording more people participation in advanced education through distance learning. Distance learning differs from other computer-assisted learning technologies by accepting the fundamentals of classroom teaching, reproducing them over the Internet, and making them available at anytime from anywhere.[17]

Since nearly half of all postsecondary students are now over the age of 25, colleges and universities are recognizing the need to make it easier for working adults to continue their education by offering distance-learning programs and, thereby, ensuring continuation of their role as education providers in the future. According to a the Department of Education, 44 percent of two-year and four-year institutions offered online courses in 1997-98, a 72 percent increase from 1994-95. And approximately 84 percent of four-year colleges are expected to offer distance-learning courses in 2002.[18]

The Sloan ALN[19] Consortium, an association of 95 accredited institutions of higher education offering associate, undergraduate, and masters de-

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[11] Ibid.

[12] The Power of the Internet for Learning, op. cit*., n. 8, p. 69.*

[13] *Ibid. p. 70.*

[14] *The Children's Partnership,* Online Content for Low Income and Underserved Americans: A Strategic Audit of Activities and Opportunities*, 2000.*

[15] *U.S. Department of Education, National Center for Economic Statistics. Fast Response Survey System,* Public School Teachers Use of Computers and the Internet*, FRSS 70, Washington, D.C., 1999.*

[16] *Market Data Retrieval.* New Teachers and Technology*. Shelton, CT, 2000.*

[17] *Ralph E. Gomory, "Internet Learning: Is it real and what does it mean for Universities?" Sheffield Lecture, Yale University, January 11, 2000.*

[18] The Power of the Internet for Learning, op. cit*., n. 8, p. 77.*

[19] *ALN is the acronym for asynchronous learning network, or*

gree programs partially or fully through online education, estimated that online course enrollments in member schools exceeded 300,000 during the 2000-2001 academic year and that nearly 50 full degree programs were offered. Members of the Consortium are required to offer degree or certificate programs that are at least as high quality as corresponding face-to-face programs.[20] Membership has steadily increased since the Consortium's inception in 1993. In addition, many of the distance learning projects initiated with Sloan grants have expanded over time, with or without further funding—an indication that distance learning can be a viable alternative or complement to traditional classroom learning.

One member of the Sloan Consortium, The University of Texas System's UT TeleCampus, is an example of a university that has incorporated accredited distance education into its curriculum delivery system. The UT TeleCampus was established in 1998 as the central support unit for online and distance education within the university system's 15 component campuses. Students apply to the participating UT campus of their choice and receive courses from other UT campuses participating in that degree plan. The same UT faculty members who teach the campus-based class also teach the online course. The UT TeleCampus currently offers seven online graduate programs and an expanding choice of undergraduate curricula.[21]

Other universities have formed partnerships with Internet education companies to bring their courses online. For example, Stanford University partnered with Unext.com to offer courses through the Stanford Center for Professional Development. The Center caters to working students, particularly engineers. To matriculate into the program, a prospective student must already be working in the field.[22]

"people networks for anytime-anywhere learning." See http://www.sloan-c.org/whatisaln.htm for more information.

[20] *For example, the student-teacher ratio of the online program must be equivalent to that of the classroom program.*

[21] *The UT TeleCampus has won five national and seven regional awards, including the U.S. Distance Learning Association's Excellence in Distance Learning Programming for its MBA Online. More information can be found on their website at http://www.telecampus.utsystem.edu/.*

[22] *Telephone interview with Carleen Wayne, Customer Service Coordinator, Stanford Center for Professional Development, September 13, 2001.*

Aside from traditional universities, a new type of for-profit institution for higher education has emerged to offer distance-learning opportunities—"virtual universities." Unlike traditional colleges and universities, virtual universities offer undergraduate and graduate degrees fully online. Although traditional universities have begun offering courses online, virtual universities still supply the majority of the demand for accredited online education from nontraditional and working students who cannot get to a physical campus. Four leading virtual universities—University of Phoenix Online, Jones International University, Cardean University, and Capella University—currently offer accredited bachelor and graduate degree programs to an enrolled student body of 27,500.[23] As of Spring 2001, the University of Phoenix is the only one of the four earning a profit, but with rising enrollments, the others expect to become profitable within the next few years.

Tuition at a virtual university can be up to 20 percent higher than for a physical one, due to the cost of building and maintaining computer networks and developing Web-based curricula.[24] Once these courses are developed, the costs of keeping them up to date should fall and their repeated use should lower average costs. However, other costs associated with providing online courses are less subject to economies of scale. These include the costs of technical and administrative support services as well as faculty and staff to answer e-mail and monitor student achievement.

In addition to higher costs, students who wish to enroll in virtual universities must be willing to bear the risk of making a two- or four-year commitment to a for-profit institution with a short record of accomplishment and/or virtually no physical presence. In March 2001, Masters Institute, a San Jose-based trade school offering computer classes and degrees online, closed its doors in mid-semester.

Still, by the end of 2000, even after much of the New Economy shakeout, virtual universities have not had problems in obtaining venture capital. Investors appear to like the revenue predictability of virtual universities—once students are enrolled and working on degrees, the university expects to receive a flow of income in the form of tuition.[25] And

[23] *Jennifer Rewick, "Off Campus,"* The Wall Street Journal*, March 12, 2001.*

[24] *Ibid.*

[25] *Danielle Sessa, "Business Plan",* The Wall Street Journal*, March 12, 2001.*

in the face of an economic slow-down, demand for education typically rises as workers look to update their skills in a more competitive labor market.

Corporate training

Corporate training is the fastest growing market for distance learning, a market that has grown from $558 million in 1998 to $2.3 billion in 2000.[26] Currently, only about one-third of the corporate training dollar spent on external training goes to e-training, but this is expected to increase. The appeal of e-training is that it provides tailor-made training to employees at exactly the time that they want and need it.

More than 200 companies now compete in offering e-training consulting services to businesses.[27] These providers include both conventional training companies going online and dot.com startups converting traditional training courses to the web. Colleges and universities are also entering the profitable corporate training market. New York University's for-profit entity, NYUonline, is marketing itself to corporations to offer classes to their employees. NYUonline uses New York University faculty and is providing 55 different classes to nearly 500 of its clients' employees. In addition, Harvard and Stanford have announced a plan to jointly design and deliver traditional and online executive education programs to companies around the world.[28]

The Federal Government is also using technology to enhance its public job training system. The U.S. Department of Labor's "America's Career Kit" uses the Internet to coach job seeking skills and help match unemployed workers with potential employers. One part of the Kit, America's Learning Exchange, is an electronic marketplace for training and education resources.[29] The Exchange currently lists 6,500 registered training providers offering 263,000 programs, seminars, and courses—roughly 7,000 of them accessible online.

IMPEDIMENTS TO E-LEARNING

Aside from uncertainty about the effectiveness of web-based learning, at least three aspects of distance-learning programs concern students and faculty participating in these programs—quality assurance, financial aid, and intellectual property rights.

Quality assurance. Traditional accreditation standards such as the number of books housed in the campus library or the number of Ph.D.s on the faculty are not meaningful for a web-based course or a virtual university.[30] Moreover, many public and private distance education institutions do not receive accreditation from the regional accreditation agencies that certify traditional colleges and universities. Rather their accreditation is from The Distance Education and Training Council.[31] Coordination among accrediting agencies to develop meaningful quality standards for both types of educational environments could help in reducing the skepticism many educators and policymakers feel toward distance learning.

Financial aid. A 1992 amendment to the Higher Education Act of 1965 barred federal student loans and grants to students enrolled in correspondence schools. Written before web-based learning became viable, this law responded to perceived problems in program quality. Congress also set limits on the amount of distance education an institution may offer if it is to retain its eligibility to participate in the federal student aid program. As a result, aid to traditional colleges and universities was threatened as schools offered more classes online. In 1999, to determine the feasibility of changing the 1992 provisions, Congress waived the financial aid limits for a small number of online schools and traditional universities with a heavy online presence. The U.S. Department of Education is monitoring a five-year demonstration project designed to provide guidance to the Congress on the quality and viability of expanded distance education.

Intellectual property rights. Traditionally, the course material a professor designed for the courses he taught (e.g., syllabi and lecture notes) was the professor's intellectual property. However, ownership of an online course costing the university several thousand dollars to produce is not as clear. Once developed, a course can be repeated, even with another faculty member in charge. The issue is who owns the online product. Cornell University's e-Cornell venture, deals with this prob-

[26] *Telephone interview with Cushing Anderson, lead e-learning analyst, International Data Corporation, January 25, 2002.*

[27] *"Lessons of a Virtual Timetable,"* The Economist*, February 15, 2001.*

[28] *"When Harvard Met Stanford,"* Business Week*, April 30, 2001.*

[29] Economic Report of the President*, February 2000, p. 163.*

[30] The Power of the Internet for Learning, op. cit.*, n. 8, p. 78.*

[31] *Ibid.*

lem by creating a three-way contract among the school, the online spin-off, and the Cornell faculty. The University and e-Cornell co-own the courseware, while the faculty member(s) owns the intellectual content behind the course.[32]

Professors at other universities are still grappling with intellectual property rights issues and considering in particular whether a university has the right to alter curricula. Faculty ownership proponents contend that the university's right to alter the curricula interferes with the professor's distribution rights. In view of online education's profit potential, this has become a major concern.[33]

[32] *Michael Totty, "The Old College Try,"* The Wall Street Journal*, March 12, 2001.*

[33] *Mark Anderson, "Professors Had Better Pay Attention,"* The Standard*, September 12, 2000. Pure online schools do not have this problem. They use an unambiguous work-for-hire arrangement and the content designers hold no stake in the courses they create.*

In a related event, MIT announced that it would make the materials for nearly all of its courses freely available on the Internet over the next ten years. According to MIT, the purpose of the program, known as MIT Open Course Ware (OCW), is knowledge sharing. Given the necessary levels of motivation and discipline, anyone with an Internet connection can access an education previously available to only an elite few. Faculty participation is voluntary. And since the MIT OCW program is not revenue generating, property rights issues have not yet been a serious concern. [34]

[34] *Policies toward the intellectual property created for MIT OCW are to be: "...clear and consistent with other policies for scholarly material used in education. Faculty will retain ownership of most materials prepared for MIT OCW, following the MIT policy on textbook authorship. MIT will retain ownership only when significant use has been made of the Institute's resources." For further information, see http://web.mit.edu/newsoffice/nr/2001/ocw-facts.html.*

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