New BEA-BLS Estimates of the Industry-level Sources of U.S. Economic Growth between 1987 and 2016

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Abstract

This article describes new historical statistics for the BEA-BLS integrated industry-level production account. The dataset includes KLEMS and integrated MFP measures that are consistent with the official BEA GDP by Industry statistics and now covers 1987-2016. The most important source of economic growth over the period was the accumulation of capital input. More than three quarters of the contribution of capital was driven by the accumulation of capital inputs in the service sector. The next most important source of economic growth over the period was the accumulation of labour input. Growth in labour input in the services sectors accounted for almost all the economy-wide contribution of labor input. MFP growth accounted for about twenty percent of aggregate economic growth. Of this, the manufacturing sector contributed more than half of this

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growth, but almost all of this was due to growth in MFP of the computer electronic products industry. Finally, the new dataset shows that the decline in the aggregate income share paid to labour in the manufacturing sector was mostly due to a decrease in the share of income paid to workers without a college degree. In contrast, workers with a college degree accounted for most of the increase in the income share of labour in the service sectors.

This article describes recently released historical statistics for the BEA-BLS integrated industry-level production account. Release of this new dataset adds more than a decade of historical data to the time series of KLEMS data and enhances the usefulness of the production account by allowing analysis of economic trends over a longer period. The dataset presented covers 1987-2016, whereas the previous data covered only 1998-2015.

These statistics were prepared as part of an ongoing collaboration between the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS). An important feature of the account is that it covers the total economy and is constructed to be consistent with the U.S. national accounts. There were two main challenges in assembling the new history presented in this article: the first was the conversion of historical SIC data to be consistent with NAICS industry classifications, and the second was a change in the reporting of educational attainment in data that was used to estimate labour composition.

These new historical data provide a view of the sources of economic growth at the industry level over roughly three decades of economic history. The data reveal that about half of economic growth over this period was due to the accumulation of capital inputs. About 30 per cent was due to growth in labour input, while the remainder (about 20 per cent) was due to growth in multifactor productivity (MFP).[2] The industry dataset shows that the aggregate growth in capital input was driven by capital services growth in the trade; information; and finance, insurance, and real estate sectors. The preponderance of the contribution of labour input was due to an increase of labour in the services industries, while most of aggregate MFP growth was accounted for by MFP growth in the computer and electronic manufacturing and trade

2 It is noteworthy that the estimates presented in this article differ from the official MFP growth estimates produced by the BLS for the business sector. For example, the BLS estimates that business sector MFP grew by 0.86 per cent per year over the 1987-2016 period, while MFP growth for the total economy is estimated to be 0.43 per cent per year for the same period. The difference is mostly attributable to the scope of the accounts (business versus total economy) but also reflects other details. See Fleck *et al.*(2012) for a broader discussion.

sectors.

The longer time series of data more clearly shows the shift from manufacturing to the services sector and the sources of this change from the input side of the production account. For example, more than three quarters of the contribution of aggregate capital input over the period as a whole was driven by the accumulation of capital inputs in the service sector and almost all of the aggregate contribution of labour input was accounted for by labour input growth in the services sectors. MFP growth in manufacturing was strong compared to its contributions of labour and capital inputs, but this was mostly as a result of MFP growth in the computer and electronics product industry.

The conceptual framework that underpins the estimates is identical throughout the time series. However, more limited data availability requires that different techniques be employed to prepare estimates in the earlier periods. The primary purpose of this article is to describe the insights gained from longer time series and the methodology underpinning these new estimates.[3]

The article is divided into four main sections. Section 1 describes the conceptual framework that underpins the full set of statistics. Section 2 describes the source data and methodologies used to prepare the data for the period prior to 1997. Section 3 describes the results. Section 4 concludes.

Conceptual Framework

To prepare these statistics, we assume a generic production function relating industry gross output to five factor inputs using the function Q = F(K, L, E, M, S, t). Assuming constant returns to scale, perfect competition, and factor payments equal to marginal product, the gross-output growth model can be written as:

$$\frac{d\ln Q}{dt} = (\frac{\partial \ln Q}{\partial \ln K} \cdot \frac{d\ln K}{d\ln t}) + (\frac{\partial \ln Q}{\partial \ln L} \cdot \frac{d\ln L}{d\ln t}) + (\frac{\partial \ln Q}{\partial \ln E} \cdot \frac{d\ln E}{d\ln t}) + (\frac{\partial \ln Q}{\partial \ln M} \cdot \frac{d\ln M}{d\ln t}) + (\frac{\partial \ln Q}{\partial \ln S} \cdot \frac{d\ln S}{d\ln t}) + (\frac{\partial \ln Q}{\partial \ln t}) \quad (1)$$

Q = Gross Output
K = Capital Input
L = Labour Input
E = Intermediate Energy Inputs
M = Intermediate Material Inputs
M = Intermediate Purchased Services Inputs
t = time

which can be rearranged to measure

3 See Fleck *et al.* (2014) for a more detailed discussion of the methodologies and source data that underpin the statistics for the more recent period.

(unobserved) multifactor productivity growth as follows:

$$\frac{d\ln Q}{dt} = \frac{\partial \ln Q}{\partial \ln t} - (\frac{\partial \ln Q}{\partial \ln K} \cdot \frac{d\ln K}{d\ln t}) - (\frac{\partial \ln Q}{\partial \ln L} \cdot \frac{d\ln L}{d\ln t}) - (\frac{\partial \ln Q}{\partial \ln E} \cdot \frac{d\ln E}{d\ln t}) - (\frac{\partial \ln Q}{\partial \ln M} \cdot \frac{d\ln M}{d\ln t}) - (\frac{\partial \ln Q}{\partial \ln S} \cdot \frac{d\ln S}{d\ln t}) \quad (2)$$

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:

$$\frac{\partial \ln Q}{\partial K} = \frac{P_K K}{P_K K + P_L L + P_E E + P_M M + P_S S} \quad (3)$$

where

P_K = Price of Capital
P_L = Price of Labour
P_E = Price of Intermediate Energy Inputs
P_M = Price of Intermediate Materials Inputs
P_S = Price of Intermediate Purchased Services Inputs

The assumption of constant returns to scale ensures that the factor shares for all inputs sum to one:

$$V_K + V_L + V_E + V_M + V_S = 1 \quad (4)$$

In discrete time, the input weights are two-year averages of the cost shares for each input in years t and t - 1, where $\tilde{v} = \frac{1}{2}v_{\mathrm{i,t}} + \frac{1}{2}v_{\mathrm{i,t\text{-}1}}$.
All of this information can be combined to rewrite MFP growth for an industry as the residual difference between growth in output and growth in the combined inputs:

$$\triangle MFP = \triangle \ln Q - \tilde{v}_K \triangle \ln K - \tilde{v}_L \triangle \ln L - \tilde{v}_E \triangle \ln E - \tilde{v}_M \triangle \ln M - \tilde{v}_S \triangle \ln S \quad (5)$$

Finally, it is worth noting that the above production function applies at the level of each industry. That is, individual industries face industry-specific output and input prices and these are reflected in the growth accounting model.

The MFP index is computed by dividing an index of real gross output by an index of combined real inputs. The combined index of real inputs is computed using a Tornqvist index number formula to aggregate real intermediate inputs by industry for energy, materials, and purchased services, real labour input, and real capital input weighted by average cost shares.

The above framework describes the approach to measuring the industry-level sources of growth, but an important objective of this article is to construct aggregate measures from the

bottom up. To aggregate the sources of growth by industry to economy-wide totals we use the "direct aggregation" approach discussed in (Jorgenson, Ho, and Stiroh, 2005). The details of the direct aggregation approach are beyond the scope of this article, but the basic idea is to weight the industry-level input and MFP contributions by "Domar" weights. Direct aggregation across industries can be expressed with the following formula:

$$\begin{aligned} \triangle \ln V = \Sigma_j (\frac{\tilde{y}_j}{\tilde{w}_v j}) \tilde{w}_K j \triangle \ln K_j \\ + \Sigma_j (\frac{\tilde{y}_j}{\tilde{w}_v}) \tilde{w}_L \triangle \ln L_j \\ + \Sigma_j (\frac{\tilde{y}_j}{\tilde{w}_v}) \triangle \ln MFP_j \end{aligned} \quad (6)$$

where $\triangle \ln V$ is aggregate value-added growth. The right-hand side decomposes this to the weighted sum of the contributions of capital, labour, and MFP growth by industry. For completeness: $\tilde{y}_{\mathrm{j}}$ is nominal value added in industry j as a share of aggregate value added and $\tilde{w}_{\mathrm{vj}}$ is the value added share in gross output in industry j. The other terms are defined as in Equation 5; and the tilde indicates average share in period t and t-1. All of the equations are implemented for each individual year in the time series.[4]

Data

A main objective of this article is to implement the above framework in a way that is consistent with the U.S. national accounts. That is, the sources of growth from the bottom up across industries and factors of production should be consistent with the GDP accounts. In this section, we briefly describe the basic data sources and how we make them internally consistent so that components "add up" to the official GDP estimates. The growth accounting framework requires industry-level data on gross output, intermediate inputs, capital, and labour in current and constant prices. Details on the data construction and the new estimates constructed are given in the Appendix.[5]

Data on industry gross output and intermediate inputs by industry are drawn from BEA's GDP by Industry statistics, thus are consistent with the GDP accounts by construction. That is, in equation (5), $\triangle \ln V$ comes directly from the official GDP by industry statistics. Only total intermediate is published in the industry ac-

4 That is, for each t from 1987 to 2016. This can be contrasted to obtaining a growth rate from 1987 to 2016 using only these two years of data.

5 Available at: http://www.csls.ca/ipm/36/Garner_etal_appendix.pdf).

counts. The Appendix describes work to split total intermediate into energy, materials, and services such that they add back up to the published total intermediate inputs. Because the output and intermediate input data that we use to implement equation (5) is consistent with the GDP accounts, industry value added, which is constructed by double deflation, is also consistent with the industry accounts; and when we sum (appropriately weighted) value added contributions across industries, we obtain aggregate value added growth that is consistent with the official U.S. accounts.

Capital inputs by industry come primarily from the BLS Productivity Program. Capital services conceptually measure the service flow from capital assets. A central notion in the construction of capital measures is the concept of "productive" capital stock, or the stock measured as "efficiency units." Conceptually, productive stock represents the amount of new investment required to produce the same capital services actually produced by existing assets of all vintages. Thus, capital services are assumed to be proportional to productive stock at the asset level by industry. To construct industry-level measures of capital input, each asset is weighted by its share of capital compensation, i.e. share in capital income. These shares are estimated as the price of capital input by asset times its productive stock divided by the total capital income in the industry. The price of the capital input is estimated by the user cost method used by the BLS Productivity Program. To ensure consistency between the BLS capital input data, and the BEA GDP by industry data, the account constructed uses the quantity of capital input from the BLS productivity program for each industry, and the capital compensation underlying the integrated BEA-BLS production account.

Labour inputs combine hours data from the BLS and a labour composition adjustment from the BEA. In order to create a constant quality index of labour input, hours worked are weighted to account for substitution between heterogeneous types of labour. The need for this adjustment reflects the assumption that the marginal product of a skilled worker is higher than that of an unskilled worker, implying that replacing hours worked by an unskilled worker with an equal number of hours worked by a skilled worker will increase economic output without an increase in MFP. Given the framework described above, it is important to capture the change in the characteristics of the workforce as a change in labour input, or a change in the composition of labour

input would manifest as an increase in MFP. This change in labour input due to shifts in worker characteristics is referred to as the labour composition effect.

In addition to the new historical data, this new dataset includes revised data for 1997-2015 and new estimates for 2016. Minor revisions throughout this period are due to the incorporation of updated data on capital and labour inputs from the BLS productivity program published on March 21, 2018. In addition, revisions in 2014 and 2015 reflect BEA's annual update to the industry accounts published on November 2, 2017.

Finally, it is worth noting why the data covers 1987-2016 when BEA's GDP by Industry accounts data covers 1947-2016. The primary reason for this is that a significant amount of additional detail is necessary to estimate the production account and this underlying data are not available at the time of writing. For example, labour and capital compensation controls are not available before 1987. The Current Population Survey (CPS) micro data that are used to estimate the labour composition are not available before 1964, and the sector detail available in the BEA GDP by Industry data is more limited before 1964 as well. Future work will examine extending the data before 1987.

Results

The major advantage of the longer time series of integrated KLEMS (K-capital, L-labour, E-energy, M-materials, and S-purchased services) data is that it permits analysis of longer-term economic trends. The description of these trends is what we focus on in the presentation of our results.[6] Over the last three decades, this includes the information technology (IT) revolution and increased globalization of the production process. The dataset described above is an important tool for identifying the structural change that has taken place between 1987 and 2016, particularly at the industry level. This section describes industry-level sources of growth, including the industry-level contributions of capital, labour, and multifactor productivity to economic growth, as well as some aspects of structural change over this longer time period. To facilitate this discussion, results are mainly focused on nine sectors that reflect major industry groupings, rather than the 63 in-

6 The dataset that we use is posted here: https://www.bea.gov/data/special-topics/integrated-industry-level-production-account-klems so that alternative decompositions can be calculated with the publicly available data.

7 This is the same industry classification used by Jorgenson and Schreyer (2013).

Table 1: Sources of Industry Output Growth in the United States, 1987-2016

	Output Growth	Capital Contribution	Labor Contribution	Intermediate Contribution	MFP Growth
Farms	1.69	0.09	-0.18	0.37	1.42
Forestry, fishing, and related activities	0.11	0.42	0.99	-0.49	-0.81
Oil and gas extraction	1.29	-0.08	-0.08	0.06	1.40
Mining, except oil and gas	0.39	0.39	-0.25	-0.51	0.77
Support activities for mining	1.46	0.21	0.45	-0.56	1.36
Utilities	0.31	0.74	0.03	0.05	-0.50
Construction	0.39	0.21	0.52	0.34	-0.68
Wood products	0.15	0.06	-0.24	0.58	-0.24
Nonmetallic mineral products	0.20	0.14	-0.07	0.05	0.08
Primary metals	0.49	-0.07	-0.30	0.18	0.68
Fabricated metal products	1.18	0.18	0.05	0.99	-0.04
Machinery	1.09	0.30	-0.04	1.00	-0.18
Computer and electronic products	6.56	0.56	-0.49	0.53	5.96
Electrical equipment, appliances, and components	0.14	0.17	-0.39	0.13	0.23
Motor vehicles, bodies and trailers, and parts	2.55	0.24	0.02	1.76	0.52
Other transportation equipment	1.04	0.23	-0.28	1.37	-0.28
Furniture and related products	0.16	0.16	-0.33	0.33	0.00
Miscellaneous manufacturing	1.75	0.46	0.21	0.41	0.67
Food and beverage and tobacco products	1.10	0.25	0.09	0.93	-0.17
Textile mills and textile product mills	-1.90	-0.10	-0.85	-1.44	0.49
Apparel and leather and allied products	-2.95	0.00	-1.74	-1.75	0.54
Paper products	-0.25	0.09	-0.29	0.17	-0.21
Printing and related support activities	-0.77	0.01	-0.53	-0.75	0.51
Petroleum and coal products	0.85	0.10	-0.07	0.00	0.81
Chemical products	1.29	1.12	-0.01	0.71	-0.53
Plastics and rubber products	1.37	0.29	0.02	0.71	0.35
Wholesale trade	3.31	1.12	0.43	0.82	0.94
Retail trade	2.93	0.86	0.37	0.78	0.91
Air transportation	0.99	0.40	0.05	-0.03	0.57
Rail transportation	1.04	0.07	-0.73	0.60	1.10
Water transportation	2.58	0.04	0.33	1.13	1.08
Truck transportation	2.89	0.35	0.49	1.73	0.31
Transit and ground passenger transportation	1.60	0.41	1.05	0.57	-0.42
Pipeline transportation	-0.44	1.12	0.03	-2.43	0.84
Other transportation and support activities	2.85	0.02	1.35	2.04	-0.56
Warehousing and storage	5.91	0.30	2.03	2.15	1.44
Publishing industries, except internet (includes software)	3.31	0.90	0.07	0.95	1.38
Motion picture and sound recording industries	2.45	1.40	0.57	0.68	-0.19
Broadcasting and telecommunications	4.77	1.90	0.00	2.29	0.58
Data processing, internet publishing, and other information services	7.12	2.58	1.09	3.62	-0.17
Federal Reserve banks, credit intermediation, and related activities	1.52	1.87	0.30	0.68	-1.33
Securities, commodity contracts, and investments	6.49	0.15	1.06	3.19	2.10
Insurance carriers and related activities	2.77	1.27	0.49	0.64	0.37
Funds, trusts, and other financial vehicles	2.78	0.11	0.07	2.35	0.26
Real estate	2.72	1.39	0.06	0.94	0.33
Rental and leasing services and lessors of intangible assets	3.63	3.99	0.18	1.73	-2.27
Legal services	0.92	0.68	0.68	0.78	-1.22
Computer systems design and related services	7.98	0.18	4.53	2.51	0.77
Miscellaneous professional, scientific, and technical services	3.69	0.80	1.38	1.64	-0.13
Management of companies and enterprises	3.06	0.29	1.57	2.27	-1.07
Administrative and support services	4.66	0.76	1.77	2.01	0.12
Waste management and remediation services	2.67	0.32	1.00	1.75	-0.41
Educational services	2.96	0.22	1.45	1.53	-0.23
Ambulatory health care services	3.35	0.22	1.79	1.58	-0.24
Hospitals and Nursing and residential care	2.77	0.26	1.15	1.86	-0.51
Social assistance	3.69	0.10	2.53	1.60	-0.54
Performing arts, spectator sports, museums, and related activities	3.73	0.08	1.19	1.86	0.61
Amusements, gambling, and recreation industries	3.68	0.68	1.03	1.79	0.18
Accommodation	2.11	0.69	0.28	0.84	0.30
Food services and drinking places	2.28	0.18	0.62	1.23	0.25
Other services, except government	1.74	0.43	0.51	1.10	-0.29
Federal	0.72	0.37	-0.17	0.46	0.07
State and local	1.90	0.45	0.64	0.73	0.08

Notes: Average annual log growth rate in percentage points. A contribution is a share-weighted log growth rate. Aggregate value added growth is the aggregate of share weighed industry value added growth. Sector aggregates are the sum of contributions over the underlying industries. A contribution in individual year t uses the log growth rate in period t and the average of the nominal shares in year t and t-1, and these contributions are then averaged over the sample periods presented in this table.
Source: Authors' calculations.

dustries described above.[7]

Industry-level sources of output growth for the entire 1987-2016 are shown in Table 1. Over this period, the three fastest growing industries were IT: computer systems design; data processing, internet publishing, and other information services; and computer and electronic products manufacturing, reflecting not only the importance of IT hardware, but also the related systems development and the shift towards cloud computing. The textile and paper manufacturing industries contracted over the period.

Since the Great Recession, imports in these industries have shown robust growth, likely reflecting increased competition from foreign products and other shifts in demand toward cheaper substitutes. Relatively strong growth in rental and leasing; broadcasting and telecommunications; and data processing was driven by capital investments, while growth in computer systems design; social assistance; and warehousing and storage was driven by growth in labour inputs, reinforcing the importance of looking at the input side when analyzing the sources of growth. Between 1987 and 2016, the computer and electronic products; securities, commodity contracts, and investments; and warehousing and storage had the largest growth in MFP.

Table 2 presents sector contributions to aggregate value-added growth and shows many familiar facets of economic growth over the last 30 years. Between 1987 and 2016, manufacturing contributed 0.34 percentage point to aggregate value-added growth of 2.38 per cent per year on average. The importance of including the new historical data is evident in this table because this contribution was skewed heavily towards the first part of the period; manufacturing contributed 0.45 percentage point to growth between 1987-95 and 0.84 percentage point during the IT-Investment boom of 1995-2000 and has fallen off since.

Between 2000 and 2007 manufacturing contributed 0.32 percentage point to aggregate growth and -0.01 between 2007 and 2016. Importantly, the manufacturing sector includes the relatively rapidly growing computer and electronic industry; excluding this industry the contribution of manufacturing to aggregate growth was 0.20 percentage point in 1987-95 and -0.08 percentage point in 2007-2016. Over the same period, value added generated by services industries increased in importance. In particular, the information industries; finance, insurance, real estate, rental and leasing; and other services accounted for about 46 per cent of real economic growth in the 1987-1995 period and 74 per cent of real growth in

Table 2: Sector Contributions to Aggregate Value-Added Growth in the United States

	1987-2016	1987-1995	1995-2000	2000-2007	2007-2016	2007-2009	2009-2016
				Contributions			
Value-Added	2.38	2.65	4.22	2.34	1.14	-1.56	1.91
Agriculture, Forestry, Fishing, Hunting, Mining	0.08	0.04	0.05	0.06	0.14	0.25	0.11
Transportation, Warehousing, Utilities	0.07	0.16	0.10	0.02	0.02	-0.17	0.08
Construction	0.00	0.03	0.13	-0.04	-0.06	-0.48	0.06
Manufacturing	0.34	0.45	0.84	0.32	-0.01	-0.64	0.18
Computer and electronic products	0.24	0.25	0.62	0.17	0.07	0.09	0.06
Trade	0.41	0.54	0.90	0.33	0.09	-0.61	0.29
Information	0.20	0.17	0.20	0.30	0.14	0.03	0.17
Finance, Insurance, Real Estate, Rental and Leasing	0.50	0.46	0.89	0.57	0.27	0.02	0.34
Other Services	0.57	0.60	0.89	0.49	0.44	-0.12	0.60
Government	0.19	0.20	0.21	0.28	0.11	0.17	0.09
				Shares			
Shares in Nominal Value-Added	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, Forestry, Fishing, Hunting, Mining	2.7	2.6	2.1	2.4	3.3	3.2	3.3
Transportation, Warehousing, Utilities	4.7	5.3	4.8	4.3	4.3	4.3	4.4
Construction	4.0	3.9	4.1	4.6	3.7	4.0	3.6
Manufacturing	13.9	16.7	15.4	12.7	11.6	11.6	11.6
Computer and electronic products	1.7	1.9	2.1	1.5	1.5	1.5	1.5
Trade	11.9	12.5	12.7	11.8	11.2	11.1	11.2
Information	4.6	4.5	4.7	4.7	4.5	4.7	4.5
Finance, Insurance, Real Estate, Rental and Leasing	18.6	17.5	18.5	19.3	19.0	18.6	19.1
Other Services	23.0	20.8	22.5	23.4	24.8	24.6	24.8
Government	16.7	16.2	15.3	16.9	17.6	17.8	17.5

Notes: Average annual log growth rate in percentage points. A contribution is a share-weighted log growth rate. Aggregate value added growth is the aggregate of share weighed industry value added growth. Sector aggregates are the sum of contributions over the underlying industries. A contribution in individual year t uses the log growth rate in period t and the average of the nominal shares in year t and t-1, and these contributions are then averaged over the sample periods presented in this table.
Source: Authors' calculations.

the 2007-2016 period.

The bottom portion of table 2 includes the nominal value-added shares of each of the major sectors and conveys a similar story. The nominal value-added share encompasses payments to labour and capital services and shows how income is distributed throughout the economy. Factors of production in the manufacturing sectors earned 16.7 per cent of aggregate income in 1987-1995, but only 11.6 per cent of income in 2009-2016, reflecting the overall decline in the share of manufacturing in the economy. Other services produced 20.8 per cent of income between 1987 and 1995, but this increased to 24.8 per cent over the 2009-2016 period. The value-added share in finance, insurance, real estate, rental and leasing also increased, from 17.5 per cent in the early periods to about 19.0 per cent in the later period.

Table 3: Contributions of Capital and Labour Input and Multifactor Productivity by Sector to Aggregate Value-Added Growth in the United States

	1987-2016	1987-1995	1995-2000	2000-2007	2007-2016	2007-2009	2009-2016
			Capital Input				
Aggregate	1.19	1.25	1.91	1.35	0.62	0.64	0.61
Agriculture,Forestry,Fishing, Hunting,Mining	0.01	0.00	0.00	0.00	0.03	0.01	0.04
Transportation, Warehousing, Utilities	0.04	0.04	0.05	0.03	0.04	0.03	0.04
Construction	0.02	0.01	0.05	0.05	-0.01	-0.02	-0.01
Manufacturing	0.14	0.17	0.26	0.07	0.11	0.13	0.10
Trade	0.17	0.17	0.31	0.22	0.08	-0.02	0.10
Information	0.14	0.13	0.22	0.13	0.09	0.10	0.09
Finance, Insurance, Real Estate, Rental and Leasing	0.42	0.49	0.70	0.52	0.11	0.12	0.11
Other Services	0.16	0.16	0.24	0.20	0.09	0.15	0.07
Government	0.10	0.09	0.08	0.13	0.09	0.15	0.07
			Labour Input				
Aggregate	0.76	1.09	1.33	0.43	0.40	-1.30	0.88
Agriculture, Forestry, Fishing, Hunting, Mining	0.00	-0.01	-0.01	0.02	0.01	-0.03	0.02
Transportation, Warehousing, Utilities	0.03	0.07	0.04	0.00	0.03	-0.07	0.06
Construction	0.04	0.04	0.16	0.07	-0.04	-0.40	0.06
Manufacturing	-0.04	0.07	0.03	-0.21	-0.04	-0.41	0.06
Trade	0.07	0.13	0.12	0.04	0.02	-0.20	0.08
Information	0.01	0.04	0.11	-0.05	-0.01	-0.08	0.01
Finance, Insurance, Real Estate, Rental and Leasing	0.07	0.07	0.16	0.08	0.02	-0.15	0.07
Other Services	0.48	0.60	0.61	0.39	0.39	-0.06	0.52
Government	0.08	0.09	0.11	0.10	0.03	0.11	0.01
			MFP				
Aggregate	0.43	0.31	0.98	0.55	0.13	-0.90	0.42
Agriculture, Forestry, Fishing, Hunting, Mining	0.07	0.06	0.07	0.04	0.10	0.27	0.05
Transportation, Warehousing, Utilities	0.00	0.05	0.01	0.00	-0.04	-0.13	-0.02
Construction	-0.06	-0.02	-0.09	-0.15	-0.01	-0.06	0.01
Manufacturing	0.24	0.21	0.55	0.46	-0.07	-0.36	0.01
Trade	0.17	0.24	0.47	0.08	0.00	-0.39	0.11
Information	0.05	0.00	-0.13	0.22	0.06	0.02	0.08
Finance, Insurance, Real Estate, Rental and Leasing	0.01	-0.10	0.03	-0.03	0.14	0.05	0.16
Other Services	-0.07	-0.16	0.04	-0.10	-0.04	-0.21	0.01
Government	0.02	0.02	0.02	0.04	-0.01	-0.10	0.01
Aggregate Value Added Growth	2.38	2.65	4.22	2.34	1.14	-1.56	1.91

Notes: Average annual log growth rate in percentage points. A contribution is a share-weighted log growth rate. Aggregate value added growth is the aggregate of share weighed industry value added growth. Sector aggregates are the sum of contributions over the underlying industries. A contribution in individual year t uses the log growth rate in period t and the average of the nominal shares in year t and t-1, and these contributions are then averaged over the sample periods presented in this table.
Source: Authors' calculations.

Table 3 shows the sector-level sources of growth. Over the entire period, growth in capital input was the predominant source of economic growth, followed by growth of labour input and then growth in MFP. Growth in capital input in the finance and trade industries accounted for about half of the total contribution of capital input. However, breaking down the contributions of capital growth across the time periods reveals important differences between the sources of growth in the later period (2009-2016) in relation to the earlier period (1987-1995). The choice of periods to compare is somewhat arbitrary, but comparisons of the 2009--2016 period to the 1987-1995 period reveal the extent and sources of the slow recovery after the financial crisis, even in comparison to the slow growth period before the IT investment boom. The most striking difference is in the contribution from the finance, insurance, real estate, rental and leasing which fell from 0.49 percentage point between 1987-1995 to 0.11 percentage point in 2009-2016; this mostly reflects the lingering effects of the housing crisis in the real estate sector. The only sector to have a larger contribution of capital input in the 2009-2016 period was the agriculture, forestry, fishing, hunting, mining sector, emphasizing the overall slowdown in capital investment in the recovery period.

More than half of the contribution of labour input over the entire period was accounted for by growth in labour input in the other services industries. Comparing the contribution of labour input by sector in the later period to the earlier period is not particularly illuminating, but we will see below that the industry data reveal significant shifts in the distribution of labour income by sector.

Finally, growth in MFP was dominated by MFP growth in manufacturing (mostly computers and electronic products) and the trade sectors over the 1987-2016 time period. MFP growth in manufacturing was much faster in the 1987-1995 period than in the 2009-2016 period. In contrast, the MFP contributions of the finance, insurance, real estate, rental and leasing and the other services industry were significantly higher in the later period.

It is worth summarizing a few of the main trends that the 1987-2016 KLEMS data reveal. Over this period, output growth shifted from manufacturing to services, and income shares shifted as well. Economic growth during the period of the ongoing recovery from 2009-2016 was significantly slower than the 1987-1995 period before the IT boom; this was driven mostly by slower capital and labour input growth. MFP growth was actually faster in the 2009-2016

period in comparison with the 1987--1995 period. The growth in other services was driven mostly by labour input growth and a recovery of MFP from negative early in the period to slightly positive towards the end of the period.

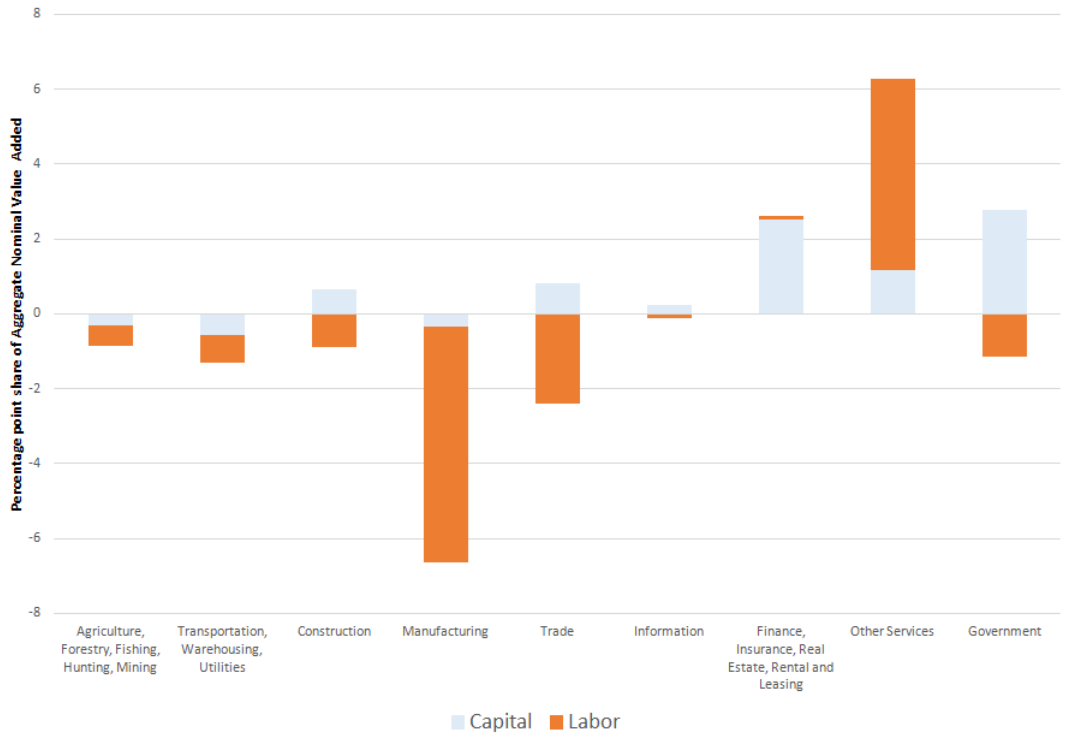
We now focus on one particular component of structural change over the last 30 years: the industry sources of the change in the distribution of income. It is relatively well known that the share of value added accruing to labour has been in decline. We present new information on the industry sources of this decline with the charts. Each component of income (whether it is total labour income, or college-educated labour, for example) is presented as a share of nominal aggregate value added.

Chart 1 shows the change in the share of capital and labour by sector in nominal aggregate value added. To reinforce the concepts, for this and the subsequent figures, the shares are defined as compensation to the factor of production in each sector divided by aggregate nominal value added. Over the 1987-2016 period, the aggregate total economy capital share increased from 38.6 per cent of income in 1987 to 45.5 per cent of income in 2016. Chart 1 indicates that this shift was not proportionate across sectors. For example, while the income share paid to labour generated in the manufacturing sector fell by a significant margin, it increased by almost as much in the other services sector. Thus, the shift in output from manufacturing to other services actually counterbalanced the aggregate trend of a falling labour share. In the trade sector, the share of aggregate income accruing to capital increased while that accruing to labour fell, providing evidence that an industry's expansion does not necessarily produce proportional gains for labour and the owners of capital.

Charts 2 and 3 provide more information on the changes in the share of aggregate income accruing to labour by sector. Chart 2 shows that even though the aggregate labour share fell over the period, the share of income accruing to college-educated labour (those with a Bachelor of Arts degree and above) increased significantly over the period, so that the decline in the aggregate labour share was entirely due to a decline in the share of income paid to workers without a college degree.

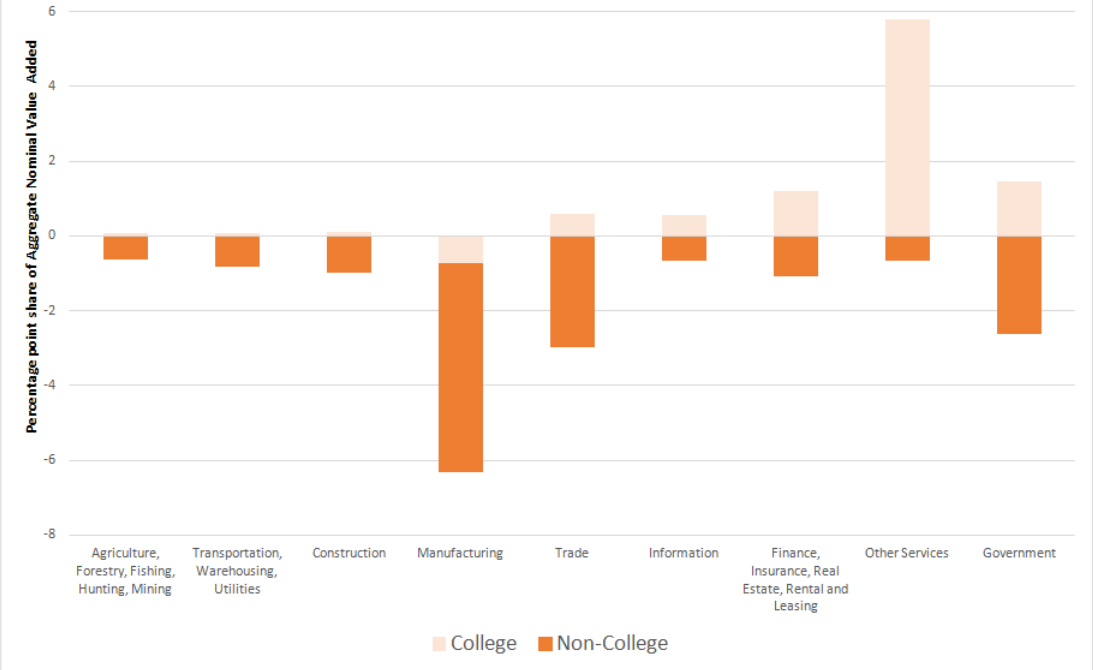
Chart 3 presents the decomposition by gender. Over the period, the share of income accruing to men fell from 44.2 per cent to 36.6 per cent between 1987 and 2016. This was driven mainly by large declines (relative to women) in the manufacturing, trade, and government sectors. With the shift towards services, the shares of in-

Chart 1: Changes in the Input Shares of Aggregate Value Added in the United States, 1987-2016



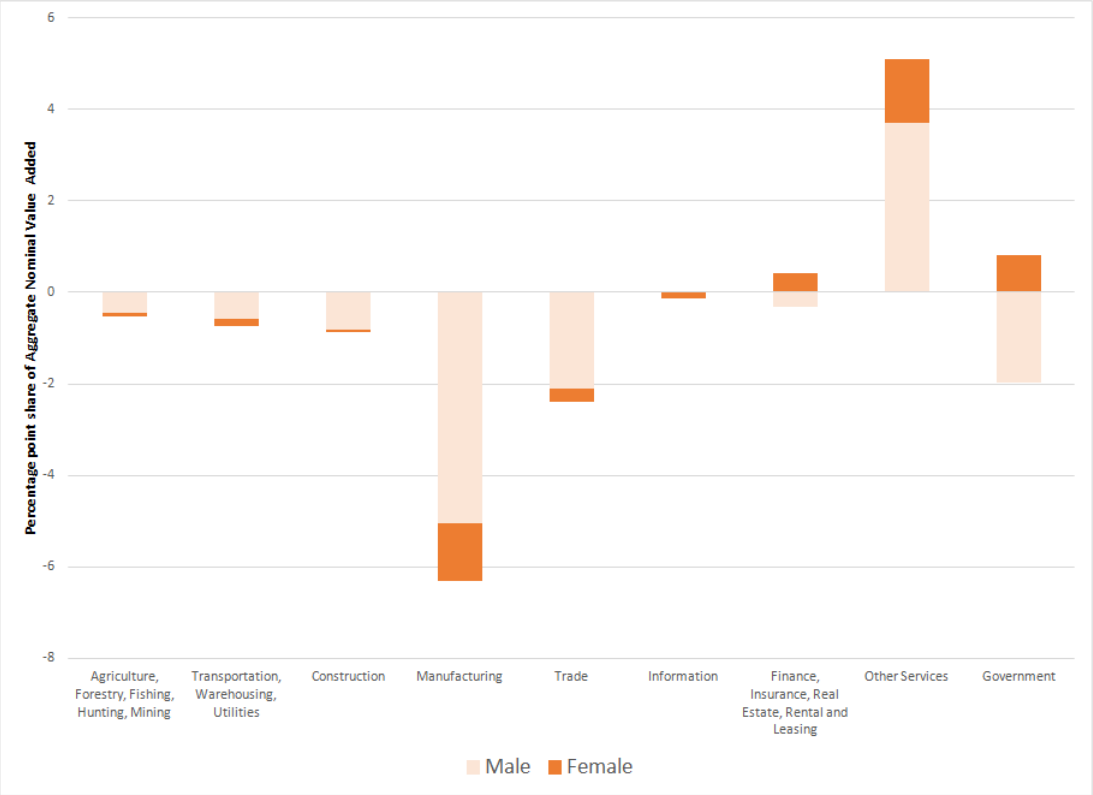
Source: Authors' calculations.

Chart 2: Changes in the Labour Shares of Aggregate Value Added in the United States, 1987-2016



Source: Authors' calculations.

Chart 3: Changes in the Labour Shares of Aggregate Value Added in the United States, 1987-2016



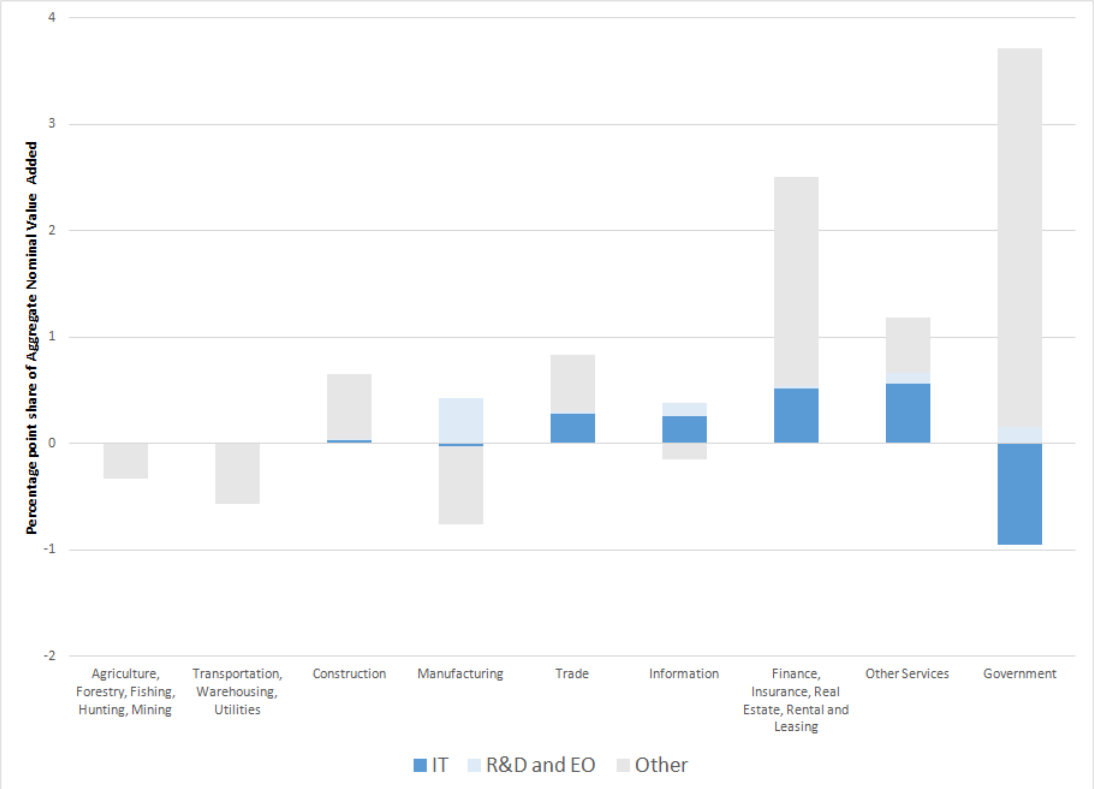
Source: Authors' calculations.

come paid to both men and women in the services sector increased, and the service sector was the largest driver of increase in the aggregate share of income paid to female workers. This is interesting in light of the findings in Ngai and Petrongolo (2017) that the shift to services has narrowed the gender pay gap.[8]

The change in the capital share was not proportionate across industries and types of capital. For example, chart 4 shows significant increases to the share of income paid to capital in the finance, insurance, real estate, rental and leasing well as in the other services sectors. Within these sectors, a significant portion of the increase was attributed to the share of IT capital. In contrast, in the construction and manufacturing sectors, there was little change in the share of aggregate income paid to IT capital. In the manufacturing sector, the share of capital income attributed to research and development actually increased, thus the decline in the overall capital income share in manufacturing

8 The finding of Ngai and Petrongolo (2017) focuses on wage rates, while the information that presented here is about aggregate income shares. While they are not directly comparable, both suggest that shift to services is an important component in how wages and income have evolved.

Chart 4: Changes in the Capital Shares of Aggregate Value Added in the United States, 1987-2016



Source: Authors' calculations.

was driven by a decrease in the share of income accruing to other types of capital.

Conclusion

The purpose of this article was to present an extended time series of integrated KLEMS-based production accounts for the United States. The longer time series yields important data on the evolution of U.S. economic growth over the last three decades. The account shows the shift from manufacturing towards services and the importance of isolating the effects of the computer and electronics product industry when studying the overall manufacturing sector (Houseman, 2018). The KLEMS approach shows not only which industries are contributing to growth, but the industry-level sources of growth. The most important source of economic growth over the period was the accumulation of capital input. Of the 1.19 percentage point that capital input contributed to growth over the period, the services industries account for 0.89 percentage point. Aggregate labour input accounted for another 0.76 percentage point of economic growth between 1987 and 2016. Of this, the other services industries

sector alone accounted for 0.48 percentage point, demonstrating the relative importance of labour in service producing industries. Finally, MFP growth accounted for 0.43 percentage point of aggregate economic growth. Almost all of this was accounted for by MFP growth in the manufacturing and trade sectors; within manufacturing almost all of the MFP growth was due to growth in MFP of the computer electronic products industry.

The account demonstrates the importance of structural change at the industry level in the evolution of the allocation of income between capital and labour. The share of aggregate income accruing to labour in the manufacturing sector shrank substantially over the period, while the share of income accruing to labour increased substantially in the services industries. In the manufacturing sector, this was mostly due to a decline in the share of income paid to workers without a college degree, while workers with a college degree accounted for the large majority of the increase in the income paid to labour in the service sectors.

The new estimates presented in this article are an important milestone because extending the account to cover 1987-1997 involved overcoming significant obstacles including the change in industrial classification between NAICS and SIC and changes in the reporting of educational attainment from years of school to attainment measures. However, this is not the final step in the development of the account. Important next steps could include extending the account even further back in time to span the entire period covered by BEA's GDP by industry accounts starting in 1947 and resolving existing difference in the measures of labour composition produced by BLS for the official MFP estimates and those produced by BEA for this set of accounts.

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