Research Spotlight

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

By Susan Fleck, Steven Rosenthal, Matthew Russell, Erich H. Strassner, and Lisa Usher

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 U.S. economy.

To better understand the sources of economic growth, productivity statistics integrated with gross domestic product (GDP) statistics have long been sought as a rich source of information for policy makers, business analysts, and economists. The usefulness of such integrated statistics on the sources of growth within the framework of the U.S. national income and product accounts (NIPAs) was first presented by Jorgenson and Landefeld (2006) in *A New Architecture for the U.S. National Accounts*. In that same volume, Fraumeni, Harper, Powers, and Yuskavage (2006) established the groundwork for a collaboration by the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS) to create a production account.

Since 2010, the two agencies have been working toward creating a prototype production account. This *Research Spotlight* summarizes a lengthier, more detailed report on the prototype integrated production account that was recently published on the BEA Web site.

The initial results of the prototype account show the following:

- In 1998–2010, capital accounted for about 60 percent of U.S. economic growth, labor accounted for about 10 percent, and MFP accounted for about 30 percent of growth.
- In 48 out of 63 industries, at least one KLEMS (K-capital, L-labor, E-energy, M-materials, and S-purchased services) input to production was a more important source of real gross output growth than was MFP.

GDP by industry statistics provide detailed 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 provide detailed information on the output per unit of capital, labor, and intermediate inputs. MFP growth is calculated as the growth that cannot be explained by changes in the combined contribution of these three factor inputs. The official MFP measures provide information on components of economic growth in the market economy but 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. GDP statistics are published by BEA, of the U.S. Department of Commerce. Labor productivity and MFP statistics are published by BLS of the U.S. Department of Labor. Differences in concepts and methods used by each agency persist because of the different nature of each program, but each statistical program depends on the other to prepare its official measures.

To estimate the contributions of MFP and each input to individual industries' output growth and to growth in the total gross output of the economy, economy-wide MFP measures have been developed in a joint exercise by BLS and BEA. This prototype account builds on the GDP by industry statistics produced by BEA and the capital, labor and MFP statistics produced by BLS to assemble an industry-level production account for the United States that is consistent with GDP. 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

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MFP and identify them as sources of GDP growth at the aggregate level.

This prototype, integrated economy-wide account for the United States spans 1998–2010 on a 2002 North American Industry Classification (NAICS) basis and covers all NIPA-level industries in the market and nonmarket sectors. The account incorporates gross output, value added, and intermediate inputs (which comprises energy, materials, and purchased services) statistics by industry from BEA and labor and capital input measures by industry from BLS. Both the BEA and BLS data are consistent with the annual industry accounts statistics as of December 2011. The BLS labor and capital measures reflect adjustments that were made where necessary to provide consistency in concepts and coverage for this prototype account.[1]

The prototype production account presents contributions of KLEMS inputs and MFP to gross output growth for the total economy at the NIPA-industry level, or roughly the three-digit NAICS level of industry detail, based on a gross-output production accounting framework.[2] The gross output concept differs from the sectoral concept used by BLS in its industry-level MFP statistics. The sectoral approach excludes intermediate production and purchases that come from within the industry (that is, 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.[3] Both approaches are discussed in Schreyer (2001).

In this production account, we used the gross-output approach because it provides a clear crosswalk to published BEA statistics on GDP, GDP by industry, and the input-output accounts, including estimates of gross output, value added, and intermediate inputs by industry. The starting point for this prototype production account is the fundamental economic accounting identity that (assuming zero profits), the value of gross output equals the value of payments for KLEMS inputs to production, including intraindustry transactions. The complete set of accounts 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.[4] We also include illustrative results of a labor composition adjustment to BLS industry labor hours in order to better understand its impact on estimating the contribution of labor input and MFP by industry. This adjustment for labor composition reflects the heterogeneity of each industry's workforce and yields a symmetric treatment of labor and capital services.

The remainder of the article discusses the following:

- Results of the prototype industry-level account
- The methodology for this prototype industry-level account
- The conceptual and measurement challenges that require resolution before this account can be released on a regular basis
- Possible future work and next steps in this important collaboration

1. 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 paper. For this account, we incorporate data across all legal forms of organization at the industry level to ensure consistency with GDP.

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

3. The National Academy of Sciences (1979) (Reese) 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.

4. Domar weights consist of the ratio of an industry's 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. All industries' Domar-weighted MFP growth, when summed, roughly equal economy-wide MFP.

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A First Look at the Results

This prototype, BEA/BLS industry-level production account can be used to trace the sources of U.S. economic growth across all goods-producing and services-producing industries in the U.S. economy in 1998–2010 (chart 1 follows the article). This new production account presents the contributions of both value added and intermediate input factors of production and the contribution of MFP to real gross output growth, at roughly the three-digit NAICS industry level as published in the annual industry accounts.

The new account provides a wealth of useful information by measuring the contributions of output growth from each industry's KLEMS inputs—both its primary, value added inputs (capital and labor), and its secondary, intermediate inputs (energy, materials and services)—and from MFP. That information can be used to estimate key contributions to economic growth. Table A presents the sources of aggregate value added growth (economic) for the United States that are attributable to the primary, value added inputs (capital and labor) and to MFP.

Table A. Contributions to Economywide Value-Added Growth in 1998–2010

Value-added growth for all industries	**1.90**
Labor input	0.20
College graduate	0.46
No college degree	–0.25
Capital input	1.15
Aggregate multifactor productivity	0.56

NOTE. Growth is expressed as the difference in natural logs. The components may not sum to totals because of rounding.

Table B extends the analysis by showing the contributions of all KLEMS inputs and MFP on gross output growth. Gross output is a broad measure of economic activity that includes intermediate activity, that is, economic activity used in the production process. GDP is defined as gross output less spending on intermediate inputs (energy, material and purchased services).

Table B ranks the NIPA-level industries by largest positive contribution of intermediate inputs, capital and labor. The contributions from at least one of the primary, value added inputs (capital and labor) or secondary, intermediate inputs (energy, materials, and purchased services) were greater than MFP growth in more than 75 percent of the 63 industries included in this account.

In the three industries with the largest percent changes in gross output—support activities for mining; securities, commodity contracts, 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 well as recent trends in the sourcing of production (table B). In 6 of the top 10 industries with the strongest output growth, intermediate inputs were the most significant factor. Conversely, in all but one of the 10 industries that showed the largest output decline, negative intermediate input contributions were the largest contributors.

Among capital-intensive industries, "rental and leasing" and "information and data processing services" were among the industries with the largest capital contributions to output growth (table B). For rental and leasing, capital contributed 2.89 percentage points to output growth of 1.7 percent. For information and data processing services, capital contributed 1.76 per-

Table B. Largest Contributions to Output Growth by Factor Input in 1998–2010

[Percentage points]

	Capital	Labor	Inter-mediate	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

MFP Multifactor productivity

centage points to real output growth of 7.8 percent.

Similarly, several labor-intensive industries had the highest labor contribution to output growth (table B). Computer systems design and related services, education services, and ambulatory health care services were among the industries with the highest labor contributions to output growth.

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. It describes the gross-output growth accounting framework, discusses the estimation methods used to prepare our results, and summarizes the source data methods used by BEA and BLS to produce the gross output, value added, intermediate inputs, capital input, and labor input used in this account, including adjustments we made to achieve better integration of these data sets.

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 inputs, L stands for labor inputs, II stands for the intermediate inputs, and t stands for time.[5]

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 ways.

$$\frac{d\ln Q}{dt} = \left(\left(\frac{\delta \ln Q}{\delta \ln K}\right)\cdot\left(\frac{d\ln K}{dt}\right) + \left(\frac{\delta \ln Q}{\delta \ln II}\cdot\frac{d\ln II}{dt}\right) + \left(\frac{\delta \ln Q}{\delta \ln L}\cdot\frac{d\ln L}{dt}\right) + \left(\frac{\delta \ln Q}{\delta t}\right)\right)$$

$$\frac{\delta \ln Q}{\delta t} = \frac{d\ln Q}{dt} - \left(\frac{\delta \ln Q}{\delta \ln K}\cdot\frac{d\ln K}{dt}\right) - \left(\frac{\delta \ln Q}{\delta \ln II}\cdot\frac{d\ln II}{dt}\right) - \left(\frac{\delta \ln Q}{\delta \ln L}\cdot\frac{d\ln L}{dt}\right)$$

With the above 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:

$$\frac{\delta \ln Q}{\delta \ln K} = \frac{P_K K = Capital Compensation}{(P_K K + P_L L + P_{II} II) = Total Compensation} = v_K$$

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.

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

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

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

Where $v_K + v_L + v_{II} = 1$

In discrete time, the input weights are 2-year averages of the cost shares for each input in years t and $t–1$, where $\tilde{v}_K = \frac{1}{2}v_{K,t} + \frac{1}{2}v_{K,t-1}$

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:

$$MFP growth = \Delta \ln Q - v_K \Delta \ln(K) - v_L \Delta \ln(L) - v_{II} \Delta \ln(II)$$

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.

Estimation methods

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 using 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.[6]

5. 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 the business sector, with the exception that Q is sectoral output and II reflects the subtraction of intraindustry inputs from intermediate inputs.

6. 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.

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 industry accounts. The current dollar labor component is a measure of the compensation of workers in that industry. The BEA published labor compensation statistics are supplemented to include the self-employed compensation estimate using the assumption that self-employed workers receive similar wages to the payrolled employees. Lastly, current-dollar capital compensation is computed as a residual of the value of gross output less the sum of labor compensation and intermediate input expenditures.[7]

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

BEA's industry accounts provide a time series of current-dollar and real gross output, intermediate inputs, and value added 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 in observing changes in spending related to energy, materials, and purchased services (Strassner, Medeiros, and Smith 2005).

Capital inputs are computed in accordance with a service flow concept for physical capital assets—equipment, structures, inventories, and land. Capital inputs are calculated in three steps: (1) a detailed array of capital stocks is identified for asset types in each industry; (2) asset-type capital stocks are aggregated by industry to measure capital input for each industry; and (3) industry capital inputs are aggregated to measure sector-level capital input. The development of nonmanufacturing productivity measures in 2010 created the foundation for the development of capital service measures for economy-wide NIPA-level industries (Harper, Khandrika, Kinoshita, and Rosenthal, 2010).

The labor hours reflect annual hours worked of all employed persons. Hours are measured separately for different categories of workers in each industry and are then summed. Hours for each industry and category of worker are calculated as the product of employment, average weekly hours, and 52 weeks per year. The hours are also adjusted to reflect hours at work. Hours worked for NIPA-level industries are based on the data and methods used to calculate hours in the BLS detailed industry productivity and cost measures, and were aggregated from estimates for more detailed industries. Industry classifications were adjusted where necessary to improve consistency with the BEA industry accounts.

Conceptual and Measurement Challenges

This prototype industry-level production account represents an important step in integrating the national accounts with MFP statistics. However, concerns and challenges remain. Differences arise in part because of the different goals of BEA and BLS. BEA's mission is to promote a better understanding of the U.S. 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. BLS's mission is to provide maximum reliability in its productivity measures using economic concepts 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. The effort to measure industry output and productivity covering the total economy, while consistent with domestic GDP, differs from the BLS approach. The official BLS productivity measures reflect the market sector rather than the total economy. They exclude certain activities (such as government,

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

private households, and nonprofit institutions) because of conceptual challenges in measuring output and capital in the nonmarket sector. In addition, the use of a gross output concept for measuring multifactor productivity in the production accounts contrasts with the sectoral output approach used in the BLS industry multifactor productivity measures.

Conclusions and Possible Next Steps

This research marks a significant milestone toward creating an integrated, industry-level production account for the United States. It builds on a long-standing history of collaboration between 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 include an increasingly tough budgetary resource environment for introducing new initiatives in addition to methodology considerations seeking resolution in future work by BEA and BLS on this account.

The full report on the prototype, integrated industry-level production account is available on the BEA Web site www.bea.gov/industry and on the BLS Web site at www.bls.gov/mfp.

References

Fraumeni, Barbara M., Michael J. Harper, Susan G. Powers, and Robert E. Yuskavage. 2006. "An Integrated BEA/BLS Production Account: A First Step and Theoretical Considerations." In *A New Architecture for the U.S. National Accounts,* eds. Dale W. Jorgenson, J. Steven Landefeld, and William D. Nordhaus, 355–435. Chicago: University of Chicago Press, for the National Bureau of Economic Research.

Harper, Michael J., Bhavani Khandrika, Randall Kinoshita, and Steven Rosenthal. 2010. "Nonmanufacturing Industry Contributions to Multifactor Productivity, 1987–2006." *Monthly Labor Review* 133, no. 6 (June): 3–15.

Jorgenson, Dale W., Frank Gollop, and Barbara Fraumeni. 1987. *Productivity and U.S. Economic Growth.* Harvard University Press.

Jorgenson, Dale W., Mun S. Ho, Kevin Stiroh. 2005. *Productivity, Information Technology and the American Growth Resurgence, Volume 3.* Cambridge, MA: The MIT Press.

Jorgenson, Dale W., and J. Steven Landefeld. 2006. "Blueprint for Expanded and Integrated U.S. Accounts: Review, Assessment, and Next Steps." In *A New Architecture for the U.S. National Accounts,* eds. Dale W. Jorgenson, J. Steven Landefeld, and William D. Nordhaus, *13–112.* Chicago: University of Chicago Press, for the National Bureau of Economic Research.

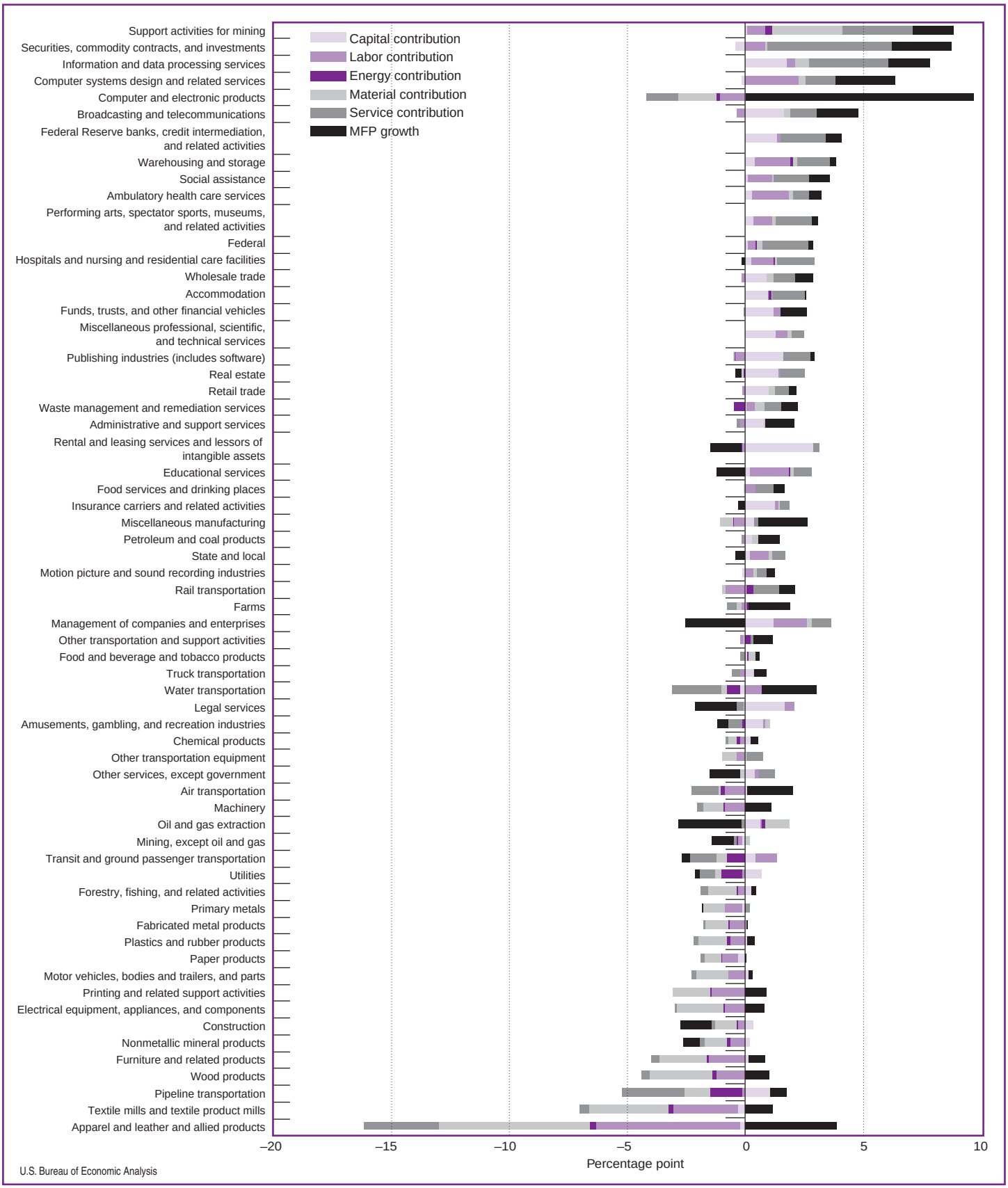
Mayerhauser, Nicole M., and Erich H. Strassner. 2010. "Preview of the Comprehensive Revision of the Annual Industry Accounts: Changes in Definitions, Classifications, and Statistical Methods." Survey of Current Business 90 (March): 21–34.

National Academy of Sciences. 1979. *Measurement and Interpretation of Productivity.* Washington, DC: National Research Council.

Schreyer, Paul. 2001. *Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity Growth.* Paris: Organisation for Economic Co-operation and Development, March.

Strassner, Erich H., Gabriel W. Medeiros, and George M. Smith. 2005. "Annual Industry Accounts: Introducing KLEMS Input Estimates for 1997–2003." Survey of Current Business 85 (September): 31–65.

Chart 1. Contributions to Growth in Output of Major Industries by Factor Input in 1998–2010



U.S. Bureau of Economic Analysis