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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[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-

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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

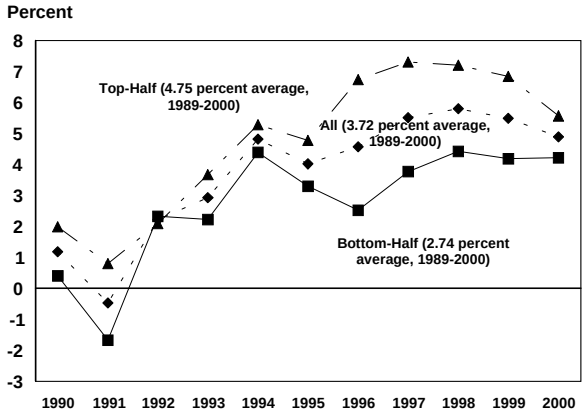
IT-INTENSITY RANKING BY RATIO OF INDIVIDUAL INDUSTRY ITEQ/FTE TO OVERALL ITEQ/FTE, 1996 AND CUMULATIVE SUM OF AVERAGE SHARES OF NOMINAL GDP, 1989-2000

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.

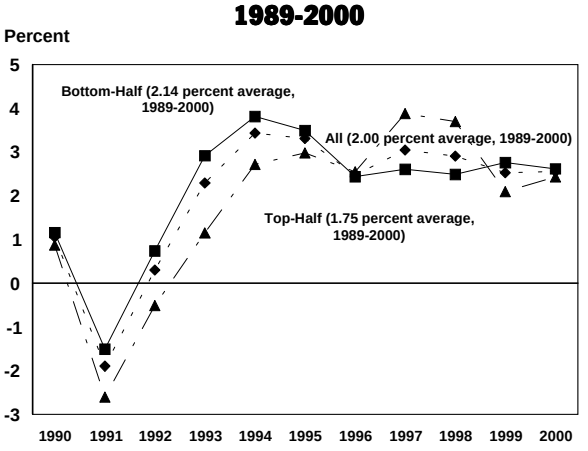
Source: ESA estimates derived from BEA data.

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)

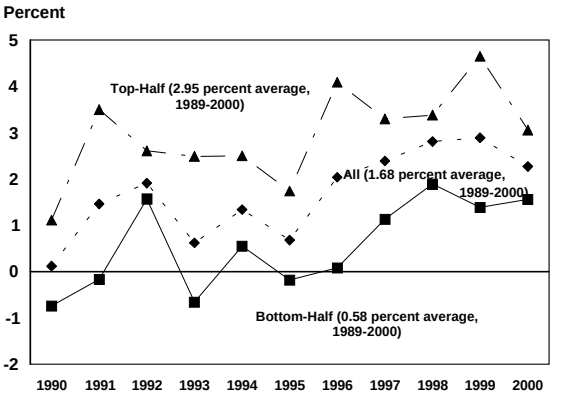
In the more IT-intensive top-half industries, productivity growth accelerated 1.38 percentage points from an average 2.32 percent during 1989-1995 to 3.70 percent average during 1995-2000. In contrast, in the less IT-intensive bottom-half industries, growth accelerated at a slower 1.15 percentage points 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.*

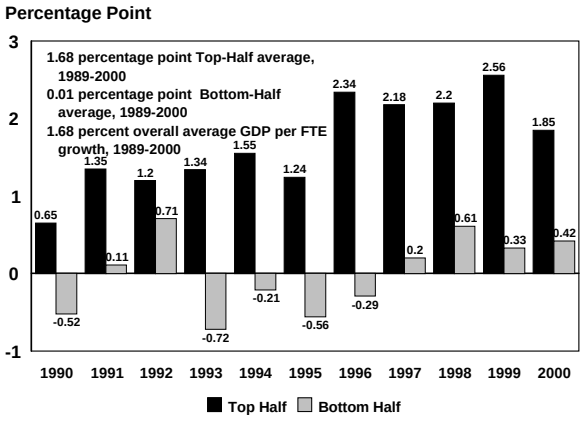
[9] *For the significant contributions of IT capital deepening to the acceleration in labor productivity from the first to the second halves of the 1990s, see Stephen D. Oliner and Daniel E. Sichel, "The Re-*

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



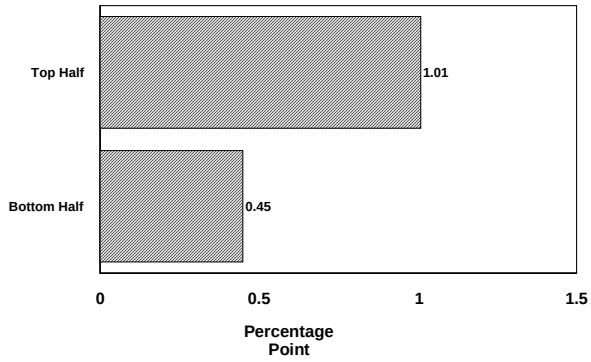
Source: ESA estimates derived from BEA data.

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.

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

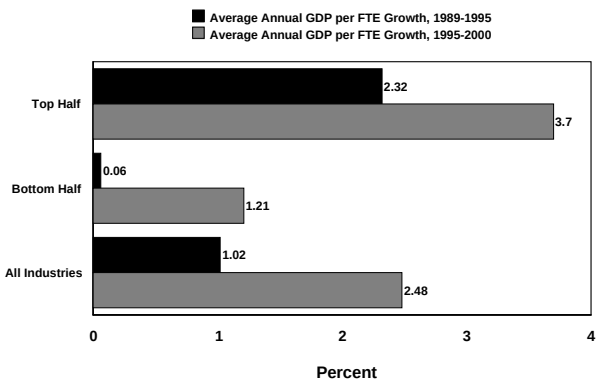


Source: ESA estimates derived from BEA data.

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

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.

Productivity Growth Widespread Across Major Industrial Sectors

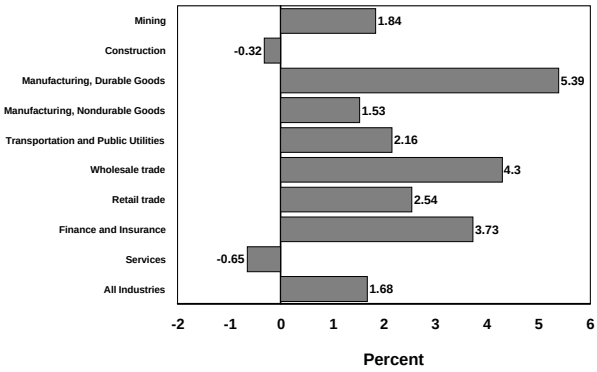
Some economists have asserted that strong productivity growth is narrowly concentrated in manufacturing durables, and, within that sector, in the computer and semiconductor producing industries. In contrast, this study shows that productivity growth during 1989-2000 has been widespread across many sectors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

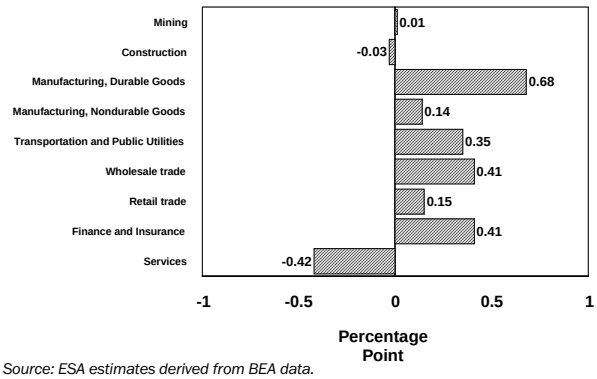
Between 1989 and 2000, IT production and use contributed substantially to restraining inflation.[13] Figure 4.11 (also, see Appendix Table A-4.11) shows

[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.

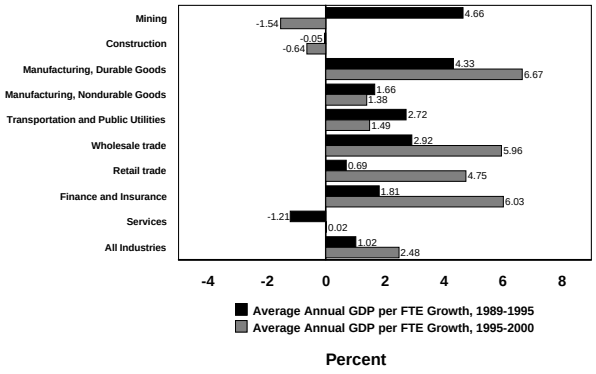
[13]To examine this issue, we looked at price growth separately within the more IT-intensive top-half group of industries and within the less IT-intensive bottom-half group, after excluding energy and food producing and processing industries consistent with the "core inflation" concept. Core inflation, 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



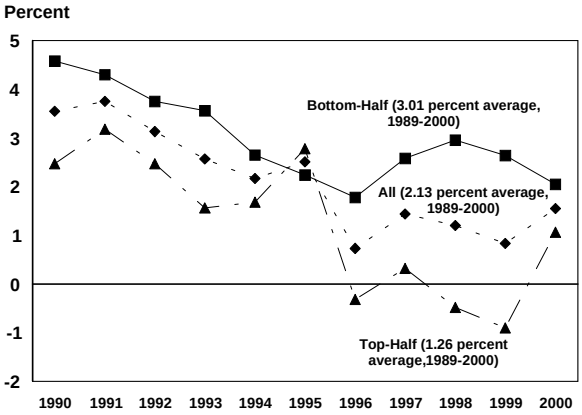
Source: ESA estimates derived from BEA data.

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.

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



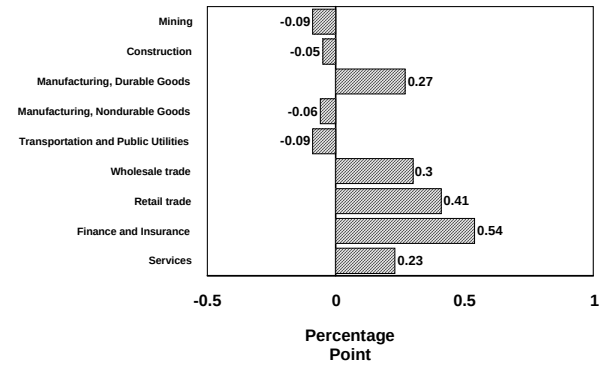
Source: ESA estimates derived from BEA data.

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.

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

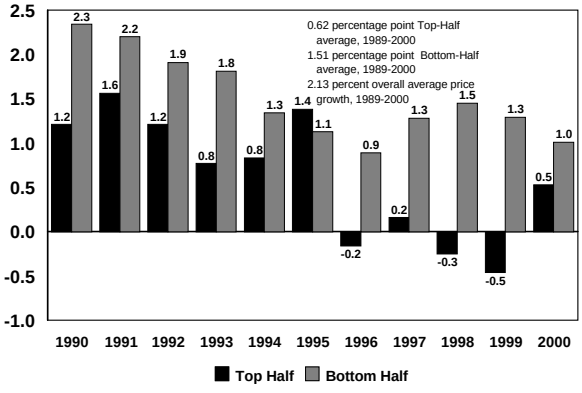
Because the roles of prices and quantities are symmetric in the definition of Fisher indexes—the index formulas that underlie BEA's chained dollar framework—switching quantities to prices and vice versa converts the quantity index to a price index. Thus, BEA's formula (Moulton and Seskin, op. cit.*) 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 4.12
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.