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A Prototype BEA/BLS Industry-Level Production Account for the United States

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In recent years, structural changes at the industry level in the United States and their implications for competitiveness have emerged as important economic issues. The most recent business cycle and subsequent recovery, in particular, led to heightened interest in understanding the sources of economic growth, including output, input, and multifactor productivity (MFP) growth across all industries in the US economy.

Gross domestic product (GDP) by industry statistics provide detailed

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information on the industry sources of aggregate value-added growth, but do not include estimates of the contributions of capital and labor inputs and MFP to economic growth. MFP measures the output per unit of capital, labor, and intermediate inputs, and is an important component of growth in GDP. MFP growth is calculated as the growth that cannot be explained by changes in the combined contribution of these factor inputs. The official MFP measures provide information on components of economic growth in the market economy; but, they do not report detailed information on the nonmarket economy. While these two sets of statistics share a common economic accounting framework, in the United States they are prepared by two separate agencies. The GDP statistics are published by the Bureau of Economic Analysis (BEA), US Department of Commerce and MFP and labor productivity statistics are published by the Bureau of Labor Statistics (BLS), US Department of Labor. Differences in concepts and methods used by each agency persist due to the different nature of each program, but each statistical program depends on the other to prepare its measures.

This chapter builds on the GDP by industry statistics produced by the BEA and the capital and labor statistics produced by the BLS to assemble an industry-level production account for the United States that is consistent with GDP.[1] The key feature of this internally consistent prototype account is to provide values, prices, and quantities of outputs and inputs used in the industry-production process. This set of accounts allows one to decompose the industry contributions of inputs and MFP to the sources of GDP growth at the aggregate level.

Productivity statistics integrated with national economic accounts' GDP statistics have long been sought to provide a rich source of information for policymakers, business analysts, and economists. The usefulness of such integrated analysis on the sources of growth within the framework of the US National Income and Product Accounts (NIPAs) was first presented by Jorgenson and Landefeld (2006) in *A New Architecture for the US National Accounts*. In 2008, the Advisory Committee on Measuring Innovation in the 21st Century Economy to the US Secretary of Commerce endorsed the development of official industry-level production account statistics for the United States. Specifically, the committee recommended that the government

> develop annual, industry-level measures of total factor productivity by restructuring the NIPAs to create a more complete and consistent set of accounts integrated with data from other statistical agencies to allow for consistent estimation of the contributions of innovation to economic growth.[2]

1. The complete data set is available on the BEA's website at https://www.bea.gov/industry/index.htm#integrated, and on the BLS website at www.bls.gov/mfp.

2. Advisory Committee on Measuring Innovation in the 21st Century Economy (2008, 5).

Integrated GDP, GDP by industry, and productivity statistics consistent with the framework of national economic accounts have been developing at an accelerating rate within the international community and have garnered significant attention in recent years. Jorgenson (2012) describes the establishment and evolution of the World KLEMS Initiative, whose goal is to develop capital (K), labor (L), energy (E), materials (M), and services (S) data sets for countries around the world, with the objective to provide a new framework for analyzing the sources of economic growth at the industry level.[3] This new framework builds on recent developments in the United Nations' *System of National Accounts 2008*, which now recommends the incorporation of labor composition in measuring labor input and the prices and quantities of capital services in measuring capital input.[4] In addition, Schreyer (2009) outlines the role of capital services in capital measurement and provides recommendations on methods used to construct the prices and quantities of capital services for those Organisation of Economic and Co-operation and Development (OECD) countries that do not measure MFP. Official industry-level production account statistics are published on a regular basis in Australia, Canada, Denmark, Finland, Italy, the Netherlands, and Sweden.

This BEA/BLS effort is the latest in a series of collaborations that was formalized in 2002 between the BEA and the BLS to better harmonize and reconcile GDP, GDP by industry, and productivity statistics. Early work involved reconciling price differences between the two agency's measures of industry output to improve industry comparisons. Fraumeni, Harper, Powers, and Yuskavage (FHPY) (2006) detailed the agency collaborations toward reconciling output measures where common data sources were used; the authors also developed a conceptual framework and illustrative production account for the nonfarm business sector. An important step undertaken by the BEA around this time involved integrating the national accounts' GDP statistics with the annual GDP by industry and input-output statistics (Moyer et al. 2004; Lawson et al. 2006). Subsequently, Strassner, Medeiros, and Smith (2005) of the BEA produced detailed KLEMS (estimates of inputs within the framework of the integrated industry accounts. Harper et al. (2009) first implemented an integrated production account for the private business sector as outlined by FHPY (2006), made recommendations of how to expand the production account to cover the total economy, and presented alternative rental prices to improve the measurement of capital

3. Jorgenson (2012) includes a summary of results from Jorgenson, Ho, and Samuels (2012) covering the period 1947–2010 that uses the same industry classification system as that used to produce the BEA/BLS prototype. The work of Jorgenson, Ho, and Samuels was financed by a grant to Harvard University, which also financed the First and Second World KLEMS conferences.

4. Chapters 19 and 20 of *System of National Accounts 2008* provide the relevant details on the measurement of labor composition and capital services.

services for the nonmarket economy.[5] Most recently, Harper et al. (2010) of the BLS integrated both the BLS and the BEA KLEMS statistics to publish BLS nonmanufacturing MFP measures.[6]

This chapter builds on these previous efforts by developing a prototype BEA/BLS industry-level production account for the United States for the period 1998 to 2010 on a 2002 North American Industry Classification (NAICS) basis. The account incorporates gross output, value added, and intermediate inputs—including energy, materials, and purchased services—statistics by industry from the BEA, and labor and capital input measures by industry from the BLS. The BEA and BLS data are both consistent with the industry accounts statistics as of December 2011. The BLS labor and capital measures reflect adjustments that were made to published BLS data where necessary to provide consistency in concepts and coverage for this prototype account.[7]

We present contributions of KLEMS inputs and MFP to gross output growth at roughly the three-digit NAICS level of industry detail based on a gross-output production accounting framework.[8] The gross output concept differs from the sectoral concept used by the BLS in its industry-level MFP statistics. The sectoral approach excludes intermediate production and purchases that come from within the industry (i.e., intraindustry transactions) from both output and inputs. This is the primary conceptual difference between the MFP measures presented here and the official BLS productivity statistics.[9] Both approaches are discussed in Schreyer (2001).

The starting point for this prototype production account is the fundamental economic accounting identity that under the zero profit assumption, the value of gross output equals the value of payments for KLEMS inputs to production, including intraindustry transactions.[10] The complete

5. This analysis laid the groundwork for the BLS to produce total economy measures of output per unit of input that included the coverage of nonmarket production by government and nonprofit institutions. The study also developed cross-agency understanding of the methodological differences between BLS private business measures and BEA GDP. Improved data tables with these measures are now updated on a periodic basis by both agencies. "Summary Integrated Production Account Tables" (April 21, 2011) are available at http://bea.gov/national/integrated_prod.htm. "1987–2010 Total Economy Production Account Tables" are available at http://www.bls.gov/mfp/mprdload.htm.

6. This article also presented Domar percentage-point contributions of these industries and sectors to private business multifactor productivity growth.

7. The BLS regularly publishes labor and capital measures that are consistent with NIPA industry-level definitions, but with differences in coverage and concepts that will be discussed later in this chapter For this account, we incorporate data across all legal forms of organization at the industry level to ensure consistency with GDP.

8. Jorgenson, Gollop, and Fraumeni (1987) and Jorgenson, Ho, and Stiroh (2005) rely on gross output measures.

9. The National Academy of Sciences (1979) (Rees) Panel to Review Productivity Statistics recommended a sectoral framework for measuring productivity. Aggregating industry-level sectoral output to the total economy produces value-added output. The sectoral framework provides a unifying rationale of output measurement from detailed industry to major sectors.

10. Intraindustry purchases can be a relatively important source of production for certain industries; for example, the semiconductor industry relies heavily on intraindustry transactions to produce microprocessor chips.

set of accounts that we present in this chapter decomposes changes in these values over time into changes in prices and changes in quantities, thus permitting an index number estimate of MFP growth by industry. This study also includes estimates of the Domar-weighted contributions of industry MFP to economy-wide MFP. We also include illustrative results of a labor composition adjustment to BLS labor hours for purposes of understanding its impact on estimating the contribution of labor input and MFP by industry.[11] This adjustment for labor composition reflects the heterogeneity of each industry's workforce and yields a symmetric treatment of labor and capital services in this prototype production account.

The initial results of the prototype account show the following:

- In 1998 to 2010, capital accounted for about 60 percent of US economic growth, labor accounted for about 10 percent, and MFP accounted for about 30 percent of growth.
- In forty-eight out of sixty-three industries, at least one KLEMS input to production was a more important source of real gross output growth than was MFP.

The remainder of the chapter proceeds in five sections. We provide a first look at prototype industry-level results. We present BLS MFP measures and compare them with the industry production account results. We describe the methodology for this prototype industry-level account, including a description of how the various data sets are compiled. We discuss some of the conceptual and estimation challenges that require resolution before this account can be released on a regular basis. Lastly, we conclude with comments on possible future work and next steps in this important collaboration.

11.1 A First Look at Prototype Results

This prototype BEA/BLS industry-level production account can be used to trace the sources of US economic growth across all goods- and services-producing industries in the US economy. This new production account presents the contributions of both value-added and intermediate input factors of production and the contribution of MFP to US real gross output growth, at roughly the three-digit NAICS industry level as published in the US industry economic accounts. This section highlights the sources of US economic growth over the period 1998 to 2010, including MFP trends during this period at the industry level, and also details the contributions of each industry's MFP to economy-wide MFP.

11. Domar weights consist of a ratio of current dollar gross output divided by aggregate value added. These weights are unique in that they sum to more than one, reflecting the fact that an increase in an industry's productivity has a direct effect on the industry's output as well a secondary effect through the output of one industry delivered to another as intermediate inputs.

Table 11.1 Aggregate factor contributions to GDP growth, 1998–2010

All industry value-added growth	**1.90**
Aggregate labor contribution	0.20
College graduate	0.46
No college degree	–0.25
Aggregate capital contribution	1.15
Aggregate MFP growth	0.56

Note: Growth is expressed as the difference in natural logs. Individual components may not sum to totals due to rounding.

11.1.1 Sources of US Output Growth, 1998 to 2010

With the development of a prototype industry-level production account spanning all industries integrated within an input-output framework, useful information can be generated by tracing the sources of output growth across each industry's KLEMS inputs—both its primary, value-added inputs, and its secondary, intermediate inputs—and to MFP. Table 11.1 presents the sources of aggregate value-added growth for the United States that are attributable to the primary, value-added inputs of capital and labor, and to MFP.[12]

Table 11.2 extends the analysis by showing the contributions of all KLEMS inputs and MFP to gross output growth for selected industries, ranked by the largest positive contributions of intermediate inputs, capital, and labor. The contributions from at least one of the primary, value-added inputs of capital and labor, or secondary, intermediate inputs of energy, materials, and purchased services were greater than MFP growth in more than 75 percent of the sixty-three industries included in this account.

In the three industries with the largest percent changes in gross output—positive or negative—support activities for mining; securities, commodity contracts, and investments; and information and data processing services—intermediate input contributions were the largest contributor to the percent changes in gross output, reflecting their relative weight as a well as recent trends in the sourcing of production. In six of the top ten industries with the strongest output growth, intermediate inputs were the most significant factor. Conversely, in all but one of the ten industries that showed the largest output decline, negative intermediate input contributions were the largest contributors (table 11A.3).

Among capital-intensive industries, rental and leasing and information and data processing services were the industries with the largest capital contributions to output growth. For rental and leasing, capital contributed 2.89 percentage points to real output growth of 1.7 percent. For information and data processing services, capital contributed 1.76 percentage points to real output growth of 7.8 percent.

12. Rates of change and contributions in all tables in this chapter reflect annual rates over the period indicated.

Table 11.2 **Largest factor input contributions to output growth, 1998–2010 (percentage point)**

Description	Capital	Labor	Intermediate	Energy	Material	Service	MFP	Output
Largest intermediate contributions								
Support activities for mining	0.13	0.78	6.26	0.27	2.98	3.01	1.70	8.86
Securities, commodity contracts, investments	–0.39	0.85	5.36	–0.02	0.10	5.28	2.52	8.33
Information and data processing services	1.76	0.34	3.93	0.03	0.60	3.31	1.77	7.81
Federal government	0.10	0.36	2.23	0.04	0.26	1.92	0.22	2.90
Federal Reserve banks, credit intermediation, and related activities	1.38	0.12	1.93	0.00	0.03	1.90	0.67	4.10
Largest capital contributions								
Rental and leasing services and lessors of intangible assets	2.89	–0.11	0.22	–0.02	0.00	0.24	–1.31	1.69
Information and data processing services	1.76	0.34	3.93	0.03	0.60	3.31	1.77	7.81
Legal services	1.68	0.39	–0.33	–0.01	–0.05	–0.27	–1.80	–0.06
Broadcasting and telecommunication	1.66	–0.36	1.35	–0.01	0.28	1.08	1.79	4.44
Publishing	1.62	–0.41	1.05	–0.02	–0.09	1.16	0.16	2.43
Largest labor contributions								
Computer systems design and related services	–0.13	2.30	1.54	–0.01	0.28	1.26	2.52	6.23
Educational services	0.21	1.67	0.96	0.03	0.16	0.77	–1.19	1.65
Ambulatory health-care services	0.29	1.60	0.85	0.00	0.11	0.73	0.53	3.27
Warehousing and storage	0.39	1.52	1.67	0.11	0.20	1.37	0.27	3.86
Management of companies and enterprises	1.19	1.44	1.01	0.00	0.20	0.81	–2.54	1.11

Similarly, several labor-intensive industries had the highest labor contribution to output growth (see table 11.2 and table 11A.3 in the appendix). Computer systems design and related services, education services, and ambulatory health-care services were among the industries with the largest labor contributions to output growth.

In the top ten industries ranked by size of workforce for 2010, the sources of output growth were mixed (table 11.3). Among the largest industries ranked by size of employment, labor was the greatest input contribution for state and local government at 0.83 percentage points, and in ambulatory health-care services at 1.60 percentage points. Among these ten industries, wholesale trade and retail trade were the industries that showed the greatest capital contributions as the largest contributor to output growth.[13] The intermediate inputs contribution was the largest contributor to output growth in federal government at 2.23 percentage points, led by the contribution of purchased-services inputs. In food services and drinking places, the intermediate input contribution of 0.74 percentage points was also led by purchased-services inputs. In hospitals and nursing and residential care facilities, the intermediate inputs contribution of 1.70 percentage points was also the most significant contributor to output growth, with, once again, purchased-services inputs accounting for the largest contribution. MFP growth or declines were the largest contributors to output growth or declines in administrative and support services at 1.22 percentage points, other services at –1.33 percentage points, and construction at –1.33 percentage points for these selected industries.

Labor Composition

In this prototype, we decompose the labor contributions to output growth into demographic characteristics that account for the contributions of the college-educated workforce and those workers that did not attend college. This adjustment to labor input allows for the contribution of labor to reflect changes in the composition of the skill level of the labor force over time, in addition to the number of hours worked by industry.

In over 80 percent of the industries measured, the contributions from the college workforce were higher than those that did not attend college, reflecting the industries' shift in demand toward college-educated workers (see table 11A.4 in the appendix). The median contribution of workers with a college education was 0.07 percentage points while the non-college-educated workers' subtracted 0.19 percentage points from economy-wide output growth over the period 1998 to 2010.

Ranking the industries by college-educated labor contributions shows that

13. Wholesale and retail trade output measures reflect the gross margin output concept, which subtracts the costs of goods sold from its sales and inventories, and therefore also excludes them from its input costs.

Table 11.3 **Contributions to output growth from ten largest employment industries, 1998–2010 (percentage point)**

2010 Employment (in thousands)	Description	Capital	Labor	Intermediates	Energy	Material	Service	MFP	Output
19,541	State and local government	0.19	0.83	0.68	0.01	0.12	0.55	–0.40	1.30
14,743	Retail trade	0.99	–0.08	0.83	–0.03	0.27	0.59	0.31	2.05
9,506	Food services and drinking places	–0.04	0.47	0.74	0.01	0.00	0.72	0.45	1.63
7,818	Hospitals and nursing and residential care facilities	0.27	0.96	1.70	0.02	0.11	1.57	–0.13	2.79
7,150	Administrative and support services	0.81	–0.22	–0.08	0.00	0.04	–0.11	1.22	1.72
6,743	Other services, except government	0.41	0.22	0.44	–0.02	–0.18	0.65	–1.33	–0.26
6,024	Ambulatory health-care services	0.29	1.60	0.85	0.00	0.11	0.73	0.53	3.27
5,767	Construction	0.34	–0.30	–1.12	–0.03	–0.93	–0.16	–1.33	–2.41
5,520	Wholesale trade	0.92	–0.17	1.21	0.00	0.28	0.93	0.76	2.71
5,425	Federal government	0.10	0.36	2.23	0.04	0.26	1.92	0.22	2.90

Table 11.4 Labor contribution, 1998–2010 (percentage point)

Description	College labor	No college labor	Labor composition
No college largest contributions			
Warehousing and storage	0.26	1.27	1.52
Social assistance	0.36	0.70	1.07
Ambulatory health-care services	1.07	0.53	1.60
College largest contributions			
Management of companies and enterprises	2.42	–0.88	1.44
Computer systems design and related services	2.10	0.20	2.30
Educational services	1.52	0.16	1.67

Note: Component input contributions may not sum to total labor contributions due to rounding.

computer systems design and related services, management of companies and enterprises, and education services have the largest labor contributions to output growth (table 11.4).

Warehousing and storage, social assistance, and administrative and support services had the highest labor contributions of non-college-educated labor to output growth.

MFP Growth Trends at the Industry Level

"High-tech" industries showed some of the strongest MFP growth over the period 1998 to 2010 (table 11.5). Computer and electronic product manufacturing, information and data processing services, computer systems design and related services, and broadcasting and telecommunications were among the industries with the largest MFP growth. These information-communications-technology-producing industries were among the top ten industries with MFP growth.

From 1998 to 2010, computer and electronic products manufacturing led MFP growth at an average annual rate of 9.6 percent (See table 11A.2 in the appendix). This MFP growth was driven by rising output at a 5.5 percent average annual rate, and falling intermediate inputs at a 6.6 percent average annual rate. Computer systems design and related services MFP grew 2.5 percent at an average annual rate, driven by strong output growth. Oil and gas extraction showed the largest MFP decline during the period, falling at an average annual rate of 2.7 percent, driven by intermediate inputs growth of 2.2 percent. Management of companies and enterprises and legal services were also among the industries with the largest average annual declines in MFP, decreasing 2.5 percent and 1.8 percent at average annual rates, respectively.

Contributions to Economy-Wide MFP

From 1998 to 2010, economy-wide MFP grew at an average annual rate of 0.56 percent. Both goods-producing industries and services-producing industries had positive contributions to aggregate MFP growth through

Table 11.5 **Multifactor productivity growth for selected industries (percent change)**

Description	1998–2000	2000–2007	2007–2010	1998–2010
Computer and electronic product manufacturing	12.2	8.5	10.7	9.6
Computer systems design and related services	–0.5	3.1	3.2	2.5
Broadcasting and telecommunication	–0.1	2.8	0.6	1.8
Information and data processing services	–13.0	6.4	0.8	1.8
Oil and gas extraction	–12.8	–1.0	0.1	–2.7
Management of companies and enterprises	–0.3	–2.6	–3.8	–2.5
Legal services	0.2	–2.1	–2.4	–1.8
Securities, commodity contracts, investments	5.3	1.0	4.2	2.5
Apparel and leather and allied products	1.2	1.3	11.8	3.9
Construction	–0.6	–2.2	0.2	–1.3

the period 1998 to 2010. Services-producing industries contributed about 0.23 percentage points to the economy-wide MFP while goods-producing industries contributed 0.33 percentage points.

From 2000 to 2007, economy-wide MFP increased at an average annual rate of 0.61 percent, while MFP increased at an average annual rate of 0.17 percent from 2007 to 2010. The goods-producing sector accounted for more of the increase in MFP, adding 0.14 percentage points of the 0.17 percentage point increase from 2007 to 2010.

Goods-Producing Sector Contributions to Economy-Wide MFP[14]

From 1998 to 2010, computer and electronic products manufacturing contributed 0.33 percentage points to economy-wide MFP, significantly more than any other industry (table 11.6). The farms industry was a distant second within the goods-producing sector, contributing 0.04 percentage points to the increase in economy-wide MFP. Miscellaneous manufacturing was also among the leading contributors, adding 0.02 percentage points to economy-wide MFP.

The contribution of computer and electronic products manufacturing to economy-wide MFP growth experienced a leveling off in recent years. Over the period studied, the contributions from computer and electronic products manufacturing were the greatest in the 1998 to 2000 period, 0.60 percentage points; in the more recent period of 2007 to 2010, the contribution was 0.28 percentage points. This trend is consistent with BLS estimates of the contributions of three-digit manufacturing industries to private nonfarm business MFP.[15] The trend also confirms the accepted story of an IT-induced productivity speed-up in the last half of the 1990s.

14. In the US industry economic accounts, the goods-producing sector consists of agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing.

15. See http://www.bls.gov/mfp/mfgcon.pdf, Bureau of Labor Statistics (2012).

Table 11.6 **Contributions to multifactor productivity growth from selected goods-producing industries (percentage point)**

Description	1998–2000	2000–2007	2007–2010	1998–2010
Computer and electronic products	0.600	0.274	0.278	0.329
Farms	0.063	0.012	0.085	0.039
Miscellaneous manufacturing	0.034	0.019	0.024	0.023
Machinery	–0.028	0.028	0.038	0.021
Nonmetallic mineral products	–0.015	–0.006	–0.005	–0.007
Utilities	0.111	–0.023	–0.061	–0.010
Oil and gas extraction	–0.123	–0.015	0.010	–0.027
Construction	–0.059	–0.210	0.014	–0.129
Total goods	0.773	0.279	0.144	0.328

Table 11.7 **Contributions to multifactor productivity growth from selected services-producing industries (percentage point)**

Description	1998–2000	2000–2007	2007–2010	1998–2010
Securities, commodity contracts, and investments	0.167	0.033	0.145	0.084
Broadcasting and telecommunications	–0.004	0.129	0.026	0.081
Wholesale trade	0.179	0.111	–0.114	0.066
Administrative and support services	–0.012	0.061	0.057	0.048
Federal Reserve banks, credit intermediation, and related activities	0.020	–0.006	0.171	0.043
Computer systems design and related services	–0.008	0.048	0.057	0.041
Information and data processing services	–0.094	0.057	0.007	0.019
Publishing industries (includes software)	–0.115	0.041	–0.009	0.002
Real estate	0.193	–0.018	–0.235	–0.037
State and local	–0.059	–0.064	–0.029	–0.055
Other services, except government	–0.021	–0.065	–0.059	–0.056
Management of companies and enterprises	–0.008	–0.068	–0.104	–0.067
Total service	0.155	0.335	0.028	0.228

Services-Producing Sector Contributions to Economy-Wide MFP[16]

From 1998 to 2010, the securities, commodity contracts, and investments and broadcasting and telecommunications industries were among the top contributors to economy-wide MFP growth with securities, commodity contracts, and investments contributing the most, 0.08 percentage points (table 11.7).

During the 2000 to 2007 subperiod, all services-producing, sector-related,

16. In the US industry economic accounts, the services-producing sector consists of utilities; wholesale trade; retail trade; transportation and warehousing; information; finance, insurance, real estate, rental, and leasing; professional and business services; educational services, health care, and social assistance; arts, entertainment, recreation, accommodation, and food services; and other services, except government.

information-communications-technology-producing industries added to economy-wide MFP growth, including publishing (which includes software publishing), broadcasting and telecommunications, information and data processing services, and computer systems design and related services. Wholesale trade was also among the largest contributors to MFP growth, contributing 0.11 percentage points to economy-wide MFP growth during this period.

From 2007 to 2010, Federal Reserve Banks, credit intermediation, and related activities led the increase in aggregate MFP, adding 0.17 percentage points to MFP growth. Credit intermediation and related activities and securities, commodity contracts, and investments were also among the largest contributors to the increase in MFP over this period, increasing aggregate MFP growth by 0.14 percentage points. These positive contributions were partly offset by negative contributions by the real estate industry, which subtracted 0.23 percentage points.

11.2 BLS MFP and Industry Contributions to BLS MFP—A Comparison

The output measures used in the BLS MFP measures are constructed to be as consistent as possible with the BLS major sector labor productivity measures (except that the MFP measures exclude government enterprises). This consistency allows BLS MFP data to help explain the sources of growth in the official labor productivity series. In a model where capital and labor are the measured inputs, sources of labor productivity growth include increases in capital intensity (i.e., capital deepening) and improvements in the skills of the labor force (i.e., labor composition). Additional sources of labor productivity are attributed to MFP, which may reflect changes in a variety of factors that are not included as measured inputs, including technology change, economies of scale, and improvements in management techniques or organization of production, among other factors.

For BLS official estimates of private business and private nonfarm business MFP, the relationship of aggregate multifactor productivity to aggregate labor productivity is given by the following equation:

$$d(\ln Y - \ln L) = d \ln A + w_k[d(\ln K - \ln L)] + w_l[d \ln LC],$$

where

Y = output,
L = labor,
K = capital,
LC = labor composition,
d denotes the derivative with respect to time, and
w_i denotes the cost share weight of input i, ($i = k, l$).

This equation shows that labor productivity growth is decomposed into the contribution of MFP growth, the contribution resulting from K/L substitution (capital deepening) and the contribution of the labor composition effect. This relationship between MFP and labor productivity ties the private business and private nonfarm business MFP measures to the official published estimates of business and nonfarm business labor productivity, with the caveat that government enterprises is excluded.

Furthermore, the BLS industry contributions roughly sum to the official published estimates of private business and private nonfarm business MFP. When compared to the industry-level Domar contributions to economy-wide MFP for the industry production account measures presented in this chapter, the industry-level Domar contributions to private business sector MFP are comparable in magnitude and order. Table 11.8 shows BLS MFP growth for selected industries. For tables 11.9 and 11.10, the Domar-weighting scheme is applied based on the relative importance of each industry to total private business MFP.

Table 11.8 BLS multifactor productivity growth for selected industries

Description	1998–2000	2000–2007	2007–2010	1998–2010
Computer and electronic products	14.1	9.9	11.7	11.0
Computer systems design and related services	–1.1	3.1	3.3	2.4
Broadcasting and telecommunications	0.4	3.3	0.5	2.1
Information and data processing services	–15.3	5.6	1.1	0.7
Oil and gas extraction	–9.3	–0.6	–0.2	–2.0
Management of companies and enterprises	0.6	–1.1	–2.5	–1.2
Legal services	1.3	–0.1	–1.0	–0.1
Securities, commodity contracts, and investments	8.6	2.0	2.5	3.2
Apparel and leather and applied products	2.6	4.2	2.6	3.6
Construction	–0.2	–2.0	0.7	–1.0

Table 11.9 Contributions to private business multifactor productivity growth from selected goods-producing industries

Description	1998–2000	2000–2007	2007–2010	1998–2010
Computer and electronic products	0.81	0.35	0.34	0.43
Farm	0.11	0.02	0.14	0.06
Miscellaneous manufacturing	0.05	0.03	0.05	0.04
Machinery	–0.05	0.05	0.09	0.04
Nonmetallic mineral products	–0.02	–0.01	0.00	–0.01
Utilities	–0.22	0.10	0.08	0.04
Oil and extraction	–0.13	–0.02	–0.03	–0.04
Construction	-0.02	–0.25	0.07	–0.13
Private business MFP	1.79	1.44	0.45	1.25

Table 11.10 **Contributions to private business multifactor productivity growth from selected services-producing industries**

Description	1998–2000	2000–2007	2007–2010	1998–2010
Securities, commodity contracts, and investments	0.38	0.08	0.16	0.15
Broadcasting and telecommunications	0.02	0.19	0.03	0.12
Wholesale trade	0.19	0.19	–0.12	0.11
Administrative and support services	0.01	0.07	0.04	0.05
Federal Reserve banks, credit intermediation, and related activities	0.09	–0.01	0.24	0.07
Computer systems design and related services	–0.02	0.06	0.08	0.05
Information and data processing services	–0.16	0.08	0.01	0.02
Publishing industries (includes software)	–0.11	0.08	–0.01	0.03
Real estate	0.18	0.06	–0.31	–0.01
Other service, except government	0.04	–0.05	–0.04	–0.03
Management of companies and enterprises	0.02	–0.04	–0.10	–0.05
Private business MFP	1.79	1.44	0.45	1.25

BLS MFP Growth Rates for Selected Industries. Table 11.8 shows that the BLS MFP growth rates for selected industries are similar to the industry production account MFP growth rates. One exception is the 2007 to 2010 MFP growth rate for apparel and leather and applied products. Computer and electronic products similarly show the largest MFP growth of these industries, an average annual rate of 11.0 percent for the 1998 to 2010 period.

Goods-Producing Sector Contributions to BLS Private Business MFP. For the 1998 to 2010 period, the industry contributions to BLS private business MFP show similar results to the industry production account contributions. As expected, computer and electronic products dominate the contributions to private business MFP, 0.43 percentage points, approximately a third of the total MFP growth rate for the 1998 to 2010 period.

Services-Producing Sector Contributions to BLS Private Business MFP. As in the industry production account measures, securities, commodity contracts and investments, broadcasting and telecommunications, and wholesale trade show the highest contributions to private business multifactor productivity growth.

Largest Differences between BLS MFP and BEA/BLS Industry-Level Production Account MFP. Table 11.11 shows the largest positive differences between BLS MFP and the industry-level production account MFP. Table 11.12 highlights the difference between BLS sectoral output and BEA gross output measures for those industries. In its sectoral approach, the BLS excludes intraindustry transactions—that is, sales between establishments

Table 11.11 **Seven largest positive differences in annual percent change in MFP measure by industry, 1998–2010 (BLS MFP less BEA MFP)**

Description	1998–2010
Air transportation	2.5
Legal services	1.7
Utilities	1.4
Computer and electronic products	1.4
Management of companies and enterprises	1.3
Educational services	0.9
Insurance carriers and related activities	0.8

Table 11.12 **Differences in output measures**

Description	BLS sectoral output (1998–2010)	BEA gross output (1998–2010)	Difference
Air transportation	1.8	–0.3	2.1
Legal services	0.1	–0.1	0.2
Utilities	–0.1	–1.4	1.3
Computer and electronic product manufacturing	3.9	5.5	–1.6
Management of companies and enterprises	1.5	1.1	0.4
Educational services	2.6	1.7	0.9
Insurance carriers and related activities	3.1	1.6	1.5

within the same industry—from both output and intermediate purchases. For half of the measures, the conceptual difference between the output measures explains most of the difference in MFP growth. A major exception is computer and electronic products. The difference for this sector is primarily due to differences in the way intermediate inputs are calculated.

Table 11.13 shows the largest negative differences between BLS and the production accounts MFP. Table 11.14 shows the differences between sectoral output and gross output measures. Some of the differences in MFP between the industries are due to the difference in output measures. The rest are attributable to differences in intermediate inputs.

11.3 Methodology

This section provides a brief overview of the conceptual framework and estimation methods used to prepare the prototype BEA/BLS industry-level production account. We provide a description of the gross-output growth accounting framework, discuss the estimation methods used to prepare our results, and summarize the source data methods used by the BEA and BLS to produce the gross output, value added, intermediate inputs, capital input,

Table 11.13 **Seven largest negative differences in annual percent change in MFP measure by industry, 1998–2010 (BLS MFP less BEA MFP)**

Description	1998–2010
Funds, trusts, and other financial vehicles	–1.6
Information and data processing services	–1.1
Petroleum and coal products	–0.6
Accommodation	–0.6
Textile mills and textile product mills	–0.5
Mining, except oil and gas	–0.4
Apparel and leather and applied products	–0.3

Table 11.14 **Differences in output measures**

Description	Sectoral output (1998–2010)	Gross output (1998–2010)	Difference
Funds, trusts, and other financial vehicles	2.6	2.6	0.0
Information and data processing services	8.3	7.8	0.5
Petroleum and coal products	0.7	1.4	–0.7
Accommodation	1.3	2.6	–1.3
Textile mills and textile product mills	–5.5	–5.9	0.4
Mining, except oil and gas	–1.2	–1.2	0.0
Apparel and leather and applied products	–12.8	–12.3	–0.5

and labor input used in this account, including adjustments we made to achieve better integration of these data sets.

11.3.1 Conceptual Overview of Measurement

For the prototype BEA/BLS production account framework, we assume the following type of production function relating gross output of an industry to three factor inputs using the gross output production function model: $Q = F(K, L, II, t)$ where Q stands for gross output, K stands for capital, L stands for labor, II stands for the intermediate inputs, and t stands for time.[17]

Under the assumption of constant returns to scale, perfect competition, and factors being paid their marginal product, the gross-output growth model can be rearranged in terms of MFP growth computed in the following, simplified way:

$$(1) \quad \frac{d\ln Q}{dt} = \left(\frac{\partial \ln Q}{\partial \ln K}\frac{d\ln K}{dt}\right) + \left(\frac{\partial \ln Q}{\partial \ln II}\frac{d\ln II}{dt}\right) + \left(\frac{\partial \ln Q}{\partial \ln L}\frac{d\ln L}{dt}\right) + \left(\frac{\partial \ln Q}{\partial t}\right)$$

17. For simplicity, we express total intermediate inputs instead of the separate cost components of energy, materials, and purchased services. This model is also used by the BLS for its published measures for industry-level MFP, with the exception that Q is sectoral output and II reflects the subtraction of intraindustry inputs from intermediate inputs.

$$(2)\quad \left(\frac{\partial \ln Q}{\partial t}\right) = \frac{d \ln Q}{dt} - \left(\frac{\partial \ln Q}{\partial \ln K}\frac{d \ln K}{dt}\right) - \left(\frac{\partial \ln Q}{\partial \ln II}\frac{d \ln II}{dt}\right) - \left(\frac{\partial \ln Q}{\partial \ln L}\frac{d \ln L}{dt}\right).$$

With these assumptions, the unknown elasticities can be replaced with the observable factor share, v_i, for each input. Shown below is the factor share for capital input:

$$(3)\quad \frac{\partial \ln Q}{\partial \ln K} = \frac{P_K K = \textit{Capital Compensation}}{(P_K K + P_L L + P_{II} II) = \textit{Total Input Cost}} = v_K,$$

where P_K is the price of capital, P_L is the price of labor, and P_{II} is the price of intermediate inputs. The assumption of constant returns to scale ensures that the factor shares sum to one.

$$(4)\quad \frac{P_K K}{(P_K K + P_L L + P_{II} II)} = v_K \text{ where } v_K + v_L + v_{II} = 1$$

$$\frac{P_L L}{(P_K K + P_L L + P_{II} II)} = v_L$$

$$\frac{P_{II} II}{(P_K K + P_L L + P_{II} II)} = v_{II}.$$

In discrete time, the input weights are two-year averages of the cost shares for each input in years t and t-1, where $\widetilde{v_K} = (1/2)v_{K,t} + (1/2)v_{K,t-1}$. MFP growth can be rewritten in the following way, relating MFP growth for an industry as the residual of the difference in the growth in output and the growth in the combined inputs:

$$(5)\quad \text{MFP growth} = \Delta \ln Q - \widetilde{v_K}\Delta \ln(K) - \widetilde{v_L}\Delta \ln(L) - \widetilde{v_{II}}\Delta \ln(II).$$

There are no assumptions restricting individual industries in this analysis of MFP; each industry faces the above production function individually and without regard to any other industry.

11.3.2 Estimation Methods—Aggregation

The MFP index is computed by dividing an index of real gross output by an index of combined inputs. A combined real input measure is computed within a Tornqvist index number formula that aggregates real intermediate inputs by industry for energy, materials, and purchased services with the labor and capital input using average cost shares.[18]

The current-dollar cost shares of the three main input components are generated using published and computed data sets. The current dollar intermediate inputs measure is a sum of the current dollar energy, material, and purchased-services expenditures of an industry from the BEA annual

18. The BEA's national and industry accounts use Fisher-ideal indexes to express official chain-type price and quantity indexes. This study follows the productivity literature and uses the Tornqvist index for aggregation.

industry accounts. The current dollar labor component is a measure of the compensation of workers in that industry. The BEA-published labor compensation figures are supplemented to include the self-employed compensation estimate that is detailed in the labor input section using the assumption that self-employed workers receive similar wages to the payrolled employees. Lastly, nominal capital compensation is computed as a residual of the value of gross output less the sum of labor compensation and intermediate input expenditures.[19]

The intermediate inputs average share is an industry's current-dollar expenditure on energy, materials, and services divided by the value of gross-output production averaged over two periods. The average share for the remaining inputs is computed in a similar fashion. The KLEMS measures are Tornqvist aggregated using the average cost shares and the quantity indexes of each input.

11.3.3 Estimation Methods—Gross Output, Value Added, and Intermediate Inputs

The BEA industry accounts provide a time series of nominal and real gross output, intermediate inputs, and value added for industries defined according to the 2002 NAICS (Mayerhauser and Strassner 2010). These accounts are integrated conceptually and statistically with final expenditures and GDP from the NIPAs, and are prepared within a balanced input-output framework that allows for integrated analysis of industry output, inputs, employment, and final demand. In 2005, these accounts were expanded to provide additional information on the composition of intermediate inputs by industry, which made these accounts more useful to observe changes in spending related to energy, materials, and purchased services (Strassner, Medeiros, and Smith 2005).

The industry accounts methodology can be summarized in four broad steps:[20]

1. Prepare annual make tables. The make table shows the production of both primary and secondary commodities (goods and services) by industries.
2. Prepare initial annual use tables. The use table shows the consumption of commodities by industries (intermediate inputs) and by final demand, as well as the contribution of value added by industry.
3. Balance the use table.
4. Prepare price and quantity indexes for gross output, intermediate inputs, and value added.

19. This is a common assumption in productivity literature and ensures that the factor shares sum to unity.

20. See Mayerhauser and Strassner (2010) for the most complete description of the industry accounts methodology.

On an annual basis, a wide array of source data as described in Gilmore et al. (2011) is used to update the annual time series. Nominal value added by industry estimates are available for the compensation of employees and taxes on production and imports less subsidies. The gross operating surplus component of value added by industry is derived from gross domestic income data adjusted to an establishment basis. Annual survey data available from the Census Bureau are used in updating industry and commodity gross output as well as for intermediate inputs by industry and the cost categories of energy, materials, and purchased services. Lastly, annual data are also used from the NIPAs and the BEA international transactions accounts for updating estimates of final expenditures to assure an integrated framework.

The balancing process ensures two simultaneous conditions. First, that each industry's output equals its intermediate inputs plus its value-added components, and second, that the sum of intermediate and final uses for each commodity is equal to its gross output. The use table is balanced with a biproportional scaling procedure that sequentially adjusts the rows and columns to meet these two conditions and other predetermined controls, including NIPA final expenditure category values including total GDP, industry compensation, and commodity and industry gross output totals from the make table.[21] Intermediate inputs, gross operating surplus, and the commodity composition of final uses are subject to adjustment during the balancing process.

Price-adjusted measures of GDP by industry are prepared using double deflation using a Fisher-ideal index number formula, which allows gross output and intermediate inputs to be deflated separately and real value added computed as the residual. Price and quantity indexes for gross output by industry are derived by deflating the commodities produced by an industry as part of its gross output. Price and quantity indexes for intermediate inputs are derived by deflating the commodities that are consumed by an industry as intermediate inputs. The domestic and imported portions of intermediate inputs are deflated separately to account for the commodities purchased as inputs from domestic and from foreign sources.[22] Intermediate inputs at a detailed product level are disaggregated to obtain the domestic and imported portions of intermediate inputs included in each KLEMS input-cost category. For each detailed commodity used by an industry, the portion attributable to imports is calculated as the economy-wide ratio of

21. The use table balancing incorporates over 350 final expenditure category "controls" as published in the NIPAs.

22. Intermediate inputs at a detailed product level are disaggregated to obtain the domestic and imported portions of intermediate inputs included in each KLEMS category using the so-called import comparability, or proportionality, assumption. For each detailed commodity used by an industry, the portion attributable to imports is calculated as the economy-wide ratio of commodity imports to the total domestic supply of the commodity.

commodity imports to the total domestic supply of the commodity.[23] Real value added is computed as the difference between real output and real intermediate inputs within a Fisher-ideal index-number formula.

11.3.4 Estimation Methods—Capital Input

Capital inputs for the MFP measures are computed in accordance with a service flow concept for physical capital assets—equipment, structures, inventories, and land. Capital inputs for major sectors are determined in three main steps: (a) a very detailed array of capital stocks is developed for various asset types in various industries; (b) asset-type capital stocks are aggregated for each industry to measure capital input for the industry; and (c) industry capital inputs are aggregated to measure sectoral level capital input.

Financial assets are excluded from capital services measures. The aggregate capital services measures are obtained by Tornqvist aggregation of the capital stocks for each asset type within each of sixty-five NAICS industry groupings using estimated rental prices for each asset type. Each rental price reflects the nominal rate of return to all assets within the industry and rates of economic depreciation and revaluation for the specific asset; rental prices are adjusted for the effects of taxes. Current-dollar capital costs can be defined as each asset's rental price multiplied by its constant-dollar stock, adjusting for capital composition effects.

11.3.5 Asset Detail

The asset detail consists of eighty-six asset types for fixed business equipment and software, structures, inventories, and land. The BLS measures of capital stocks for equipment and structures are prepared using NIPA data on real gross investment. Real stocks are constructed as vintage aggregates of historical investments (in real terms) in accordance with an "efficiency" or service flow concept (as distinct from a price or value concept). The efficiency of each asset is assumed to deteriorate only gradually during the early years of an asset's service life and then more quickly in its later life. These "age/efficiency" schedules are based, to the extent possible, on empirical evidence of capital deterioration. Inventory stocks are developed using data from the NIPA and IRS. The BLS measures farm and nonfarm nonmanufacturing final inventories and manufacturing inventories by stage of processing: finished goods, work in process, and materials and supplies. Farm land input is based on data from the Economic Research Service of the US Department of Agriculture. A benchmark for nonfarm land is estimated by applying a

23. For example, if imports represent 35 percent of the domestic supply of semiconductors, then the estimates in the import-use table assume that imports comprise 35 percent of the value of semiconductors in each industry that uses semiconductors.

land-structure ratio based on unpublished estimates by the BLS to the value of structures.

Among equipment, the BLS provides additional detail on information processing equipment and software (IPES). The IPES is composed of four broad classes of assets: computers and related equipment, software, communications equipment, and other IPES equipment. Computers and related equipment includes mainframe computers, personal computers, printers, terminals, tape drives, storage devices, and integrated systems. Software is comprised of prepackaged, custom, and own-account software. Communications equipment is not further differentiated. Other IPES includes medical equipment and related instruments, electromedical instruments, nonmedical instruments, photocopying and related equipment, and office and accounting machinery. Structures include nonresidential structures and residential capital that are rented out by profit-making firms or persons.

11.3.6 Capital Stocks

A central concept in the production of BLS capital measures is that of the "productive" capital stock, or the stock measured in efficiency units. Conceptually, the productive stock represents the amount of new investment required to produce the same capital *services* actually produced by existing assets of all vintages. Thus, total current services from assets of all vintages are proportional to the productive stock. It is this measure of capital stock that is directly associated with productivity. The measurement of the productive stock involves vintage aggregation, which requires historical data on real investment and an "age/efficiency" function that describes the pattern of services that capital goods supply as they age.

The BLS computes each type of stock by the perpetual inventory method. The stock at the end of a period is equal to a weighted sum of all past investment, where the weights are the asset's efficiency (defined below) as of a given age.

Mathematically, the productive stock K_t, at the end of the period t is given by:

$$K_t = \sum_{\tau=t}^{\infty} s_{\tau-t} I_{2t-\tau},$$

where I_t is investment in period t and s_t is the efficiency function.

The efficiency function is a schedule that indicates the quantity of services provided by an asset of a given age, relative to a new asset of the same type. This function is generally assigned a value of 1.00 when the asset is new and declines as the asset ages, eventually approaching or reaching zero. Consequently, investments in the more distant past contribute less to current output.

The mathematical form BLS uses for the age/efficiency relationship is the hyperbolic function:

$$s_t = \frac{(L - t)}{(L - \beta_t)} \text{ where } 0 < t < L,$$

$$s_t = 0 \qquad t > L,$$

where

s_t is the relative efficiency of a t-year-old asset,
L is the service life,
t is the age of the asset, and
β is the parameter allowing the shape of the curve to vary.

The BLS uses an efficiency function that declines initially at one-half the straight-line depreciation rate for equipment ($\beta = 0.5$) and at one-fourth the straight-line rate for structures ($\beta = 0.75$).

11.3.7 Rental Prices

The "implicit rental price" of capital is based on the neoclassical principle that inputs should be aggregated using weights that reflect their marginal products. The assumption used to formulate the rental price expression is that the purchase price of a capital asset equals the discounted value of the stream of services (and, hence, implicitly the rents) that the asset will provide.

Rental prices are calculated for each asset as:

$$C_t = \left(\frac{(1 - u_t z_t - e_t)(p_t r_t + p_t d_t - \Delta p_t)}{(1 - u_t)} \right) + p_t x_t,$$

where

u_t is the corporate income tax rate,
z_t is the present value of \$1 of tax depreciation allowances,
e_t is the effective rate of the investment tax credit,
r_t is the nominal rate of return on capital,
d_t is the average rate of economic depreciation,
p_t is the deflator for new capital goods,
Δp_t is the revaluation of assets due to inflation in new goods prices, and
x_t is the rate of property taxation on wealth.

The following equation is used to derive the implicit internal rate of return, r_t, by substituting c_t from the above equation in the product $c_t K_t$:

$$r_t = \left(\frac{[Y_t - K_t p_t x_t - K_t (p_t d_t - \Delta p_t)(1 - u_t z_t - e_t)]/(1 - u_t)}{[K_t p_t (1 - u_t z_t - e_t)]/(1 - u_t)} \right),$$

where

Y_t is capital income and
K_t is productive capital stock.

After determining the internal rate of return in each industry, rental prices are computed separately for each type of asset within each industry.[24]

11.3.8 Government, Nonprofit, and Owner-Occupied Capital

For the purposes of the industry production account, the BLS prepared capital measures that are conceptually consistent with the total economy production accounts as described in Harper et al. (2009). These measures are not consistent with BLS major sector published measures, which exclude government, household and nonprofit institutions, and owner-occupied housing capital.

For the industry production account, the addition of government, household and nonprofit institutions, and owner-occupied housing capital measures require detailed capital stock for each so that a rental price can be calculated. Industry-specific rates of return are used in generating rental prices for nonprofit and owner-occupied housing. For government (federal, state, and local), rental prices are based on a weighted average of the rates of return and capital gains for the private business industries to calculate capital income, capital stock, and capital input. A detailed breakdown of capital data for the government stock, owner-occupied housing, and nonprofits was collected from the BEA NIPA tables in order to generate rental prices on those assets.

11.3.9 Estimation Methods—Labor Input

Labor Hours

The labor hours reflect annual hours worked. Hours are measured separately for different categories of workers in each industry and are then summed. Hours for each industry and class of worker are calculated as the product of employment, average weekly hours, and fifty-two weeks per year. They are also adjusted to reflect hours at work. The measures generally reflect the data and methods underlying the hours used in the BLS industry productivity and cost measures, but have been adjusted where necessary to improve consistency with the BEA industry accounts. Hours for NIPA industries were aggregated from estimates for more detailed industries.

The primary source of hours and employment data is the BLS Current Employment Statistics (CES) program. The CES data are based on payroll records from a sample of establishments in which the probability of sample selection is related to the establishment size. Data on employment and hours are collected monthly; the reference period for these data is the payroll period including the 12th of the month. Jobs rather than persons are counted in the CES, so that multiple jobholders are counted more than

24. It is worth noting that Jorgenson, Ho, and Stiroh (2005) estimate capital services prices that take into account tax differences across legal forms of organization.

once. Average weekly hours for production and nonsupervisory workers are obtained directly from the CES, while those for nonproduction and supervisory workers are derived using data from the Current Population Survey (CPS) in conjunction with the CES data.[25]

To adjust from hours paid to hours worked, ratios of hours at work to hours paid, developed from information on employer leave practices in the BLS National Compensation Survey (NCS), are used to adjust the CES paid hours (which includes paid holidays, sick leave, and vacation time) to an hours-worked basis. The BLS Hours at Work Survey provided the ratios for years prior to 2000.

To include the self-employed, data from the Current Population Survey (CPS) are used to estimate the number of self-employed workers (partners and proprietors) and their hours. The CPS, a monthly survey of households, counts persons employed, not jobs. Information about primary and secondary jobs for each person is identified and processed separately in order to accurately assign employment and hours estimates to the proper industry and worker category. The CPS-based hours of the self-employed reflect hours worked.

To include employment and hours in other sectors not covered by CES data, other source data are used. Estimates of employment and hours for industries in the farm sector are based on data from the US Department of Agriculture. Measures for industries in the nonfarm agriculture sector are based primarily on data from the CPS, together with data from the BLS Quarterly Census of Employment and Wages (QCEW). For mining industries, estimates of nonproduction worker hours are derived from data collected by the Mine Safety and Health Administration. Employment data for the postal service industry are from the CES survey, but estimates of hours for this industry are from the US Postal Service.

Labor Composition

Accounting for labor composition—that is, adjusting labor input of total hours by industry to reflect differences in time and skill—has become an important component of productivity measurement. The importance of this work has been described by Jorgenson, Gollop, and Fraumeni (1987) and by the BLS (1993), among others. Just as a key component of including heterogeneous types of assets for capital allows for the measurement of not just the increases in investment, but also the shift in investment to asset types with a higher marginal product, similarly, including a labor input measure that captures demographic characteristic improves the MFP measure by not

25. "Construction of Average Weekly Hours for Supervisory and Nonproduction Wage and Salary Workers in Detailed Industries," available at http://www.bls.gov/lpc/iprswawhtechnote.pdf.

just capturing an increase in hours worked, but also industry shifts toward higher-skilled workers.

Consequently, we have incorporated labor composition indexes in the quantity measures of labor input in this prototype, integrated account. These measures account for the heterogeneity of the workforce across sex, employment class, age, and education. This approach in measuring labor input is currently used by the BLS in official private business and private nonfarm business productivity, and is being investigated at the industry level.

A labor composition index was generated using the comprehensive set of hours' measures from BLS and labor matrices of demographic characteristics provided by Dale Jorgenson Associates (DJA) consistent with data used in Jorgenson, Ho, and Samuels (2012). The 192 unique demographic categories are divided by gender, class of worker, age (eight categories), and education (six categories).

Using the DJA labor matrices, a set of compensation shares were generated for payrolled workers. These shares were multiplied by the published BEA labor compensation figures to produce a sixty-three-industry set of ninety-six unique demographic categories of compensation for payrolled workers. Similarly, a set of hours' shares were generated and applied to the BLS payrolled worker hours to allocate payrolled hours by industry by ninety-six demographic categories.[26] The payrolled compensation data are consistent with published BEA data and the self-employed compensation estimates are based on the assumption that payrolled employees of a given demographic characteristic will receive similar compensation per hour of work as the self-employed workers.

11.4 Conceptual and Measurement Challenges

While this prototype industry-level production account represents an important step in integrating the national accounts with MFP statistics, concerns and challenges remain. Differences arise, in part, because of the different goals of each agency. The BEA's mission is to promote a better understanding of the US economy by providing the most timely, relevant, and accurate economic accounts, which has led to the development of a set of accounts that provides complete and consistent coverage of the domestic output of the entire economy. The BLS mission has been to provide maximum reliability in its productivity measures using economic concepts

26. While detailed data exist for self-employed income from the national accounts, a labor compensation measure for the self-employed does not exist mainly for reasons of conceptual problems. A common assumption in the productivity literature and one adopted by this study is to assume that the payrolled compensation per hour is the same as the self-employed compensation per hour. The BEA adjusted this assumption in two cases where anecdotal evidence suggested that this assumption may not be valid and the results from the model suggested a change; those two industries were NAICS 624–Social Assistance and NAICS Performing Arts, Spectator Sports, Museums, and Related Activities.

and methods that are most appropriate for measuring productivity, and to ensure consistency between its official labor productivity series and multifactor productivity series. As a result, some of the data presented here reflect differences in concepts and coverage from the official BLS productivity data. Some challenges remain, including:

The use of a gross-output concept for measuring MFP in the industry-level production account contrasts with the sectoral industry output approach used in the official productivity measures produced by the BLS. The BLS adjusts output and intermediate inputs to exclude the double-counting that occurs when sales between firms in the same industry or sector are included. Double counting occurs both in the output measure and in the purchased intermediates used to produce that output, and therefore is added identically to both the numerator and denominator of the productivity ratio. Inputs of materials produced and consumed in the same sector are already represented by the inputs used to make them. Counting both the intrasector transaction and the inputs that they embody gives an overstated importance to these inputs relative to other inputs. Additionally, adding the same transactions to both the numerator and denominator of the productivity equation causes productivity change to be dampened.

The production accounts and MFP measures presented here reflect output consistent with GDP for the total economy. These accounts are in keeping with the BEA goal to measure total domestic production. Official BLS productivity measures exclude certain activities because reliable data are lacking to construct output estimates independently of input costs. Estimates for real gross products of general government, private households, and nonprofit institutions are largely based on labor compensation. Owner-occupied housing and rental value of nonprofit equipment and buildings have no adequate measures for corresponding labor inputs. Government enterprises are excluded because subsidies account for a substantial portion of capital income. Therefore, there is no adequate measure of government enterprise capital income in GDP.

Because of these issues, the BLS constructs private business and private nonfarm business MFP measures that exclude from GDP general government, government enterprises, private households, nonprofit institutions, and the rental value of owner-occupied dwellings. The private business sector accounted for approximately 74 percent of gross domestic product in 2010. In the more aggregate sectors, private business and private nonfarm business, the delivery of goods to final users closely corresponds to value-added output. In these measures, output, consisting of only goods and services sold to final consumers, is measured net of price changes and interindustry transactions and the input measure is an aggregate of labor input and capital service flows.

For its total economy production account measures, the BLS replaces the capital consumption allowances that are included in GDP with its own

measures of nominal capital services of government and nonprofit assets, therefore altering GDP to account for a more complete estimate of capital services input. This adjustment to GDP is based on recommendations in the Harper et al. (2008) paper on BLS-BEA integrated GDP-productivity accounts.

This prototype confirms a long-standing challenge related to the presence of negative MFP growth within the nonmanufacturing sector, implying the likelihood that some mismeasurement of outputs and/or inputs remains.[27] Long-term declining productivity in such industries as construction, management of companies, rental and leasing services, legal services and other services is counterintuitive and raises questions about the accuracy of the data. Challenges remain in accurately measuring the output of many industries. These results suggest further work by the BEA and BLS to reconcile output differences, as well as work with the US Census Bureau to continue to improve services-sector measurement, including the expansion of business expense data reported on the annual business expenses and services annual surveys, which would be used to improve the measurement of intermediate inputs by industry.

For many of the industries presented here the MFP trends are similar to those published by the BLS, but for some industries these trends differ. Reconciling the reasons for these differences will be part of the ongoing collaborative work of the two agencies.

11.5 Conclusion and Possible Next Steps

This chapter provides an important down payment on an integrated, industry-level production account for the United States. It builds on a long-standing history of collaboration between the BEA and BLS and illustrates the importance of understanding the sources of economic growth, including KLEMS inputs and MFP growth, within an integrated national economic accounts framework, as first described by Jorgenson and Landefeld (2006).

However, much work remains before a BEA/BLS industry-level production account will be released on a regular basis. Challenges to a regular release include an increasingly tough US budgetary resource environment for introducing new initiatives in addition to methodology considerations seeking resolution in future work.

This prototype was prepared absent any new resources at the BEA or BLS, which poses a practical challenge for continuing this initiative in future years. Within the BEA, there are many near-term initiatives to improve the

27. Harper et al. (2010) provide a clear exposition of both the so-called "productivity paradox" of negative multifactor productivity growth as well as some of the improvements that have occurred in services-sector measurement.

accuracy, relevance, and timeliness of its national and industry accounts. For example, Strassner and Wasshausen (2012) recently described the BEA's work on a fiscal year 2013 budget initiative to produce US quarterly GDP by industry on a near "real-time" basis, which currently is also unfunded. Within the BLS, resource constraints and other important initiatives pose a challenge to expanding work in the productivity program. For example, the BLS is also working on developing a prototype for calculating quarterly MFP.

Future work on an integrated, industry-level production account will build on this effort and the upcoming release of the 2013 comprehensive revision of the industry accounts. The 2013 comprehensive revision will include the publication of the 2007 benchmark input-output accounts on a 2007 NAICS basis, fully integrated with the time series of annual industry accounts and NIPAs.[28] This release will mark the completion of "full integration" of the industry accounts with the NIPAs, first described by Lawson et al. (2006). The enhanced integration will allow for a higher degree of consistency among the NIPAs, the benchmark input-output accounts, and the annual industry accounts.

Further work to incorporate a labor composition adjustment at the industry level remains a research item on both the BEA and BLS research agendas. This project makes use of the DJA labor matrices used in similar studies such as that by Jorgenson, Ho, and Samuels (2012). The illustrative adjustments incorporated into this account are based on a good approximation, but further work remains in this area. The BLS is close to finalizing a methodology to incorporate industry labor composition measures into its official major sector manufacturing and NIPA-level industry MFP measures.

This initiative to produce an integrated, industry-level production account, despite budgetary considerations, remains one of the BEA's flagship projects (Moyer 2009). Toward this goal, the BEA has been working to produce an internally consistent industry-level production account, consistent with GDP, that incorporates capital measures based on a set of assumptions that are consistent with the BEA's fixed assets account. Using the assumption that the age-efficiency profile is defined by a constant geometric rate along with similar tax factors as was used in the BLS measure, an alternate capital measure was computed and below is an illustrative example of some of the results that were generated. The age-efficiency assumption implies a geometric pattern in the acquisition price of capital goods as well as a geometric

28. Traditionally, the benchmark input-output accounts have been released before the comprehensive revision of the NIPAs, and as a consequence, they have not been fully consistent with the NIPAs and with the annual industry accounts. With this comprehensive revision, the benchmark I-O accounts will be released after the NIPA comprehensive revision, and will be updated to reflect future revisions of the NIPAs and the industry accounts, creating—for the first time—a times series of benchmark input-output accounts for the United States.

Table 11.15 Preliminary capital input growth rates versus BLS capital input (percent growth)

	1998–2010		2000–2007		2007–2010		2009–2010	
Description	BEA	BLS	BEA	BLS	BEA	BLS	BEA	BLS
Apparel and leather and allied products	–2.1	–2.2	–2.4	–2.8	–5.0	–3.9	–5.9	–3.8
Furniture and related products	1.1	1.4	1.6	1.5	–3.9	–2.3	–4.3	–3.3
Miscellaneous professional, scientific, and technical	9.0	8.4	8.8	8.6	3.9	3.8	3.1	2.7

rate of economic depreciation, which is consistent with BEA measures of private investment in equipment and software in the NIPAs and in the fixed assets account. Since the age-price profile is geometric, the age efficiency profile must also follow the same geometric pattern.[29]

Table 11.15 presents results for two manufacturing industries and one service sector industry where the rates of capital input growth are similar. Despite the differing assumptions with respect to the capital input model, the two measures are remarkably similar in the time periods evaluated. Since official BLS statistics are available through 2010 and the underlying NIPA data are also available through 2010, growth rates incorporate one extra year of data in this comparison. The MFP produced likely would have yielded similar results as well since the capital input measures would not have differed by much.

29. Jorgenson, Ho, Stiroh (2005, 152).

Appendix

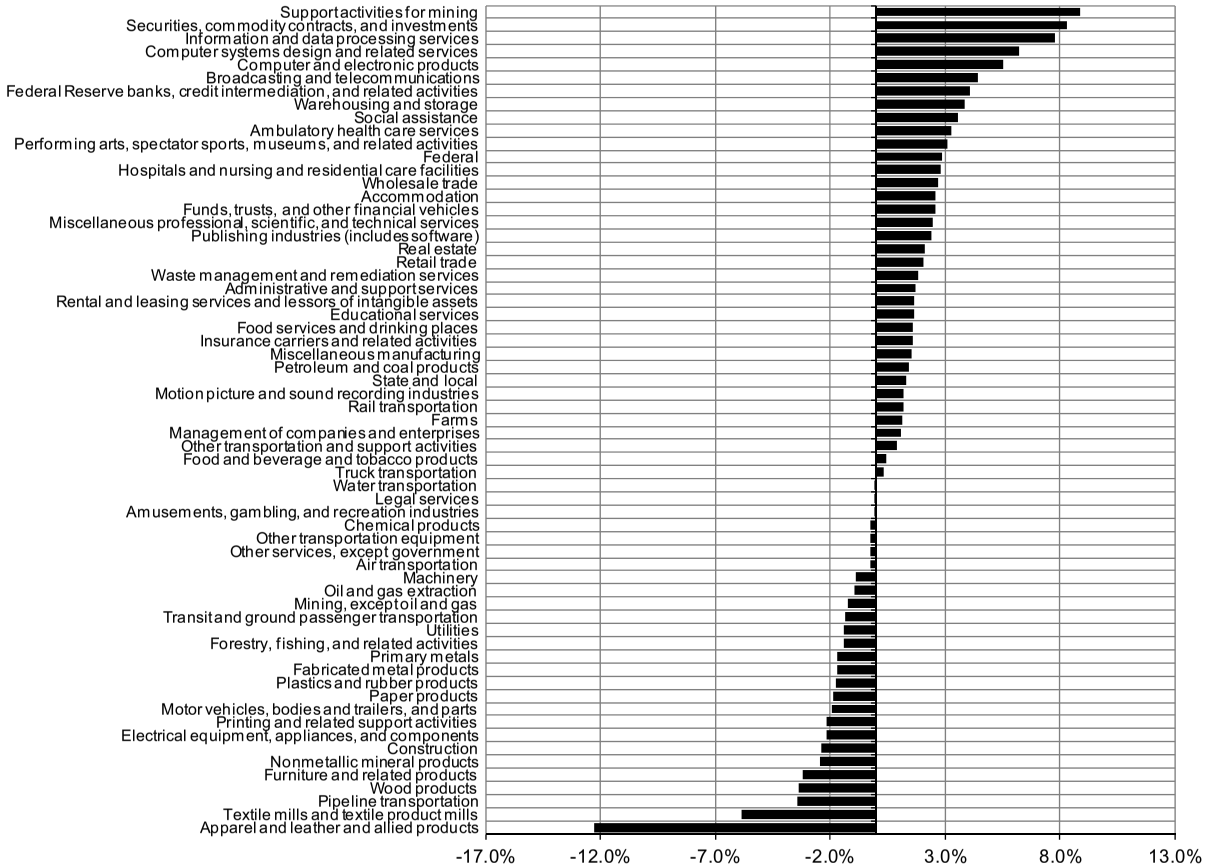

Fig. 11A.1 Output growth, 1998–2010

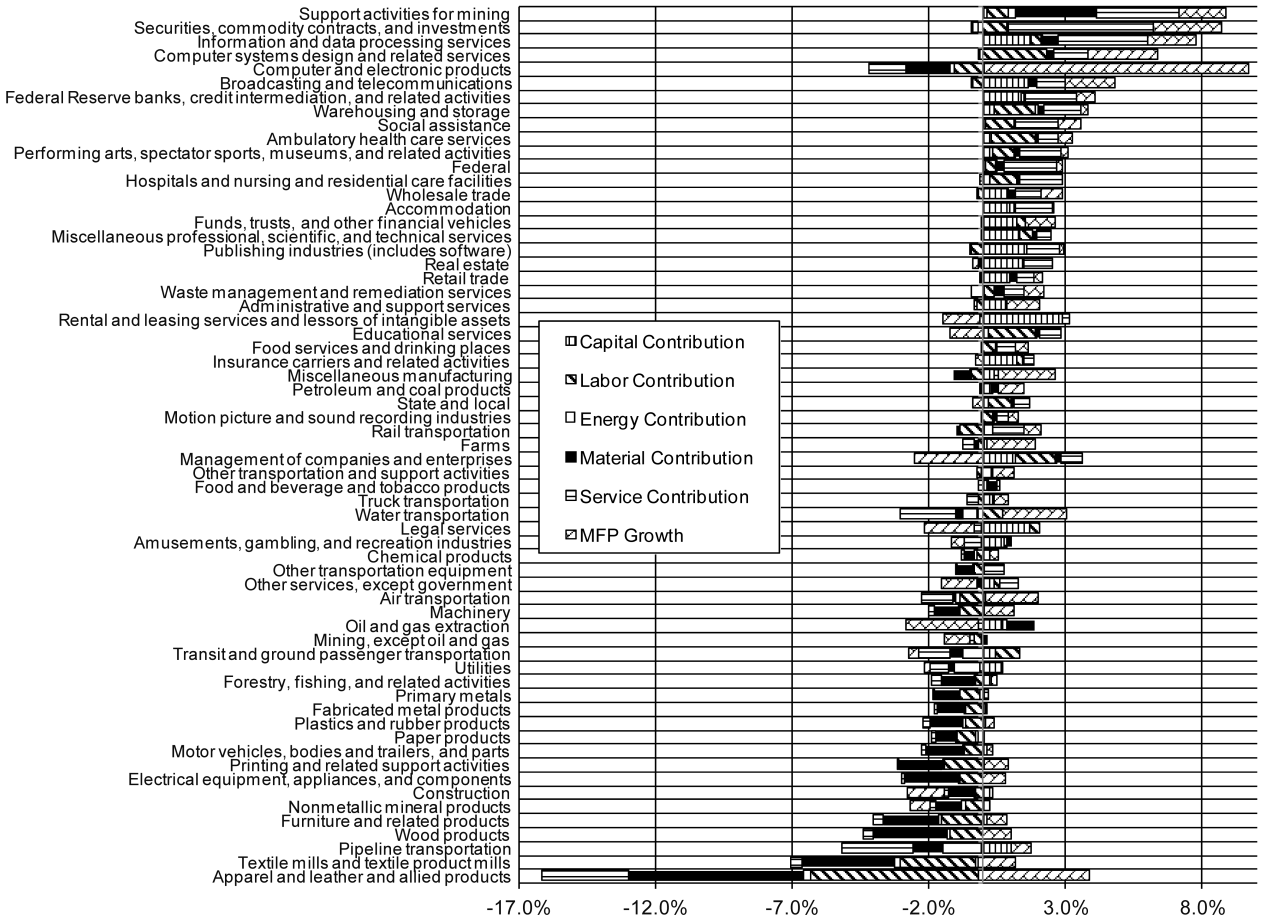

Fig. 11A.2 Output growth by component contribution, 1998–2010

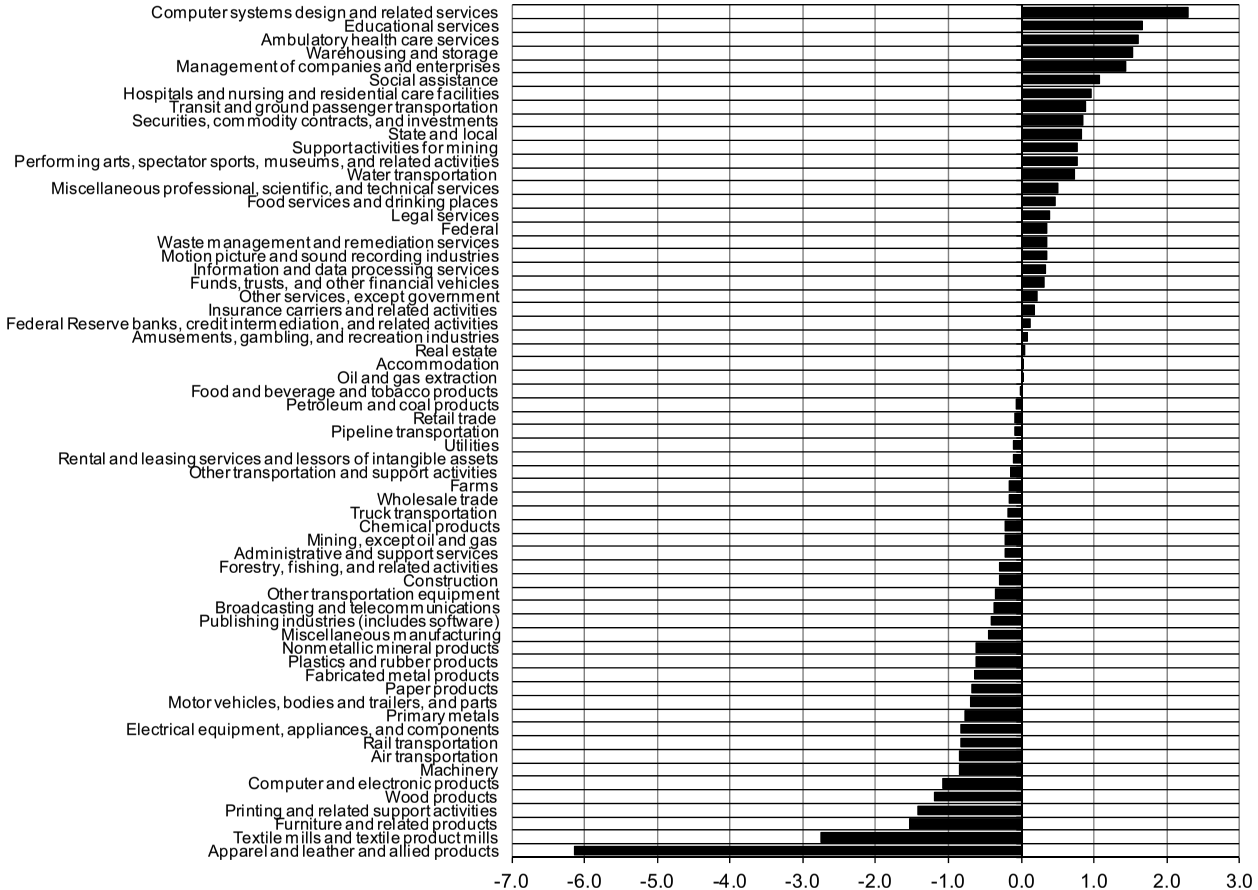

Fig. 11A.3 Labor input contribution to output growth, 1998–2010 (percentage point)

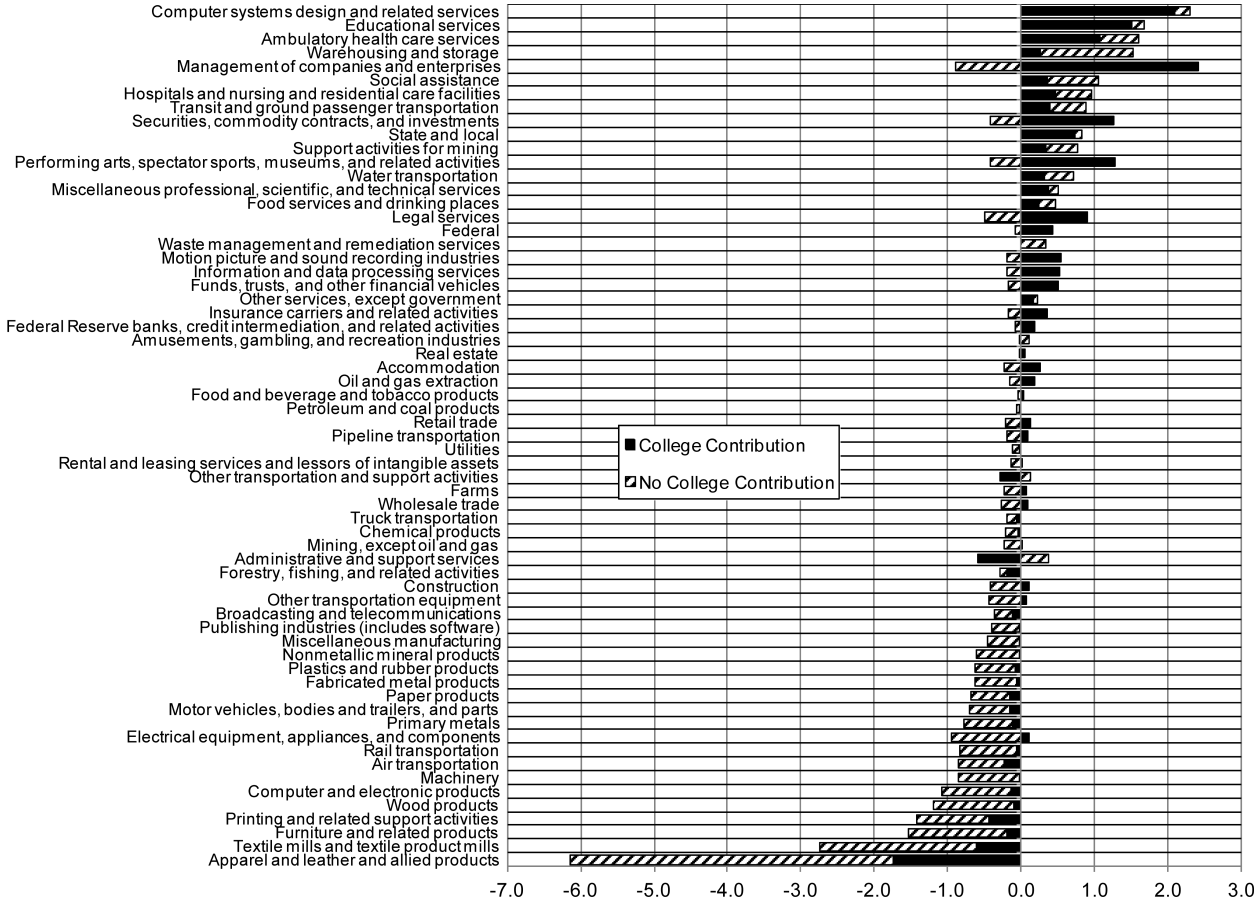

Fig. 11A.4 Labor input contribution to output growth by education, 1998–2010 (percentage point)

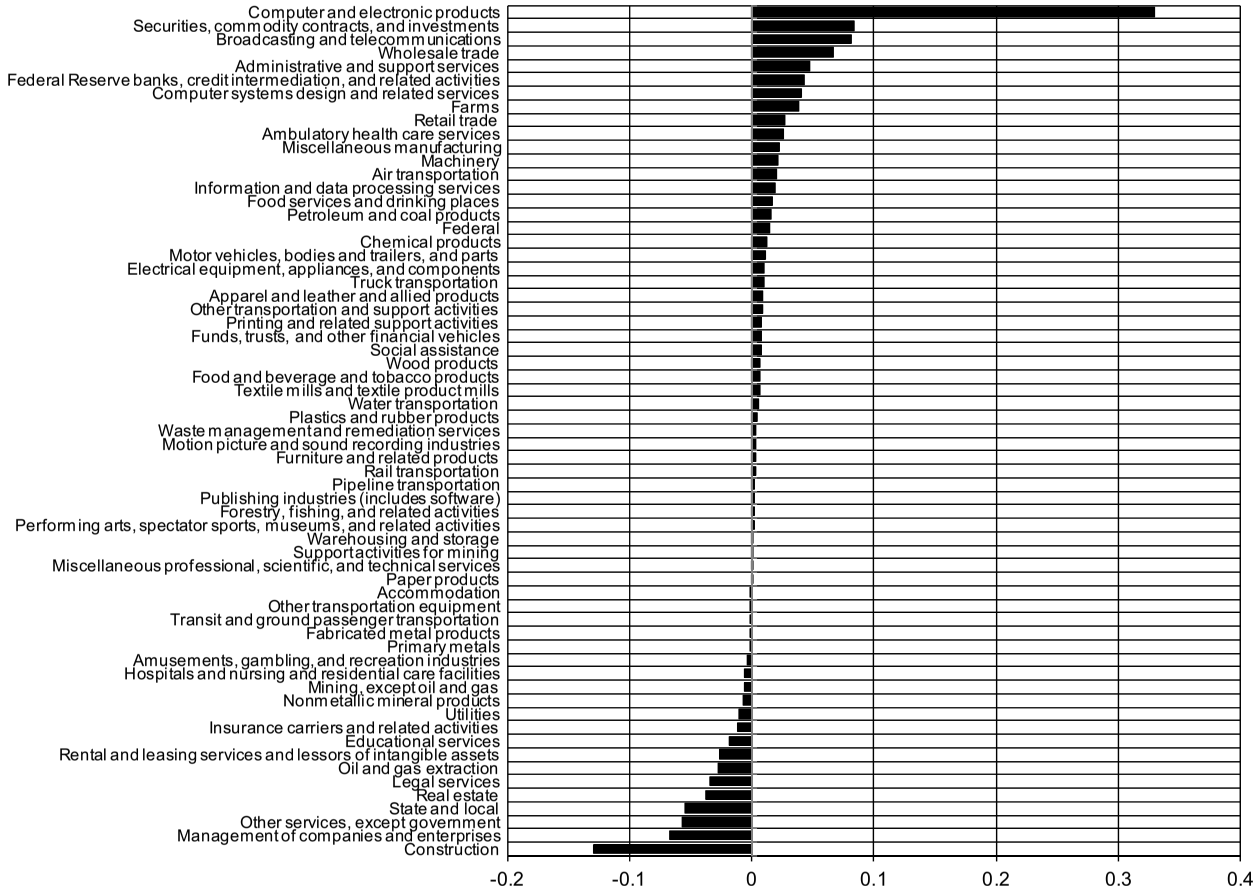

Fig. 11A.5 Contributions to aggregate MFP growth, 1998–2010

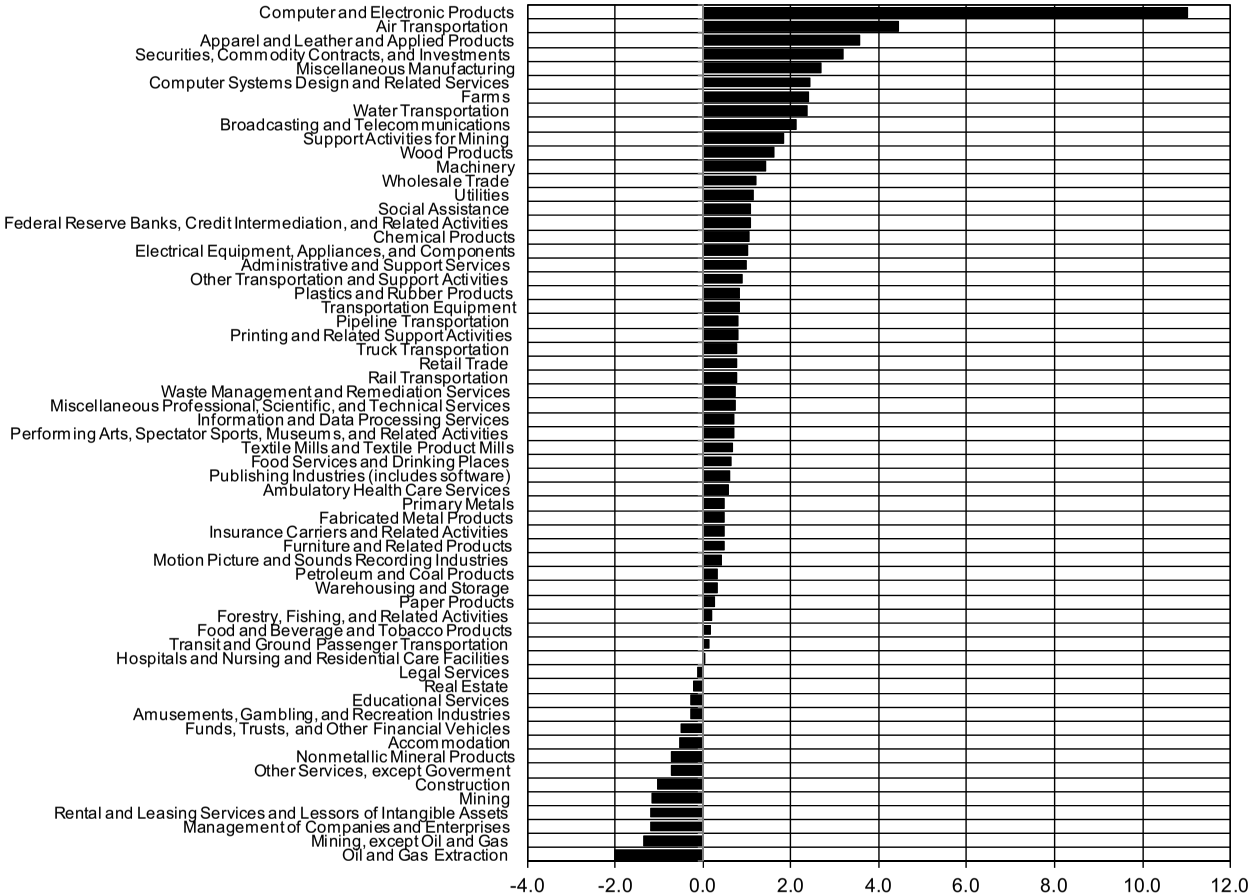

Fig. 11A.6 BLS multifactor productivity growth, 1998–2010

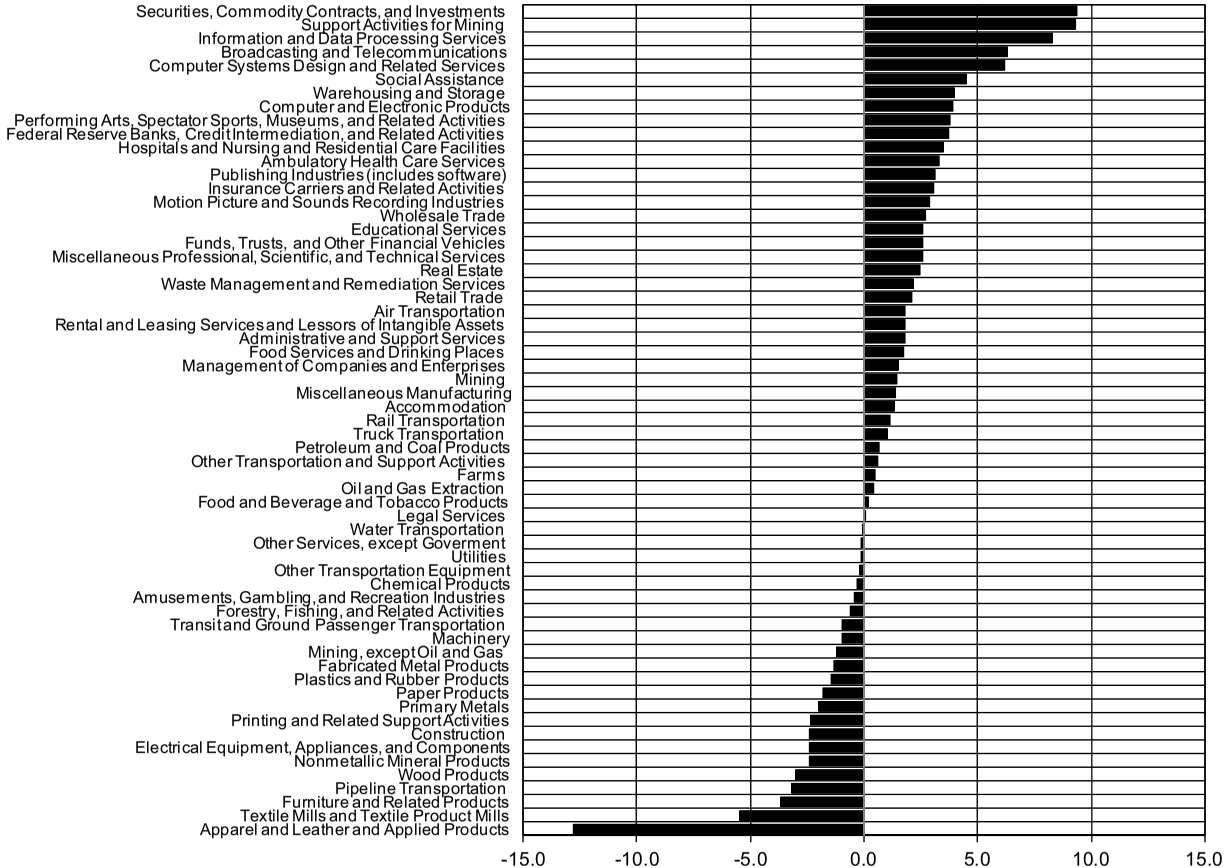

Fig. 11A.7 BLS sectoral output growth, 1998–2010

Table 11A.1 Contributions to aggregate multifactor productivity growth (percentage point)

Description	1998–2000	2000–2007	2007–2010	1998–2010
Farms	0.063	0.012	0.085	0.039
Forestry, fishing, and related activities	0.008	0.008	–0.014	0.002
Oil and gas extraction	–0.123	–0.015	0.010	–0.027
Mining, except oil and gas	0.018	–0.014	–0.002	–0.006
Support activities for mining	0.033	–0.010	0.007	0.001
Utilities	0.111	–0.023	–0.061	–0.010
Construction	–0.059	–0.210	0.014	–0.129
Food and beverage and tobacco products	0.021	0.018	–0.029	0.006
Textile mills and textile product mills	0.008	0.006	0.007	0.006
Apparel and leather and allied products	0.009	0.005	0.016	0.009
Wood products	0.002	0.008	0.009	0.007
Paper products	0.005	0.006	–0.015	0.000
Printing and related support activities	0.005	0.011	0.004	0.008
Petroleum and coal products	–0.013	0.022	0.018	0.015
Chemical products	0.026	0.054	–0.093	0.013
Plastics and rubber products	0.009	0.006	–0.003	0.004
Nonmetallic mineral products	–0.015	–0.006	–0.005	–0.007
Primary metals	0.008	–0.008	0.007	–0.002
Fabricated metal products	0.013	0.008	–0.031	–0.001
Machinery	–0.028	0.028	0.038	0.021
Computer and electronic products	0.600	0.274	0.278	0.329
Electrical equipment, appliances, and components	0.037	0.007	–0.003	0.010
Motor vehicles, bodies and trailers, and parts	–0.024	0.057	–0.070	0.012
Other transportation equipment	0.023	0.014	–0.050	–0.001
Furniture and related products	0.002	0.003	0.003	0.003
Miscellaneous manufacturing	0.034	0.019	0.024	0.023
Wholesale trade	0.179	0.111	–0.114	0.066
Retail trade	–0.021	0.013	0.091	0.027
Air transportation	0.031	0.031	–0.013	0.020
Rail transportation	0.015	0.001	–0.002	0.003
Water transportation	–0.002	0.008	0.005	0.005
Truck transportation	0.024	0.009	0.003	0.010
Transit and ground passenger transportation	0.003	–0.001	–0.003	–0.001
Pipeline transportation	0.017	0.001	–0.003	0.003
Other transportation and support activities	0.005	0.021	–0.018	0.008
Warehousing and storage	–0.006	0.003	0.003	0.001
Publishing industries (includes software)	–0.115	0.041	–0.009	0.002
Motion picture and sound recording industries	–0.036	0.020	–0.011	0.003
Broadcasting and telecommunications	–0.004	0.129	0.026	0.081
Information and data processing services	–0.094	0.057	0.007	0.019
Federal Reserve banks, credit intermediation, and related activities	0.020	–0.006	0.171	0.043
Securities, commodity contracts, and investments	0.167	0.033	0.145	0.084
Insurance carriers and related activities	0.049	–0.024	–0.024	–0.012
Funds, trusts, and other financial vehicles	–0.006	0.010	0.013	0.008
Real estate	0.193	–0.018	–0.235	–0.037
Rental and leasing services and lessors of intangible assets	–0.148	–0.020	0.042	–0.026
Legal services	0.004	–0.041	–0.045	–0.035

Table 11A.1 (continued)

Description	1998–2000	2000–2007	2007–2010	1998–2010
Miscellaneous professional, scientific, and technical services	–0.099	0.008	0.048	0.000
Computer systems design and related services	–0.008	0.048	0.057	0.041
Management of companies and enterprises	–0.008	–0.068	–0.104	–0.067
Administrative and support services	–0.012	0.061	0.057	0.048
Waste management and remediation services	0.007	0.003	0.003	0.004
Educational services	–0.012	–0.018	–0.021	–0.018
Ambulatory health-care services	0.089	–0.001	0.046	0.026
Hospitals and nursing and residential care facilities	–0.018	–0.016	0.027	–0.005
Social assistance	0.000	0.012	0.004	0.008
Performing arts, spectator sports, museums, and related activities	0.011	–0.004	0.010	0.002
Amusements, gambling, and recreation industries	0.002	–0.003	–0.009	–0.004
Accommodation	–0.001	0.008	–0.019	0.000
Food services and drinking places	0.064	0.026	–0.037	0.017
Other services, except government	–0.021	–0.065	–0.059	–0.056
Federal	–0.051	0.028	0.027	0.015
State and local	–0.059	–0.064	–0.029	–0.055
Sum	0.928	0.614	0.171	0.556

Table 11A.2 **Multifactor productivity growth (percent growth)**

Description	1998–2000	2000–2007	2007–2010	1998–2010
Farms	3.0	0.6	3.7	1.8
Forestry, fishing, and related activities	1.8	2.0	–4.9	0.2
Oil and gas extraction	–12.8	–1.0	0.1	–2.7
Mining, except oil and gas	3.2	–2.4	–0.1	–0.9
Support activities for mining	13.2	–1.3	1.0	1.7
Utilities	3.4	–0.5	–2.1	–0.2
Construction	–0.6	–2.2	0.2	–1.3
Food and beverage and tobacco products	0.4	0.4	–0.6	0.1
Textile mills and textile product mills	0.8	1.0	1.8	1.2
Apparel and leather and allied products	1.2	1.3	11.8	3.9
Wood products	0.2	0.9	1.7	1.0
Paper products	0.3	0.5	–1.2	0.0
Printing and related support activities	0.5	1.2	0.6	0.9
Petroleum and coal products	–1.0	1.6	0.6	0.9
Chemical products	0.6	1.2	–1.9	0.3
Plastics and rubber products	0.5	0.4	–0.1	0.3
Nonmetallic mineral products	–1.5	–0.6	–0.4	–0.7
Primary metals	0.4	–0.3	0.3	0.0
Fabricated metal products	0.5	0.4	–1.2	0.0
Machinery	–0.9	1.3	2.0	1.1
Computer and electronic products	12.2	8.5	10.7	9.6
Electrical equipment, appliances, and components	3.0	0.8	–0.6	0.8

(*continued*)

Table 11A.2 (continued)

Description	1998–2000	2000–2007	2007–2010	1998–2010
Motor vehicles, bodies and trailers, and parts	–0.5	1.4	–2.2	0.2
Other transportation equipment	1.1	0.9	–2.9	0.0
Furniture and related products	0.2	0.5	1.5	0.7
Miscellaneous manufacturing	2.9	1.7	2.3	2.1
Wholesale trade	2.0	1.3	–1.4	0.8
Retail trade	–0.2	0.1	1.1	0.3
Air transportation	2.4	3.2	–1.3	1.9
Rail transportation	3.4	0.3	–0.4	0.6
Water transportation	–0.6	3.3	2.0	2.3
Truck transportation	1.2	0.4	0.3	0.5
Transit and ground passenger transportation	1.0	–0.3	–1.4	–0.4
Pipeline transportation	6.6	0.1	–2.0	0.7
Other transportation and support activities	0.4	2.0	–1.8	0.8
Warehousing and storage	–2.0	0.8	0.6	0.3
Publishing industries (includes software)	–4.5	1.7	–0.4	0.2
Motion picture and sound recording industries	–4.7	2.6	–1.5	0.4
Broadcasting and telecommunications	–0.1	2.8	0.6	1.8
Information and data processing services	–13.0	6.4	0.8	1.8
Federal Reserve banks, credit intermediation, and related activities	0.4	0.0	2.4	0.7
Securities, commodity contracts, and investments	5.3	1.0	4.2	2.5
Insurance carriers and related activities	1.1	–0.6	–0.4	–0.3
Funds, trusts, and other financial vehicles	–0.6	1.3	1.6	1.1
Real estate	1.3	–0.1	–1.5	–0.2
Rental and leasing services and lessors of intangible assets	–7.4	–1.1	2.2	–1.3
Legal services	0.2	–2.1	–2.4	–1.8
Miscellaneous professional, scientific, and technical services	–1.6	0.1	0.7	0.0
Computer systems design and related services	–0.5	3.1	3.2	2.5
Management of companies and enterprises	–0.3	–2.6	–3.8	–2.5
Administrative and support services	–0.3	1.6	1.4	1.2
Waste management and remediation services	1.2	0.7	0.5	0.7
Educational services	–0.9	–1.3	–1.3	–1.2
Ambulatory health-care services	1.9	0.0	0.9	0.5
Hospitals and nursing and residential care facilities	–0.4	–0.3	0.5	–0.1
Social assistance	0.1	1.2	0.4	0.8
Performing arts, spectator sports, museums, and related activities	1.5	–0.4	1.0	0.3
Amusements, gambling, and recreation industries	0.2	–0.3	–1.4	–0.5
Accommodation	–0.1	0.6	–1.1	0.1
Food services and drinking places	1.8	0.7	–1.0	0.5
Other services, except government	–0.5	–1.5	–1.5	–1.3
Federal	–0.8	0.4	0.4	0.2
State and local	–0.5	–0.5	–0.2	–0.4

Table 11A.3 Contributions to output growth, 1998–2010 (percentage point)

Description	Output	Capital	Labor	Energy	Material	Service	MFP
Farms	1.16	0.03	–0.17	0.11	–0.17	–0.43	1.78
Forestry, fishing, and related activities	–1.41	0.27	–0.29	–0.05	–1.21	–0.33	0.21
Oil and gas extraction	–0.95	0.68	0.03	0.16	1.02	–0.17	–2.67
Mining, except oil and gas	–1.21	–0.08	–0.22	–0.03	0.18	–0.14	–0.93
Support activities for mining	8.86	0.13	0.78	0.27	2.98	3.01	1.70
Utilities	–1.40	0.69	–0.11	–0.92	–0.21	–0.67	–0.23
Construction	–2.41	0.34	–0.30	–0.03	–0.93	–0.16	–1.33
Food and beverage and tobacco products	0.42	0.12	–0.01	0.02	0.34	–0.17	0.12
Textile mills and textile product mills	–5.87	–0.29	–2.74	–0.19	–3.40	–0.42	1.17
Apparel and leather and allied products	–12.26	–0.18	–6.14	–0.26	–6.39	–3.20	3.89
Wood products	–3.39	0.01	–1.20	–0.14	–2.68	–0.38	1.00
Paper products	–1.85	–0.28	–0.68	–0.06	–0.69	–0.18	0.04
Printing and related support activities	–2.15	0.01	–1.42	–0.06	–1.59	–0.02	0.92
Petroleum and coal products	1.43	0.31	–0.07	0.01	0.24	–0.06	0.93
Chemical products	–0.23	0.23	–0.22	–0.11	–0.39	–0.07	0.33
Plastics and rubber products	–1.76	0.11	–0.62	–0.12	–1.21	–0.23	0.31
Nonmetallic mineral products	–2.43	0.22	–0.61	–0.17	–0.92	–0.21	–0.73
Primary metals	–1.66	–0.10	–0.77	0.05	–0.92	0.13	–0.04
Fabricated metal products	–1.70	0.07	–0.63	–0.08	–0.95	–0.12	0.03
Machinery	–0.89	0.02	–0.85	–0.04	–0.87	–0.25	1.09
Computer and electronic products	5.52	0.05	–1.08	–0.11	–1.65	–1.35	9.64
Electrical equipment, appliances, and components	–2.17	–0.02	–0.82	–0.06	–1.97	–0.12	0.83
Motor vehicles, bodies and trailers, and parts	–1.94	0.14	–0.70	–0.02	–1.36	–0.18	0.18
Other transportation equipment	–0.24	0.04	–0.35	–0.01	–0.59	0.71	–0.03
Furniture and related products	–3.17	0.15	–1.53	–0.08	–2.02	–0.38	0.69
Miscellaneous manufacturing	1.54	0.40	–0.45	–0.03	–0.60	0.17	2.05
Wholesale trade	2.71	0.92	–0.17	0.00	0.28	0.93	0.76
Retail trade	2.05	0.99	–0.08	–0.03	0.27	0.59	0.31
Air transportation	–0.27	0.09	–0.84	–0.16	–0.12	–1.15	1.91
Rail transportation	1.17	0.05	–0.83	0.32	–0.13	1.12	0.65
Water transportation	–0.01	–0.22	0.72	–0.52	–0.27	–2.06	2.32
Truck transportation	0.34	0.35	–0.19	0.03	0.01	–0.38	0.53
Transit and ground passenger transportation	–1.35	0.48	0.88	–0.76	–0.44	–1.14	–0.36
Pipeline transportation	–3.44	1.05	–0.09	–1.37	–1.12	–2.60	0.70
Other transportation and support activities	0.92	–0.05	–0.15	0.28	0.00	0.06	0.80
Warehousing and storage	3.86	0.39	1.52	0.11	0.20	1.37	0.27
Publishing industries (includes software)	2.43	1.62	–0.41	–0.02	–0.09	1.16	0.16
Motion picture and sound recording industries	1.20	–0.08	0.34	0.00	0.16	0.39	0.38

(*continued*)

Table 11A.3 (continued)

Description	Output	Capital	Labor	Energy	Material	Service	MFP
Broadcasting and telecommunications	4.44	1.66	–0.36	–0.01	0.28	1.08	1.79
Information and data processing services	7.81	1.76	0.34	0.03	0.60	3.31	1.77
Federal Reserve banks, credit intermediation, and related activities	4.10	1.38	0.12	0.00	0.03	1.90	0.67
Securities, commodity contracts, and investments	8.33	–0.39	0.85	–0.02	0.10	5.28	2.52
Insurance carriers and related activities	1.59	1.24	0.18	0.00	0.05	0.41	–0.29
Funds, trusts, and other financial vehicles	2.57	1.22	0.32	–0.01	–0.01	–0.04	1.08
Real estate	2.14	1.44	0.05	–0.06	–0.11	1.04	–0.22
Rental and leasing services and lessors of intangible assets	1.69	2.89	–0.11	–0.02	0.00	0.24	–1.31
Legal services	–0.06	1.68	0.39	–0.01	–0.05	–0.27	–1.80
Miscellaneous professional, scientific, and technical services	2.47	1.32	0.51	–0.01	0.14	0.53	0.00
Computer systems design and related services	6.23	–0.13	2.30	–0.01	0.28	1.26	2.52
Management of companies and enterprises	1.11	1.19	1.44	0.00	0.20	0.81	–2.54
Administrative and support services	1.72	0.81	–0.22	0.00	0.04	–0.11	1.22
Waste management and remediation services	1.83	0.05	0.35	–0.43	0.39	0.72	0.73
Educational services	1.65	0.21	1.67	0.03	0.16	0.77	–1.19
Ambulatory health-care services	3.27	0.29	1.60	0.00	0.11	0.73	0.53
Hospitals and nursing and residential care facilities	2.79	0.27	0.96	0.02	0.11	1.57	–0.13
Social assistance	3.60	0.08	1.07	0.02	0.03	1.55	0.85
Performing arts, spectator sports, museums, and related activities	3.09	0.37	0.77	0.03	0.15	1.51	0.26
Amusements, gambling, and recreation industries	–0.10	0.76	0.08	–0.09	0.20	–0.59	–0.46
Accommodation	2.60	0.97	0.03	0.11	0.07	1.36	0.05
Food services and drinking places	1.63	–0.04	0.47	0.01	0.00	0.72	0.45
Other services, except government	–0.26	0.41	0.22	–0.02	–0.18	0.65	–1.33
Federal	2.90	0.10	0.36	0.04	0.26	1.92	0.22
State and local	1.30	0.19	0.83	0.01	0.12	0.55	–0.40

Table 11A.4 Labor contribution, 1998–2010 (percentage point)

Description	College labor contribution	No college labor contribution	Labor composition contribution
Farms	0.07	–0.23	–0.17
Forestry, fishing, and related activities	–0.19	–0.09	–0.29
Oil and gas extraction	0.20	–0.16	0.03
Mining, except oil and gas	0.01	–0.23	–0.22
Support activities for mining	0.33	0.45	0.78
Utilities	–0.02	–0.09	–0.11
Construction	0.12	–0.42	–0.30
Food and beverage and tobacco products	0.03	–0.04	–0.01
Textile mills and textile product mills	–0.61	–2.14	–2.74
Apparel and leather and allied products	–1.74	–4.39	–6.14
Wood products	–0.09	–1.10	–1.20
Paper products	–0.15	–0.53	–0.68
Printing and related support activities	–0.43	–0.98	–1.42
Petroleum and coal products	–0.02	–0.05	–0.07
Chemical products	–0.03	–0.18	–0.22
Plastics and rubber products	–0.09	–0.54	–0.62
Nonmetallic mineral products	–0.03	–0.59	–0.61
Primary metals	–0.11	–0.67	–0.77
Fabricated metal products	–0.06	–0.56	–0.63
Machinery	–0.03	–0.82	–0.85
Computer and electronic products	–0.14	–0.93	–1.08
Electrical equipment, appliances, and components	0.12	–0.94	–0.82
Motor vehicles, bodies and trailers, and parts	–0.16	–0.54	–0.70
Other transportation equipment	0.08	–0.43	–0.35
Furniture and related products	–0.18	–1.35	–1.53
Miscellaneous manufacturing	–0.01	–0.43	–0.45
Wholesale trade	0.09	–0.26	–0.17
Retail trade	0.13	–0.21	–0.08
Air transportation	–0.23	–0.61	–0.84
Rail transportation	–0.05	–0.78	–0.83
Water transportation	0.33	0.39	0.72
Truck transportation	–0.05	–0.14	–0.19
Transit and ground passenger transportation	0.40	0.48	0.88
Pipeline transportation	0.09	–0.19	–0.09
Other transportation and support activities	–0.28	0.12	–0.15
Warehousing and storage	0.26	1.27	1.52
Publishing industries (includes software)	–0.03	–0.38	–0.41
Motion picture and sound recording industries	0.55	–0.20	0.34
Broadcasting and telecommunications	–0.12	–0.24	–0.36
Information and data processing services	0.53	–0.19	0.34
Federal Reserve banks, credit intermediation, and related activities	0.19	–0.07	0.12
Securities, commodity contracts, and investments	1.26	–0.41	0.85
Insurance carriers and related activities	0.36	–0.18	0.18
Funds, trusts, and other financial vehicles	0.50	–0.18	0.32
Real estate	0.06	–0.01	0.05

(*continued*)

Table 11A.4 (continued)

Description	College labor contribution	No college labor contribution	Labor composition contribution
Rental and leasing services and lessors of intangible assets	0.02	–0.13	–0.11
Legal services	0.90	–0.50	0.39
Miscellaneous professional, scientific, and technical services	0.37	0.14	0.51
Computer systems design and related services	2.10	0.20	2.30
Management of companies and enterprises	2.42	0.88	1.44
Administrative and support services	–0.59	0.37	–0.22
Waste management and remediation services	0.00	0.34	0.35
Educational services	1.52	0.16	1.67
Ambulatory health-care services	1.07	0.53	1.60
Hospitals and nursing and residential care facilities	0.47	0.48	0.96
Social assistance	0.36	0.70	1.07
Performing arts, spectator sports, museums, and related activities	1.28	–0.41	0.77
Amusements, gambling, and recreation industries	–0.02	0.11	0.08
Accommodation	0.26	–0.22	0.03
Food services and drinking places	0.24	0.23	0.47
Other services, except government	0.17	0.06	0.22
Federal	0.43	–0.08	0.36
State and local	0.74	0.09	0.83

Table 11A.5 **Aggregate multifactor productivity growth, sorted by contribution, 1998–2010**

Description	2009 value added share	Domar weight	MFP growth	Contribution to aggregate MFP
Computer and electronic products	1.5	0.035	9.6	0.329
Securities, commodity contracts, and investments	1.2	0.033	2.5	0.084
Broadcasting and telecommunications	2.4	0.047	1.8	0.081
Wholesale trade	5.5	0.084	0.8	0.066
Administrative and support services	2.6	0.040	1.2	0.048
Federal Reserve banks, credit intermediation, and related activities	3.8	0.064	0.7	0.043
Computer systems design and related services	1.2	0.016	2.5	0.041
Farms	0.8	0.021	1.8	0.039
Retail trade	6.0	0.096	0.3	0.027
Ambulatory health-care services	3.6	0.050	0.5	0.026
Miscellaneous manufacturing	0.6	0.011	2.1	0.023
Machinery	0.8	0.024	1.1	0.021
Air transportation	0.4	0.011	1.9	0.020
Information and data processing services	0.6	0.009	1.8	0.019
Food services and drinking places	2.1	0.037	0.5	0.017
Petroleum and coal products	0.7	0.030	0.9	0.015
Federal	4.4	0.068	0.2	0.015
Chemical products	1.7	0.044	0.3	0.013
Motor vehicles, bodies and trailers, and parts	0.2	0.039	0.2	0.012
Electrical equipment, appliances, and components	0.4	0.010	0.8	0.010

Table 11A.5 (continued)

Description	2009 value added share	Domar weight	MFP growth	Contribution to aggregate MFP
Truck transportation	0.8	0.019	0.5	0.010
Apparel and leather and allied products	0.1	0.004	3.9	0.009
Other transportation and support activities	0.7	0.010	0.8	0.008
Printing and related support activities	0.2	0.009	0.9	0.008
Funds, trusts, and other financial vehicles	0.2	0.008	1.1	0.008
Social assistance	0.6	0.009	0.8	0.008
Wood products	0.1	0.008	1.0	0.007
Food and beverage and tobacco products	1.6	0.054	0.1	0.006
Textile mills and textile product mills	0.1	0.006	1.2	0.006
Water transportation	0.1	0.003	2.3	0.005
Plastics and rubber products	0.5	0.015	0.3	0.004
Waste management and remediation services	0.3	0.005	0.7	0.004
Motion picture and sound recording industries	0.4	0.007	0.4	0.003
Furniture and related products	0.2	0.006	0.7	0.003
Rail transportation	0.2	0.005	0.6	0.003
Pipeline transportation	0.1	0.002	0.7	0.003
Publishing industries (includes software)	1.0	0.023	0.2	0.002
Forestry, fishing, and related activities	0.2	0.004	0.2	0.002
Performing arts, spectator sports, museums, and related activities	0.5	0.008	0.3	0.002
Warehousing and storage	0.3	0.004	0.3	0.001
Support activities for mining	0.3	0.006	1.7	0.001
Miscellaneous professional, scientific, and technical services	4.7	0.066	0.0	0.000
Paper products	0.4	0.014	0.0	0.000
Accommodation	0.7	0.015	0.1	0.000
Other transportation equipment	0.6	0.017	0.0	–0.001
Transit and ground passenger transportation	0.2	0.002	–0.4	–0.001
Fabricated metal products	0.8	0.023	0.0	–0.001
Primary metals	0.3	0.016	0.0	–0.002
Amusements, gambling, and recreation industries	0.4	0.007	–0.5	–0.004
Hospitals and nursing and residential care facilities	3.3	0.049	–0.1	–0.005
Mining, except oil and gas	0.3	0.005	–0.9	–0.006
Nonmetallic mineral products	0.2	0.009	–0.7	–0.007
Utilities	1.9	0.031	–0.2	–0.010
Insurance carriers and related activities	2.7	0.045	–0.3	–0.012
Educational services	1.1	0.015	–1.2	–0.018
Rental and leasing services and lessors of intangible assets	1.3	0.020	–1.3	–0.026
Oil and gas extraction	0.9	0.014	–2.7	–0.027
Legal services	1.5	0.019	–1.8	–0.035
Real estate	12.0	0.161	–0.2	–0.037
State and local	9.4	0.138	–0.4	–0.055
Other services, except government	2.4	0.042	–1.3	–0.056
Management of companies and enterprises	1.8	0.026	–2.5	–0.067
Construction	3.9	0.091	–1.3	–0.129
Sum	100.0	1.8		0.556

Notes: Value-added share is the share of industry value added to GDP. Domar weights are calculated as a ratio of gross output of an industry to GDP. Aggregate MFP growth calculated as the sum of industry percentage point contributions to aggregate MFP.

Table 11A.6 Contributions to BLS aggregate multifactor productivity growth (percentage point)

Description	1998–2000	2000–2007	2007–2010	1998–2010
Farms	0.11	0.02	0.14	0.06
Forestry, fishing, and related activities	0.01	0.01	–0.02	0.00
Oil and gas extraction	–0.13	–0.02	–0.03	–0.04
Mining, except oil and gas	0.01	–0.02	0.00	–0.01
Support activities for mining	0.05	–0.01	0.01	0.00
Utilities	–0.22	0.10	0.08	0.04
Construction	–0.02	–0.25	0.07	–0.13
Food and beverage and tobacco products	–0.01	0.04	–0.05	0.01
Textile mills and textile product mills	0.01	0.01	–0.01	0.01
Apparel and leather and allied products	0.02	0.01	0.01	0.01
Wood products	0.02	0.01	–0.02	0.00
Paper products	0.00	0.01	0.00	0.01
Printing and related support activities	–0.04	–0.03	0.18	0.02
Petroleum and coal products	0.05	0.10	–0.05	0.05
Chemical products	0.02	0.01	0.02	0.01
Plastics and rubber products	0.01	0.01	0.02	0.01
Nonmetallic mineral products	–0.02	–0.01	0.00	–0.01
Primary metals	0.03	–0.01	0.02	0.00
Fabricated metal products	0.02	0.02	0.01	0.01
Machinery	–0.05	0.05	0.09	0.04
Computer and electronic products	0.81	0.35	0.34	0.43
Electrical equipment, appliances, and components	0.05	0.02	–0.01	0.02
Other transportation equipment	0.02	0.10	–0.01	0.06
Furniture and related products	0.00	0.01	–0.01	0.00
Miscellaneous manufacturing	0.05	0.03	0.05	0.04
Wholesale trade	0.19	0.19	–0.12	0.11
Retail trade	0.02	0.07	0.18	0.09
Air transportation	0.07	0.05	0.02	0.05
Rail transportation	0.02	0.00	0.00	0.00
Water transportation	0.00	0.01	0.01	0.01
Truck transportation	0.04	0.02	0.02	0.02
Transit and ground passenger transportation	0.01	0.00	0.00	0.00
Pipeline transportation	0.02	0.00	0.00	0.01
Other transportation and support activities	0.01	0.03	–0.02	0.01
Warehousing and storage	–0.01	0.00	0.01	0.00
Publishing industries	–0.11	0.08	–0.01	0.03
Motion picture and sound recording industries	–0.05	0.03	–0.01	0.01
Broadcasting and telecommunications	0.02	0.19	0.03	0.12
Information and data processing services	–0.16	0.08	0.01	0.02
Federal Reserve banks, credit intermediation, and related activities	0.09	–0.01	0.24	0.07
Securities, commodity contracts, and investments	0.38	0.08	0.16	0.15
Insurance carriers and related activities	0.14	–0.02	0.03	0.02
Funds, trusts, and other financial vehicles	0.02	–0.01	0.00	0.00
Real estate	0.18	0.06	–0.31	–0.01
Rental and leasing services and lessors of intangible assets	–0.18	–0.02	0.06	–0.03
Legal services	0.03	0.00	–0.02	0.00

Table 11A.6 (continued)

Description	1998–2000	2000–2007	2007–2010	1998–2010
Computer systems design and related services	–0.02	0.06	0.08	0.05
Miscellaneous professional, scientific, and technical services	–0.07	0.04	0.22	0.07
Management of companies and enterprises	0.02	–0.04	–0.10	–0.05
Administrative and support services	0.01	0.07	0.04	0.05
Waste management and remediation services	0.01	0.00	0.00	0.00
Educational services	0.01	–0.01	0.00	0.00
Ambulatory health-care services	0.07	0.02	0.05	0.03
Hospitals and nursing and residential care facilities	0.00	–0.01	0.03	0.00
Social assistance	0.00	0.01	0.01	0.01
Performing arts, spectator sports, museums, and related activities	0.02	0.00	0.01	0.00
Amusements, gambling, and recreation industries	0.01	0.00	–0.01	0.00
Accommodation	0.03	–0.01	–0.03	–0.01
Food services and drinking places	0.05	0.03	–0.01	0.02
Other services, except government	0.04	–0.05	–0.04	–0.03
Total NMF Contributions	**0.59**	**0.72**	**0.63**	**0.68**
Total MFG Contribution	**0.93**	**0.72**	**0.49**	**0.70**
Private Business MFP	**1.79**	**1.44**	**0.45**	**1.25**

Table 11A.7 **BLS multifactor productivity growth (percent growth-BLS data)**

Description	1998–2000	2000–2007	2007–2010	1998–2010
Farms	4.1	0.7	5.1	2.4
Forestry, fishing, and related activities	1.6	2.6	–6.0	0.2
Oil and gas extraction	–9.3	–0.6	–0.2	–2.0
Mining, except oil and gas	1.3	–2.5	–0.5	–1.3
Support activities for mining	14.3	–1.2	1.1	1.8
Utilities	–6.2	2.9	2.3	1.2
Construction	–0.2	–2.0	0.7	–1.0
Food and beverage and tobacco products	–0.1	0.7	–0.8	0.2
Textile mills and textile product mills	0.9	1.6	–1.7	0.7
Apparel and leather and allied products	2.6	4.2	2.6	3.6
Wood products	0.8	1.0	3.6	1.6
Paper products	0.7	0.7	–1.2	0.3
Printing and related support activities	0.1	1.3	0.0	0.8
Petroleum and coal products	–2.8	0.4	2.3	0.3
Chemical products	1.0	1.9	–0.9	1.0
Plastics and rubber products	0.7	0.6	1.5	0.8
Nonmetallic mineral products	–1.7	–0.7	–0.1	–0.7
Primary metals	1.9	–0.4	1.7	0.5
Fabricated metal products	0.6	0.6	0.1	0.5
Machinery	–1.4	1.6	2.9	1.4

(*continued*)

Table 11A.7 (continued)

Description	1998–2000	2000–2007	2007–2010	1998–2010
Computer and electronic products	14.1	9.9	11.7	11.0
Electrical equipment, appliances, and components	3.6	1.4	–1.6	1.0
Other transportation equipment	0.3	1.7	–0.9	0.8
Furniture and related products	0.4	1.1	–0.9	0.5
Miscellaneous manufacturing	3.2	2.0	4.1	2.7
Wholesale trade	2.0	2.1	–1.4	1.2
Retail trade	0.2	0.6	1.6	0.8
Air transportation	5.4	5.3	1.8	4.5
Rail transportation	3.4	0.4	–0.2	0.7
Water transportation	–0.7	3.4	2.0	2.4
Truck transportation	1.7	0.6	0.6	0.8
Transit and ground passenger transportation	3.3	–0.2	–1.1	0.1
Pipeline transportation	7.2	0.2	–1.9	0.8
Other transportation and support activities	0.8	2.0	–1.6	0.9
Warehousing and storage	–1.8	0.6	1.0	0.3
Publishing industries	–4.1	2.4	–0.4	0.6
Motion picture and sound recording industries	–7.5	3.7	–1.7	0.4
Broadcasting and telecommunications	0.4	3.3	0.5	2.1
Information and data processing services	–15.3	5.6	1.1	0.7
Federal Reserve banks, credit intermediation, and related activities	1.6	0.0	3.3	1.1
Securities, commodity contracts, and investments	8.6	2.0	2.5	3.2
Insurance carriers and related activities	4.7	–1.0	1.1	0.5
Funds, trusts, and other financial vehicles	1.3	–0.7	–1.2	–0.5
Real estate	2.1	0.6	–3.6	–0.2
Rental and leasing services and lessors of intangible assets	–7.0	–1.0	2.4	–1.2
Legal services	1.3	–0.1	–1.0	–0.1
Computer systems design and related services	–1.1	3.1	3.3	2.4
Miscellaneous professional, scientific, and technical services	–0.9	0.5	2.4	0.7
Management of companies and enterprises	0.6	–1.1	–2.5	–1.2
Administrative and support services	0.1	1.3	0.9	1.0
Waste management and remediation services	1.4	0.7	0.5	0.7
Educational services	0.9	–0.8	0.1	–0.3
Ambulatory health-care services	1.2	0.3	0.8	0.6
Hospitals and nursing and residential care facilities	–0.1	–0.3	0.7	0.0
Social assistance	0.0	1.4	1.0	1.1
Performing arts, spectator sports, museums, and related activities	3.1	0.1	0.5	0.7
Amusements, gambling, and recreation industries	1.3	–0.5	–0.8	–0.3
Accommodation	1.7	–0.7	–1.7	–0.5
Food services and drinking places	1.5	0.8	–0.2	0.6
Other services, except government	0.8	–1.0	–1.0	–0.7

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