CHAPTER IV:

INDUSTRY-LEVEL EFFECTS OF INFORMATION TECHNOLOGY USE ON OVERALL PRODUCTIVITY

By Jesus Dumagan, Gurmukh Gill and Cassandra Ingram*

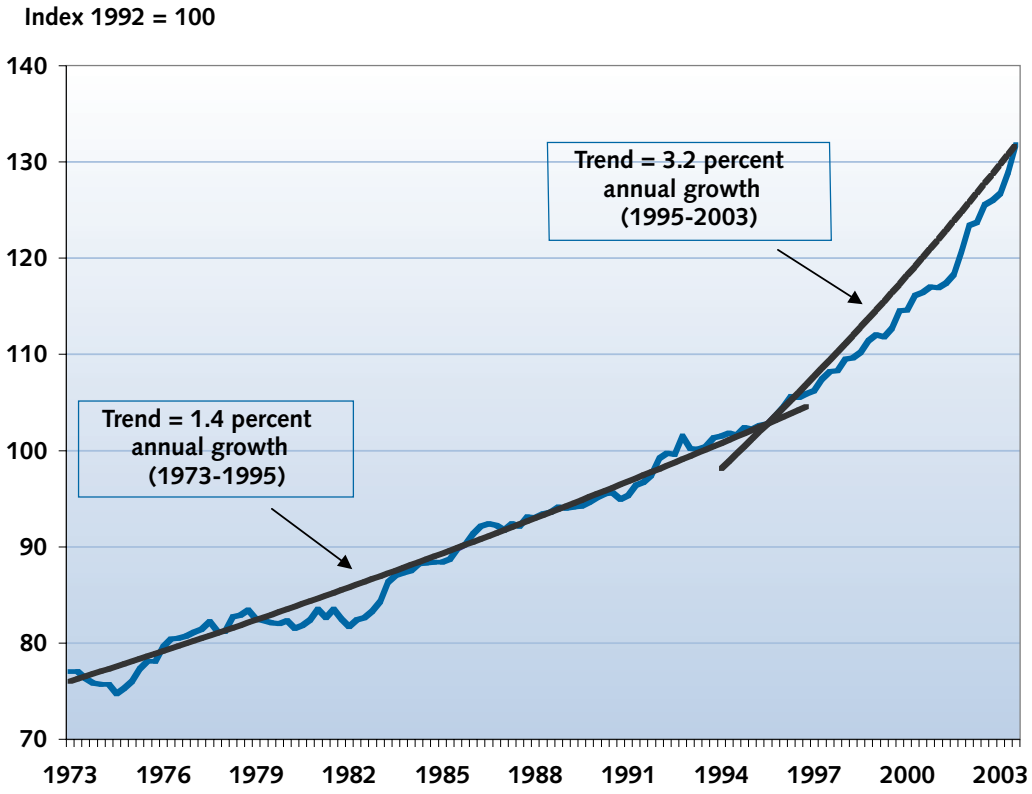
Beginning in the mid-1990s and continuing until mid-2000, the U.S. economy experienced a resurgence of labor productivity growth—accompanied by high output growth, low overall price growth, and low unemployment. (Figure 4.1.) This resurgence in labor productivity growth stemmed mostly from investment in and use of information technology (IT). Using industry-level BEA data, this chapter examines the role of IT in reviving and spreading productivity growth in the U.S. non-farm economy during 1989–2001.

The widespread dispersion of productivity growth across major sectors of the economy—largely paralleling the spread of IT—suggests that massive IT investments by U.S. industries are producing positive and probably lasting changes in the nation's economic potential. These conclusions add to recent findings by other economists concerning the widespread and lasting impacts of IT on the revival of U.S. productivity growth.[1]

* Mr. Dumagan (jess.dumagan@esa.doc.gov) is a senior economist; Mr. Gill (gurmukh.gill@esa.doc.gov) is senior executive for economic research; and Ms. Ingram (cassandra.ingram@esa.doc.gov) is an economist, all in the Office of Policy Development, Office of the Chief Economist, Economics and Statistics Administration.

[1] The findings in this chapter are consistent with those of recent studies by Baily and Lawrence, *ibid*.; Council of Economic Advisers, "Annual Report of the Council of Economic Advisers," in *Economic Report of the President* (January 2001); 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); 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; McKinsey Global Institute, "US Productivity Growth 1995–2000: Understanding the Contribution of Information Technology Relative to Other Factors," Washington, DC (October 2001); Stephen D. Oliner and Daniel E. Sichel, "Information Technology and Productivity: Where Are We Now and Where Are We Going?" The Federal Reserve Board, Washington, DC (May 10, 2002), available at http://www.federalreserve.gov//pubs/feds/2002/200229/200229abs.html; and Dale W. Jorgenson, Mun S. Ho, and Kevin J. Stiroh, "Lessons from the U.S. Growth Resurgence," presented at the U.S. Department of Commerce Transforming Enterprise Conference, Washington, DC (January 27–28, 2003), available at http://post.economics.harvard.edu/faculty/jorgenson/papers/CESIfo6final.pdf.

Figure 4.1. Average Annual Productivity Growth Accelerated in Non-farm Business Sector after 1995



Source: Bureau of Labor Statistics. Index on logarithmic scale

Productivity growth from 1973 to 1995 averaged about 1.4 percent annually. After mid-1995, including the recession year and the strong productivity growth experienced during 2002 and 2003, productivity growth has been robust and maintained a trend growth rate of 3.2 percent annually.

Data and Methods

In this study we calculate the contributions of individual industries to the growth of gross domestic product (GDP), total full-time equivalent (FTE) workers, and overall productivity (GDP/FTE). 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. The analysis is based on BEA annual data for the period 1989–2001 on industry-level GDP and FTE workers for 55 industries of the U.S. private non-farm business sector.[2]

[2] Since this study is an update, we start from 1989, the starting year of our earlier analysis in Chapter 4 of *DE 2002*, and add one more year 2001 for which the latest data are available. (See Appendix 4.A and Appendix 4.B for more details.) As in *Digital Economy 2002*, Chapter 4, the nonfarm business sector industries include those classified by BEA under *mining*, *construction*, *manufacturing durables*, *manufacturing nondurables*, *transportation and 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 this analysis because real estate includes value-added from owner-occupied housing for which there is no corresponding FTE.

To determine IT's effects on productivity growth, we ranked industries based on the intensity in their use of IT equipment[3] per worker (FTE). We then grouped these industries into two groups, either IT-intensive or less IT-intensive, each group accounting for 50 percent of aggregate GDP. This grouping enables us to compare the performance of the IT-intensive to less IT-intensive industries.

Appendix 4.A explains in more detail the method used in this chapter to estimate each industry's contribution to the economy's productivity growth and to calculate IT-intensities. Appendix 4.B presents the industry rankings. Appendix 4.C compares the methods used in this study with those used in similar studies that analyze the impacts of IT on productivity growth revival and acceleration (see footnote 1).

IT and Growth in GDP and FTE

Overall productivity growth is growth in the economy's GDP/FTE ratio. Alternatively, productivity growth is the difference between GDP growth and FTE growth. Thus, as a background to the analysis of the effects of IT on productivity growth, we first review growth trends in GDP and FTE separately for the IT-intensive group of industries, the less IT-intensive group, and for all industries in the non-farm business sector.

GDP Growth

Table 4.1 presents real GDP growth figures for various analytically interesting time periods and by IT-intensity grouping. From 1989 to 2001, the average annual GDP growth of 4.41 percent in the IT-intensive industries was almost twice the 2.44 percent growth in the less IT-intensive industries. During sub-periods in the time span 1989 to 2001, GDP growth in the IT-intensive industries was consistently greater than GDP growth in less IT-intensive industries.

Average annual GDP growth also accelerated (1995–2001 over 1989–1995) more in IT-intensive industries (2.55 percentage points) than in less IT-intensive industries (1.29 percentage points). In the economic downturn of 2001, however, GDP growth was weak and slowed to 0.29 percent in IT-intensive and to 0.17 percent in less IT-intensive industries.

Table 4.1. GDP Growth, 1989–2001

Industry	Avg GDP Growth 1989–2001	Avg GDP Growth 1989–1995	Avg GDP Growth 1995–2000	2000–01	Avg GDP Growth 1995–2001
IT-Intensive	4.41	3.13	6.76	0.29	5.68
Less IT-Intensive	2.44	1.80	3.68	0.17	3.09
All Industries	3.41	2.45	5.20	0.23	4.37

Note: GDP is gross domestic product. The industries covered are those in the non-farm business sector excluding real estate, as explained in footnote 2.

Source: ESA estimates derived from BEA data.

[3] IT equipment covers computers and peripheral equipment, software, and other information processing equipment.

Table 4.2. FTE Growth, 1989–2001

Industry	Avg FTE Growth 1989–2001	Avg FTE Growth 1989–1995	Avg FTE Growth 1995–2000	2000–01	Avg FTE Growth 1995–2001
IT-Intensive	1.33	0.73	2.87	–2.73	1.93
Less IT-Intensive	2.01	1.80	2.59	0.43	2.23
All Industries	1.77	1.42	2.69	–0.68	2.13

Note: FTE is full-time equivalent worker. The industries covered are those in the non-farm business sector excluding real estate, as explained in footnote 2.

Source: ESA estimates derived from BEA data.

FTE Growth

Table 4.2 presents information on employment growth, as measured by change in the number of FTE workers for various time periods, highlighting differences between IT-intensive and less IT-intensive industries. From 1989 to 2001, average annual FTE growth was lower in the IT-intensive industries (1.33 percent) than in less IT-intensive industries (2.01 percent). This changed during the 1995 to 2000 period, when average annual FTE growth was somewhat greater in the IT-intensive industries (2.87 percent) compared to the less IT-intensive industries (2.59 percent). During the economic downturn of 2001, however, FTE growth in IT-intensive industries declined dramatically to –2.73 percent, whereas FTE growth in less IT-intensive industries recorded a modest increase of 0.43 percent.

Major Findings

Productivity Growth Remains High in IT-intensive Industries

Our industry-level analysis shows that between 1989 and 2001 average productivity growth for all industries was 1.60 percent (Table 4.3 and Figure 4.2). Average growth for IT-intensive industries for this period was 3.03 percent, far exceeding growth in the less IT-intensive industries which averaged 0.42 percent. During the economic downturn of 2001, productivity growth in IT-intensive industries remained strong and relatively stable at 3.10 percent, buoying productivity growth for all industries into positive territory at 0.91 percent.[4] Growth in the less IT-intensive industries, however, fell to –0.26 percent.

[4] The calculations in this chapter are based on BEA industry-level GDP and FTE data for nonfarm business sector industries (defined in footnote 2) available at the start of this year. BEA has not updated these data since then. At the time we calculated the above 2001 GDP per FTE annual growth rate of 0.91 percent, BLS released a comparable 2001 annual output per hour growth rate of 1.1 percent for the nonfarm business sector. The slight difference could be explained by differences in industry coverage. This could lead to differences (1) between our aggregate GDP and the aggregate output used by BLS and (2) between our total FTE and the equivalent total hours used by BLS. However, BLS has since updated the 2001 annual output per hour growth from 1.1 to 1.9 percent based largely on BLS' revised estimates of 2001 total hours. However, we are unable to update our 2001 GDP per FTE annual growth rate of 0.91 percent, or any of our calculations, because the next updates will be released after the release of this report. BEA's NIPA Comprehensive Revision will be released in December 2003 and BEA's GDP-by industry Comprehensive Revision will be released in June 2004.

Table 4.3. Productivity (GDP per FTE) Growth, 1989–2001

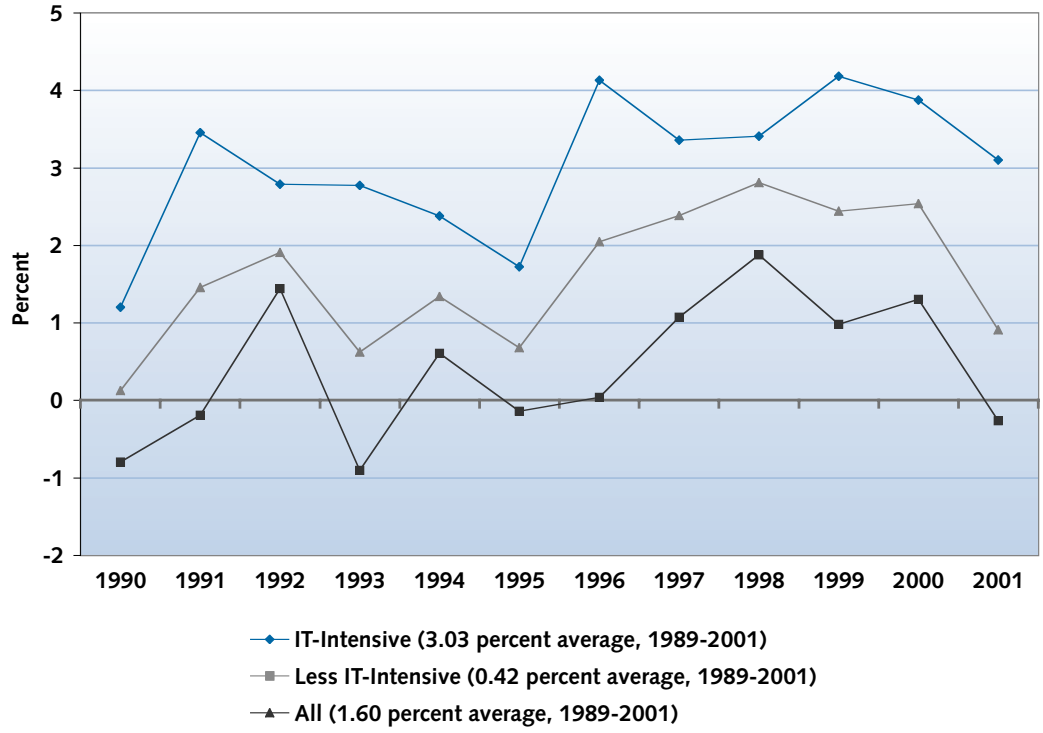
Industry	Avg GDP/FTE Growth 1989–2001	Avg GDP/FTE Growth 1989–1995	Avg GDP/FTE Growth 1995–2000	2000–01	Avg GDP/FTE Growth 1995–2001
IT-Intensive	3.03	2.39	3.79	3.10	3.67
Less IT-Intensive	0.42	0.00	1.05	–0.26	0.83
All Industries	1.60	1.02	2.44	0.91	2.19

Note: GDP is gross domestic product. FTE is full-time equivalent worker. The industries covered are those in the non-farm business sector excluding real estate, as explained in footnote 2.

Source: ESA estimates derived from BEA data.

For comparison purposes, Table 4.3 and Figure 4.2 also present productivity growth for the above grouping of industries by IT-intensity for analytically interesting time periods. All post-1995 groupings, for IT-intensive industries, including even the recession year of 2001, exhibit stronger productivity growth than the pre-1995 groupings, suggesting that the increase in labor productivity growth in IT-intensive industries is not transitory.

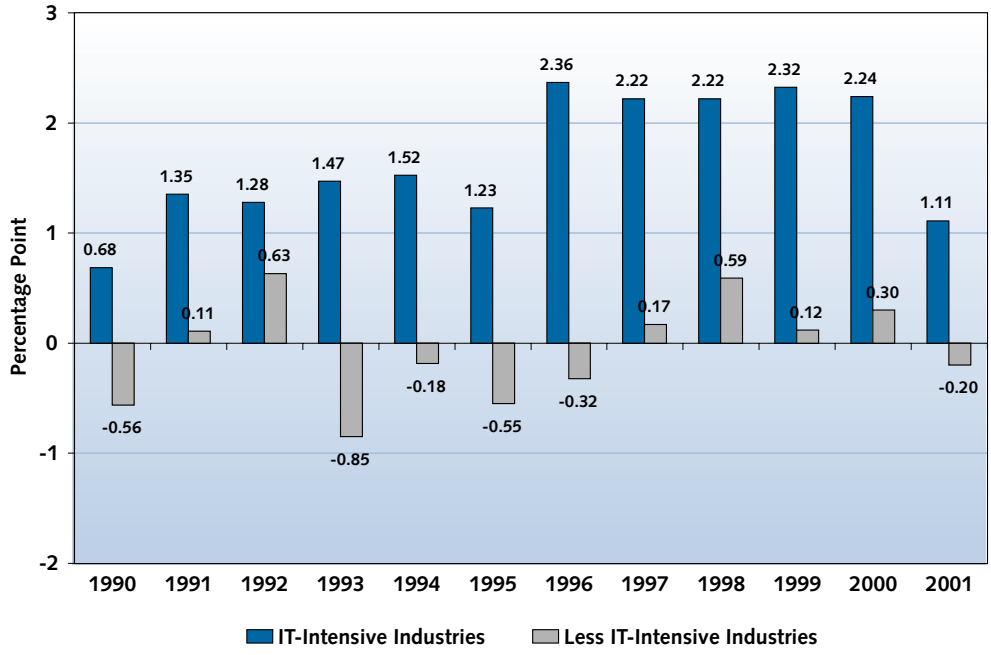
Figure 4.2. Labor Productivity Growth in IT-Intensive, Less IT-Intensive and All Industries of the U.S. Non-Farm Business Sector 1989–2001



Note: The industries covered are those in the non-farm business sector, excluding real estate.

Source: ESA estimates derived from BEA data.

Figure 4.3. Contributions to Overall Labor Productivity Growth by IT-Intensive and Less IT-Intensive Industries of the U.S. Non-farm Business Sector 1990–2001



Note: The industries covered are those in the non-farm business sector, excluding real estate.

Source: ESA estimates derived from BEA data.

IT's Contribution to Productivity Growth Also Significant

Annual comparisons of contributions to overall productivity growth further demonstrate that contributions of IT-intensive industries to productivity growth were much greater than those of less IT-intensive industries (Figure 4.3).

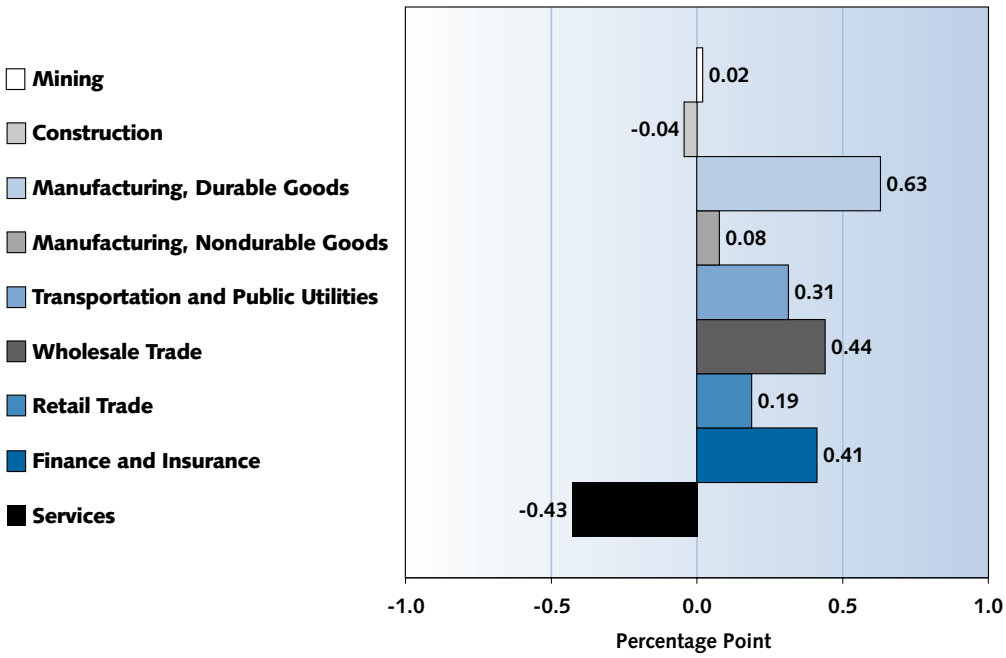
For the 1989–2001 period as a whole, the contribution of IT-intensive industries to the average annual labor productivity growth for the non-farm economy of 1.60 percent was 1.67 percentage points. This was more than 100 percent of this overall labor productivity growth. Less IT-intensive industries had a slightly negative contribution of –0.06 percentage points.[5]

Labor Productivity Growth Widely Spread Across Industries

Contributions to long-run productivity growth (1989 to 2001) are widely dispersed among industries (Figure 4.4.) While manufacturing durables made the largest contribution, 0.63 percentage points (39 percent), to the average annual growth of 1.60 percent, sectors outside of manufacturing durables also made significant contributions. Wholesale trade contributed 0.44 percentage points (28 percent) to productivity growth and accounts for a larger percent of productivity growth contribution than even the finance and insurance industry.

[5] Because Figure 4.3 involves *additive* "contributions," productivity growth of all industries for each year can be calculated by adding the IT-intensive industries' contribution to the less IT-intensive industries' contribution. For example, in 2001, productivity growth was 0.91 percent or 1.11 percentage points plus –0.20 percentage points. To get the average growth contribution by either the IT-intensive or less IT-intensive industries over the 1989–2001 period, simply sum the contributions for each industry group across 12 years and then divide by twelve.

Figure 4.4. Contributions to Labor Productivity Growth in U.S. Non-Farm Business Sector by Major Industry Group 1989–2001



Note: The Finance and Insurance group excludes real estate.

Source: ESA estimates derived from BEA data.

Other recent studies have reached similar conclusions.[6] McKinsey Global Institute (MGI) found that 38 industry sectors recorded productivity increases after 1995; together, these sectors accounted for 70 percent of GDP. Analyses by the Council of Economic Advisers (CEA) and Kevin Stiroh, each found that more than half of the industry sectors registered productivity increases. Robert Gordon, who asserted in 2000 that labor productivity growth was narrowly concentrated in durable manufacturing sectors has updated his analysis. He now also finds evidence of acceleration of productivity growth well beyond the durable goods sector.[7] Finally, a 2002 study by Jack Triplett and Barry Bosworth took a detailed look at the service sector (examining 27 industries in this sector) and concluded that IT-intensive industries in the US economy are predominantly services industries and that the labor productivity growth in this sector has been comparable with that in the overall economy. Moreover, within services, productivity is broad-based and not just limited to a few large industries.[8]

---

[6] For a review and synthesis of the relevant literature, see Jason Dedrick, Vijay Gurbuxani, and Kenneth L. Kraemer, "Information Technology and Economic Performance: A Critical Review of Empirical Evidence," Center for Research on Information Technology and Organization, University of California, Irvine (March 2003).

[7] See the studies by Kevin Stiroh, CEA, MGI noted in footnote 1, Robert J. Gordon, "Does the 'New Economy' Measure Up to the Great Inventions of the Past?," *Journal of Economic Perspectives* (Fall 2000), 49–74 and Robert J. Gordon, "Technology and Economic Performance in the American Economy," National Bureau of Economic Research, Working Paper, no. 8771 (2002).

[8] Jack Triplett and Barry Bosworth, "Services Industries and U.S. Productivity Acceleration: Contributions of IT and MFP," presented at the Brookings Institution Workshop on Economic Measurement, Washington, DC (May 17, 2002).

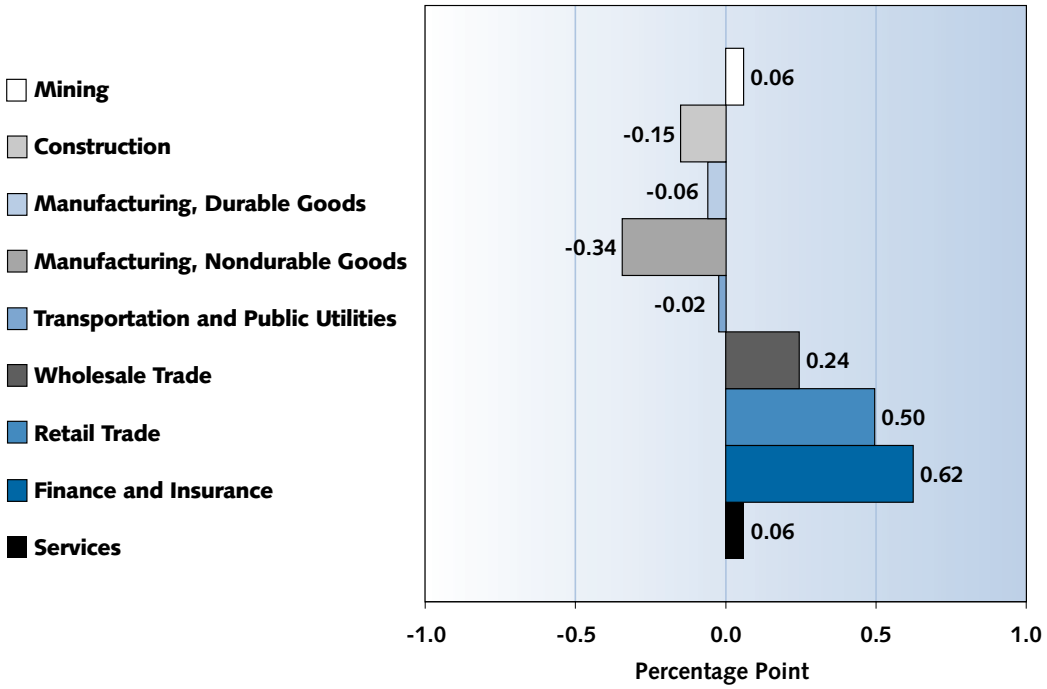
LABOR PRODUCTIVITY GROWTH WIDELY SPREAD EVEN DURING THE 2001 RECESSION

During the 2001 recession, productivity growth for all industries averaged 0.91 percent. Positive growth contributions were widely spread among 29 of the 55 industries comprising the U.S. non-farm economy. Five major sectors (mining, wholesale trade, retail trade, finance and insurance, and services) had positive contributions while four major sectors (construction, durable manufacturing, nondurable manufacturing, and transportation and public utilities) made negative contributions to productivity growth in 2001. (Figure 4.5.)

Among major sectors that made positive contributions, the finance and insurance sector contributed most. It contributed about 0.62 percentage points (68 percent) of the 0.91 percent productivity growth in 2001. A more detailed analysis of this sector showed that the largest contributions came from IT-intensive industries, namely, securities and commodity brokers (26 percent), holdings and other investment offices (26 percent) and nondepository institutions (15 percent).

Among the remaining major industry sectors, retail trade (one of the less IT-intensive industries) made the second highest contribution (54 percent)—largely because of its large weight in the economy—followed by IT-intensive wholesale trade (27 percent). The mining and services sectors made small positive contributions to productivity growth in 2001.

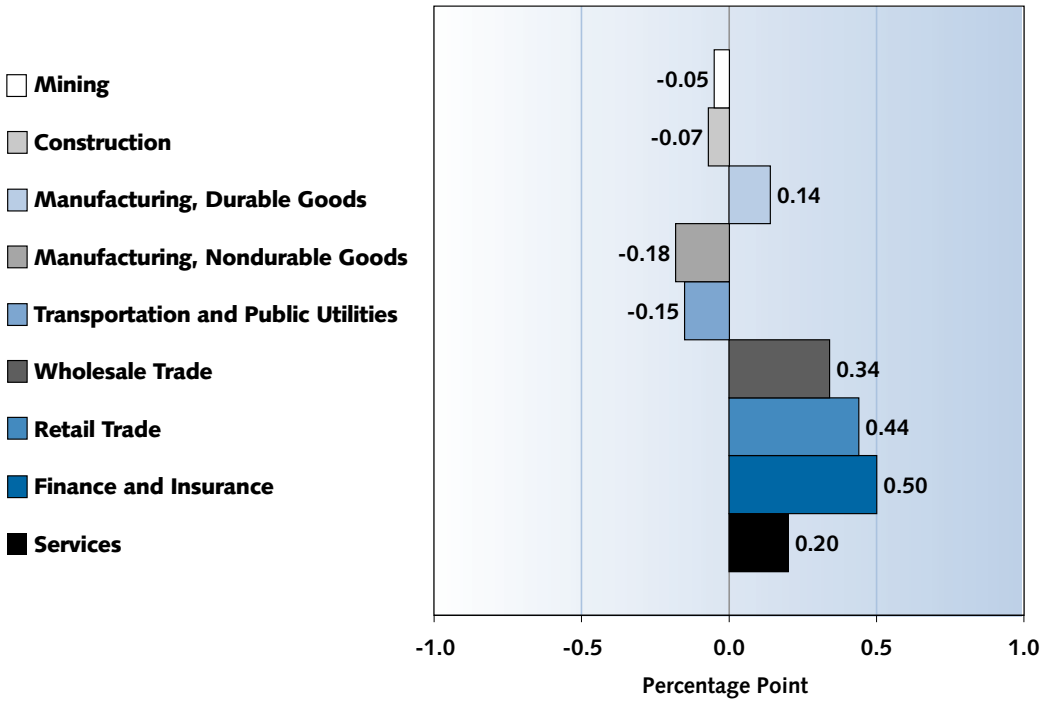
Figure 4.5. Contributions to Labor Productivity Growth in U.S. Non-Farm Business Sector by Major Industry Group, 2001



Note: The Finance and Insurance group excludes real estate.

Source: ESA estimates derived from BEA data.

Figure 4.6. Contributions to Productivity Growth Acceleration in U.S. Non-Farm Business Sector by Major Industry Group 1995–2001 Over 1989–1995



Note: The Finance and Insurance group excludes real estate.

Source: ESA estimates derived from BEA data.

Within the services sector, IT-intensive business services stood out with a large positive contribution of 0.37 percentage points (41 percent). This was mostly offset by the negative contributions of many other industries in this sector.

Even within sectors that made negative contributions overall, some individual IT-intensive industries had notable positive contributions. For example, the electronic and other electric equipment industry (which includes IT-producers among others in the durable manufacturing sector) made a robust 0.24 percentage points (26 percent) contribution to the 0.91 percent productivity growth in 2001. Likewise, the telephone and telegraph along with the radio and television industries (in the transportation and public utilities sector) made robust contributions of 0.31 percentage points (34 percent) and 0.11 percentage points (12 percent), respectively, to overall productivity growth.

ACCELERATION IN LABOR PRODUCTIVITY GROWTH WIDELY SPREAD ACROSS INDUSTRIES

Contributions to productivity growth acceleration (i.e., growth during 1995–2001 over that during 1989–1995) of 1.17 percentage points were also widely distributed across industries and also differed from the analysis of long-run (1989–2001) and 2001 growth contributions. (Figure 4.6.) The bulk of this acceleration during the post-1995 period can be attributed to IT-intensive

industries, which accounted for 0.82 percentage points (71 percent) of this growth acceleration. In contrast, the less IT-intensive half of industries contributed only 0.34 percentage points (29 percent) to overall acceleration in productivity growth.

Twenty-nine industries contributed positively to the 1.17 percentage point growth acceleration during 1995 to 2001 over growth during 1989 to 1995. Productivity growth accelerated not only in manufacturing durables but also in wholesale trade, retail trade, finance and insurance and services. Manufacturing durables contributed 0.14 percentage points (12 percent) to the overall 1.17 percentage point productivity growth acceleration. The largest contribution came from finance and insurance (42 percent), followed by retail trade (38 percent), wholesale trade (29 percent) and services (17 percent).

EMPLOYMENT AND PRODUCTIVITY GROWTH IN 2001—THE RECESSION YEAR

Our analysis of the components of productivity growth, finds that modest GDP growth coupled with a sharp decline in FTE growth in the 2001 recession year kept productivity growth in IT-intensive industries high. Therefore, productivity growth in the IT-intensive industries in 2001 appears to arise largely from the ability of these industries to shed jobs during lean periods.

Moreover, some of this job shedding may be related directly to IT. A review of Occupational Employment Statistics data in some industries suggests that management and office and administrative support occupations represent the bulk of employment losses in a number of IT-intensive industries.[9]

For example, of the IT-intensive industries that contributed significantly to productivity growth, wholesale trade and business services had the largest job losses or reductions in employment growth and only a slight decline in GDP growth. The shares of total jobs eliminated in wholesale trade, by occupation, were office and administrative services (24 percent), management occupations (18 percent), and transportation and material moving occupations (16 percent). Similarly, in business services, the largest decline in jobs was in the office and administrative support occupations (27 percent), followed by installation, maintenance and repair occupations (20 percent) and computer and mathematical occupations (12 percent). While occupations, such as office and administrative occupations, were clearly IT-displaceable, others such as management occupations also appear susceptible to IT-enabled cost-cutting during a recessionary environment. Many of these occupations also have been susceptible to outsourcing/offshoring.

[9] Bureau of Labor Statistics, "Occupational Employment Statistics by Industry" (January 2003) at http://www.bls.gov/oes/home.htm.

Appendix 4.A. Data and Methods

The present analysis applies the growth decomposition methodology of Chapter 4, U.S. Department of Commerce, *Digital Economy 2002*, Washington, DC (February 2002), to *more* data over a *longer* period. [The *DE 2002* report is available at http://www.esa.doc.gov/pdf/DE2002r1.pdf.] A description of this methodology is included in Box 4.1, p. 32, of that report and spelled out in a separate mathematical Appendix to Chapter 4. The methodology follows BEA's chained-dollar procedures to determine aggregate real (chained 1996 dollars) GDP and to decompose real GDP growth into the contributions of industries. The appendix also presents a decomposition of total FTE growth into the contributions of industries. These two decompositions are then combined to show the decomposition of aggregate GDP/FTE growth into industry-level contributions. The procedure is described below.

Decomposing Aggregate Productivity Growth (GDP per FTE) Into Industry-Level Contributions

The contribution of an industry to growth of aggregate GDP equals the growth of the industry's GDP multiplied by its share in aggregate GDP. Similarly, an industry's contribution to total FTE growth equals the growth of the industry's FTE multiplied by its share in total FTE. In this study, overall labor productivity growth equals growth of aggregate GDP minus growth of total FTE. Therefore, an industry's contribution to overall labor productivity growth equals the *growth of the industry's GDP multiplied by its share in aggregate GDP* minus the *growth of the industry's FTE multiplied by its share in total FTE*. Contrast this, however, with the labor productivity growth of an industry viewed in isolation. In the latter case, the industry's productivity growth equals the growth of its GDP minus the growth of its FTE. Thus, it can be seen that an industry with a *positive* productivity growth viewed in isolation could make a *negative* contribution to overall productivity growth if the industry has a *smaller* share in aggregate GDP than its share in total FTE. The converse case is possible that an industry with a *negative* productivity growth viewed in isolation could make a *positive* contribution to overall productivity growth if the industry has a *larger* share in aggregate GDP than its share in total FTE. In general, these possibilities imply that it could be misleading to gauge an industry's contribution to the overall performance of the economy simply by looking at the performance of the industry in isolation. These considerations underlie this chapter's decomposition of overall productivity growth into the contributions of individual industries.

Determining More IT-Intensive Top-Half and Less IT-Intensive Bottom-Half Groups of Industries

In Chapter 4 of *DE 2002*, the IT-intensity ranking was determined for 55 two-digit SIC industries based on the highest to lowest *1996 value* of the *ratio* of IT capital to FTE workers for *each* industry divided by the *overall ratio* of IT capital to FTE workers for *all* industries. Industries were then divided into a top-half group (i.e., those relatively more IT-intensive industries accounting for a 50 percent share of aggregate nominal GDP) and a bottom-half group (i.e., those relatively less IT-intensive industries accounting for the remaining 50 percent of GDP). Each industry's share is the *average* of its annual shares of nominal GDP during 1989–2000. Data on IT capital, GDP and FTE are from BEA. IT data are net stocks at current cost that include 15 of BEA's nonresidential fixed asset types from mainframe computers to office and accounting equipment.

In this analysis, the IT-intensity ranking of industries is new in that it is no longer based only on the 1996 value defined above but on the *average* of similar annual values for each industry during 1989–2001. This matches the determination of the top-half and bottom-half groups of industries above based on the *average* of annual shares of nominal GDP for the period 1989–2001, which adds 2001 to the period covered by Chapter 4, *DE 2002*. As a result, three industries that were close to the cut-off between the top-half and bottom-half groups in the previous ranking were shifted in this new ranking. (See Appendix 4.B for a listing of industries based on the new ranking.) Two industries [nonmetallic minerals, except fuels (SIC 14) and miscellaneous repair services (SIC 76)] that were in the top-half group of industries in the earlier analysis of Chapter 4 above are now in the bottom-half. In exchange, one industry group [primary metal industries (SIC 33)] that was in the bottom-half of Chapter 4 is in the top-half group in the present analysis.

Appendix 4.B. IT-Intensity Rankings

Table 4.B. Part 1. IT-Intensity Rankings by Ratio of Individual Industry Average ITEQ/FTE to Overall Average ITEQ/FTE and Cumulative Sum of Average Shares of Nominal GDP

Industry	SIC	Industry Average ITEQ/FTE over Overall Average ITEQ/FTE (1989–2001)	Cumulative Sum of Average Shares of Nominal GDP (%) (1989–2001)
Top-Half IT-intensive Industries with 50 Percent Nominal GDP Shares			
Telephone and telegraph	481,482,489	22.21	2.82
Nondepository institutions	61	11.41	3.55
Pipelines, except natural gas	46	9.96	3.65
Radio and television	483,484	9.70	4.49
Electric, gas, and sanitary services	49	6.22	8.08
Petroleum and coal products	29	5.80	8.66
Oil and gas extraction	13	3.59	10.11
Chemicals and allied products	28	3.23	12.67
Transportation services	47	2.27	13.11
Depository institutions	60	2.17	17.48
Holding and other investment offices	67	2.13	17.69
Security and commodity brokers	62	2.12	19.30
Motion pictures	78	2.00	19.73
Tobacco products	21	1.99	20.00
Metal mining	10	1.98	20.10
Insurance carriers	63	1.73	22.17
Railroad transportation	40	1.71	22.59
Instruments and related products	38	1.51	23.56
Wholesale trade	50,51	1.44	32.73
Transportation by air	45	1.35	33.92
Electronic and other electric equipment	36	1.19	36.40
Paper and allied products	26	0.93	37.35
Printing and publishing	27	0.85	38.93
Industrial machinery and equipment	35	0.83	41.35
Business services	73	0.79	47.20
Other transportation equipment	37exc 371	0.77	48.28
Primary metal industries	33	0.57	49.15
Coal mining	12	0.57	49.35

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 other 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 I) 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.

Table 4.B. Part 2. IT-Intensity Rankings by Ratio of Individual Industry Average ITEQ/FTE to Overall Average ITEQ/FTE and Cumulative Sum of Average Shares of Nominal GDP

Industry	SIC	Industry Average ITEQ/FTE over Overall Average ITEQ/FTE (1989–2001)	Cumulative Sum of Average Shares of Nominal GDP (%) (1989–2001)
Bottom-Half Less IT-intensive Industries with 50 Percent Nominal GDP Share			
Food and kindred products	20	0.57	51.44
Personal services	72	0.56	52.31
Nonmetallic minerals, except fuels	14	0.55	52.48
Legal services	81	0.55	54.35
Miscellaneous repair services	76	0.52	54.73
Motor vehicles and equipment	371	0.47	56.25
Stone, clay, and glass products	32	0.45	56.83
Water transportation	44	0.43	57.05
Health services	80	0.41	64.81
Other services, n.e.c.	83,84,86,87,89	0.37	70.21
Insurance agents, brokers, and service	64	0.37	71.07
Local and interurban passenger transit	41	0.34	71.31
Trucking and warehousing	42	0.32	72.98
Fabricated metal products	34	0.29	74.54
Miscellaneous manufacturing industries	39	0.27	74.97
Rubber and miscellaneous plastics products	30	0.24	75.81
Textile mill products	22	0.24	76.26
Auto repair, services, and parking	75	0.21	77.46
Retail trade	52–59	0.17	89.54
Lumber and wood products	24	0.17	90.24
Hotels and other lodging places	70	0.15	91.37
Leather and leather products	31	0.15	91.45
Furniture and fixtures	25	0.15	91.82
Amusement and recreation services	79	0.13	92.80
Apparel and other textile products	23	0.12	93.29
Construction	15,16,17	0.08	98.98
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 other 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 I) 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.

Appendix 4.C. Comparison With Other 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 (see Appendix 4.A) for each year during 1989–01. This entire period is then broken into two sub-periods, 1989–95 and 1995–01, and the simple averages of each industry's annual percentage point contributions are computed for each sub-period. The difference between the 1995–2001 average and the 1989–95 average is the industry's contribution to the *acceleration* (i.e., average overall growth during 1995–2001 less the average overall growth during 1989–95) in overall productivity growth. IT's role in this acceleration is assessed by classifying the industries into two groups, the *more* IT-intensive top-half group and the *less* IT-intensive bottom-half group. (See Appendix 4.B.) Because the 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, "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) 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 there are 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 GDP per FTE for both aggregate and industry level productivity. Our use of GDP is based on the fact that GDP is value-added and, by definition, is the industry's *contribution* to aggregate output. Moreover, the use of GDP at the industry level makes the decomposition simpler because it does not involve intermediate inputs that cancel out at the aggregate level.

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 1987–95 to that during 1995–99.

Martin Neil 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) 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 1995–99 and the average during 1989–95. Then they compare each industry's productivity growth acceleration to the *overall* (for all private industries) average productivity growth acceleration from 1989–95 to 1995–99. 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, *US Productivity Growth*, 1995–2000, Washington, DC (October 2001) implemented a procedure similar to this chapter's framework for decomposing aggregate productivity growth into individual industry contributions where at both the aggregate and industry levels output is a value-added measure (GDP) from BEA. One difference is that MGI uses BEA's "persons engaged in production" (PEP) for employment while this chapter uses BEA's FTE. 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 of the chapter on "Objectives & Approach.") Overall, however, this chapter's and MGI's empirical findings are quantitatively similar.

A more recent study by Dale Jorgenson, Mun Ho, and Kevin Stiroh, "Lessons from the U.S. Growth Resurgence" (January 17, 2003), presented at the First International Conference on the Economic and Social Implications of Information Technology, Department of Commerce, Washington DC, January 27–28, 2003, re-examined the role of IT during 1995 to 2000 when the U.S. experienced the unusual combination of rapid growth and lower inflation. They conclude that the U.S. productivity revival remains intact and that IT is the predominant source of this revival. Specifically, they found that the contribution of IT capital deepening from computer hardware, software, and telecommunications equipment greatly exceeded the contribution from all other forms of investment to labor productivity growth after 1995. Their findings are consistent with those of this chapter.