BEA BRIEFING

Integrated Historical Input-Output and GDP by Industry Accounts, 1947–1996

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THIS MONTH, the Bureau of Economic Analysis (BEA) released revised, fully integrated, historical statistics from the industry economic accounts (IEAs), spanning 1947–1996. The release brings to completion BEA's long-term goal of developing a fully integrated and consistent time series of IEA and national income and product account (NIPA) statistics. The revised statistics include data on real and nominal value added, intermediate inputs, and gross output for 46 industries for 1947–1962 and 65 industries for 1963–1996. In addition, the revised historical data extend the integrated time series of input-output (I-O) accounts back to 1947.[1]

Beginning with the release of the 2007 benchmark I-O accounts, the IEAs and the NIPAs were fully integrated and made consistent with one another for the first time.[2] These fully integrated statistics were first released on January 23, 2014, by BEA as part of the comprehensive revision of the IEAs and spanned 1997–2012.[3] Within the IEAs, this marked the first time that the benchmark I-O accounts were fully integrated with the annual time series of both the I-O accounts and the gross domestic product (GDP) by industry accounts. The IEAs were subsequently updated on November 13, 2014, and on November 5, 2015, to reflect results of the 2014 and 2015 annual revisions, respectively, which collectively spanned 1997–2014.

The benefits of fully integrated benchmark I-O accounts, annual industry accounts, and the NIPAs are numerous. For example, the benchmark I-O accounts establish both the levels and the commodity composition of GDP final use categories. This provides critical information for estimating NIPA GDP (by extrapolation) for periods following benchmark years. If the benchmark I-O account is inconsistent with the published NIPA statistics, then the accuracy of the extrapolated NIPA estimates may be affected. The integration also allows for a higher degree of consistency between the NIPAs and IEAs, which enables data users the ability to track time series trends in a NIPA final expenditure category at a detailed commodity level in benchmark years and at a slightly higher level of commodity aggregation for nonbenchmark years. Users interested in more detailed statistics on outputs, inputs, and value added at the industry level can crosswalk between a time series of benchmark statistics and a slightly higher level of industry aggregation for nonbenchmark years. Moreover these integrated statistics shed new light on structural changes in the U.S. economy over time, including business-cycle dynamics and changes due to economic globalization.

The final step in this full integration effort was to develop fully integrated historical IEA statistics, which BEA has recently completed. Revised and newly available historical annual estimates for GDP by industry and I-O accounts have been developed in a fully integrated framework to create a consistent set of industry statistics spanning 1947–2014.

The remainder of this article includes the following:

- A description of some of the more significant improvements to the historical statistics. Several notable improvements were incorporated with the most recent comprehensive revision of the IEAs, including the recognition of research and development (R&D) expenditures as capital.
- An analysis of newly available sector trends from the historical time series of I-O accounts. Analyzing the historical impact of the improvements for the first time in an I-O framework brings a unique perspective that will likely spur additional, future research.

1. Before this release, the historical time series included information on nominal and real value added for 22 industries for 1947–1986 and data on nominal and real value added, intermediate inputs, and gross output for 65 industries for 1987–1996. Integrated I-O tables were available only for 1997 forward.

2. For additional details, see Erich H. Strassner and David B. Wasshausen, "Preview of the 2013 Comprehensive Revision of the Industry Economic Accounts," SURVEY OF CURRENT BUSINESS 93 (June 2013): 19–33.

3. For additional details, see Donald D. Kim, Erich H. Strassner, and David B. Wasshausen, "Industry Economic Accounts: Results of the Comprehensive Revision, Revised Statistics for 1997–2012," SURVEY 94 (February 2014): 1–18.

Jennifer Lee and Edward T. Morgan contributed significantly to the development of the integrated, historical estimates. Special thanks to Dale W. Jorgenson, Mun Ho, and Jon D. Samuels for providing historical price statistics. Former BEA Industry directorate senior staff Mark A. Planting and Robert E. Yuskavage provided valuable contributions to the early work on integrating these statistics and supported the review and analysis of the final results. Louis E. Feagans prepared the tables and charts for this briefing.

- A discussion of industry contributions during expansions and contractions.
- An appendix that describes the methodology used to prepare these historical statistics.

Improvements

As noted, fully harmonizing historical benchmark and annual I-O time series, along with annual GDP by industry statistics and annual NIPA statistics ensures the most accurate and reliable statistics possible over the full time period, beginning with 1947.

In addition to achieving full integration throughout the entire period, other significant improvements from the 2013 comprehensive revision of the IEAs have been implemented into the historical time series. These improvements include the following:

- The incorporation of intellectual property products as capital investment, including R&D expenditures and the production costs associated with entertainment, literary, and other artistic originals.
- The expansion of the capitalization of the ownership transfer costs of residential fixed assets.
- The use of an improved measure of transactions for defined benefit pension plans.
- The use of the double-deflation method to calculate real value added as the difference between real gross output and real intermediate inputs.[4] Previously published statistics were prepared using a modified double-deflation methodology for 1987–1996, and single-deflation for years before 1987.

Overall, revisions to the historical GDP by industry statistics were minimal. The previously published trends, drivers of growth, and sources of contraction are largely unchanged. The primary highlight of the revised statistics reflects the incorporation of R&D as capital investment, which resulted in upward revisions to gross output and to value added, in particular for the manufacturing sector. Chemical products manufacturing (chart 1), computer and electronic products manufacturing (chart 2), and motor vehicles, bodies and trailers, and parts manufacturing (chart 3) were the industries that were most impacted by the introduction of intellectual property products as capital investment.[5]

4. Separately deflating gross output and intermediate inputs requires fewer assumptions about the relationships between gross output and intermediate inputs by industry thereby ensuring more accurate measures of real value added by industry.

5. This result is consistent with previously released trends for the period 1997 through the present, first introduced as part of the results of the 2013 comprehensive revision of the IEAs.

Sector Trends

Based on average shares by decade, services-producing industries show a steady increase in the share of current-dollar GDP throughout the historical time period, while goods-producing industries show a steady decline (table 1). Government's share of GDP increased from the 1940s through the 1970s, fell in the 1980s, and remained steady into the 1990s.

Chart 1. Value Added for Chemical Products Manufacturing

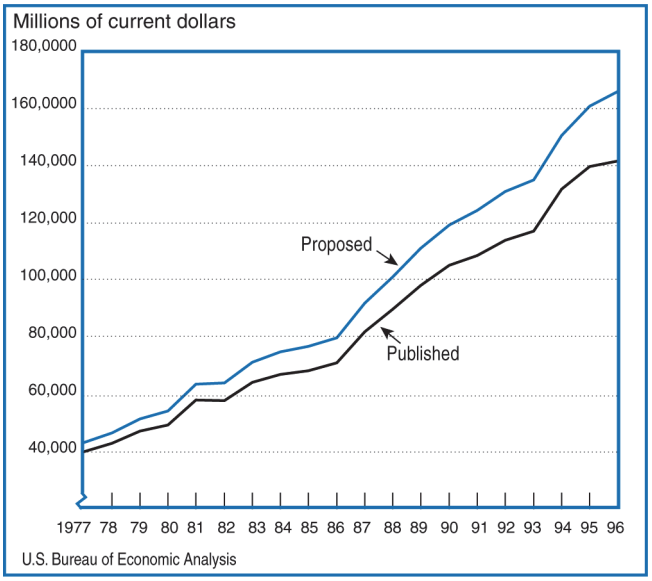
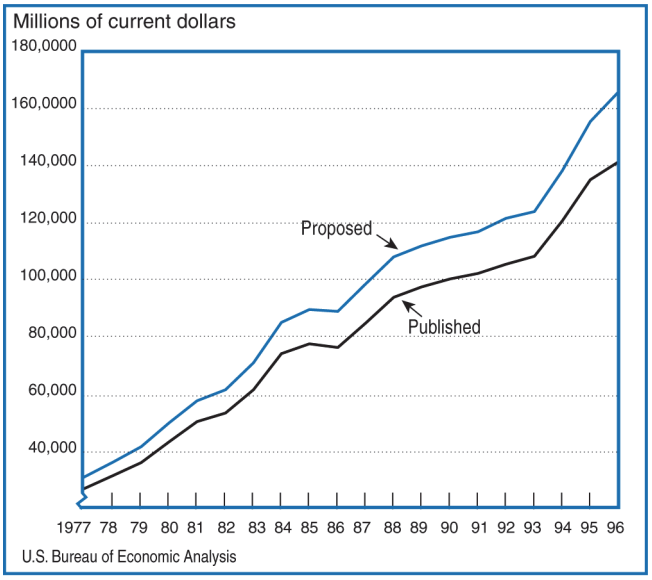


Chart 2. Value Added for Computer and Electronic Products Manufacturing



The largest increase in the services-producing sector's share of current-dollar GDP occurred in the 1980s, when its share increased 5.2 percentage points, from 53.2 percent to 58.3 percent. Most of this increase was accounted for by increases in finance, insurance, real estate, rental, and leasing (2.2 percentage points) and in professional and business services (2.0 percentage points). The increase in the share of finance, insurance, real estate, rental, and leasing reflected an increase in the real estate sector. The increase in the share of professional and business services reflected growth in miscellaneous professional, scientific, and technical services, which includes services that were much more likely to be outsourced, such as architectural, engineering, research and development (R&D), and management consulting. These types of services became more prevalent in the U.S. economy as part of the restructuring that accompanied the recovery from the recessions of the early 1980s.

Chart 3. Value Added for Motor Vehicles, Bodies and Trailers, and Parts Manufacturing

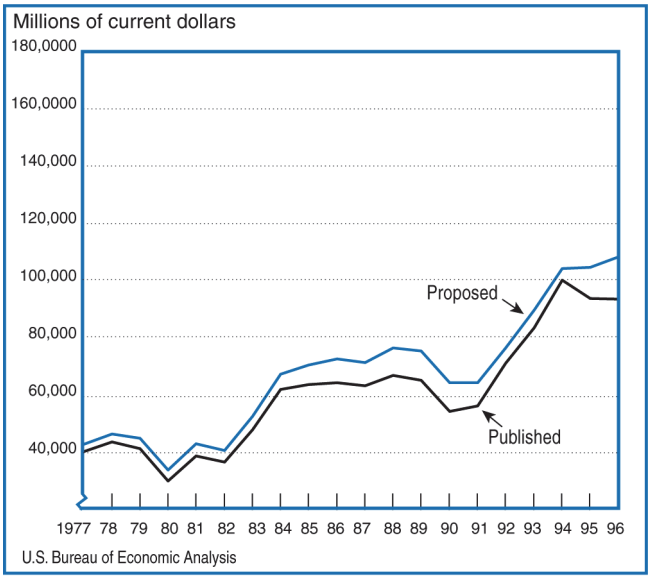


Table 1. Value Added by Industry Group in Current Dollars as a Percentage of Gross Domestic Product for Selected Years

	1947	1957	1967	1977	1987	1997
Gross domestic product	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Private industries	**86.5**	**86.0**	**84.3**	**84.9**	**85.7**	**86.7**
Agriculture, forestry, fishing, and hunting	8.0	3.9	2.7	2.5	1.6	1.3
Mining	2.3	2.3	1.4	2.1	1.5	1.1
Utilities	1.4	2.0	2.0	2.3	2.6	2.0
Construction	3.6	4.5	4.4	4.5	4.3	4.0
Manufacturing	25.4	26.9	25.3	21.9	18.1	16.1
Durable goods	13.1	16.2	15.7	13.4	11.0	9.6
Nondurable goods	12.3	10.7	9.6	8.5	7.1	6.5
Wholesale trade	6.2	6.0	6.3	6.5	5.9	6.2
Retail trade	9.3	7.7	7.5	7.7	7.1	6.8
Transportation and warehousing	5.7	4.8	3.8	3.7	3.1	3.0
Information	3.1	3.3	3.8	4.0	4.6	4.6
Finance, insurance, real estate, rental, and leasing	10.3	12.8	13.8	14.7	17.5	18.9
Professional and business services[1]	3.3	4.0	4.7	5.5	8.0	9.8
Educational services, health care, and social assistance	1.8	2.3	3.2	4.4	5.7	6.8
Arts, entertainment, recreation, accommodation, and food services	3.2	2.7	2.7	2.9	3.2	3.5
Other services, except government	3.0	2.8	2.7	2.3	2.5	2.7
Government	**13.5**	**14.0**	**15.7**	**15.1**	**14.3**	**13.3**
Addenda:						
Private goods-producing industries[2]	39.3	37.6	33.8	30.9	25.6	22.5
Private services-producing industries[3]	47.2	48.4	50.6	54.0	60.2	64.2

1. Consists of professional, scientific, and technical services; management of companies and enterprises; and administrative and waste management services.

2. Consists of agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing.

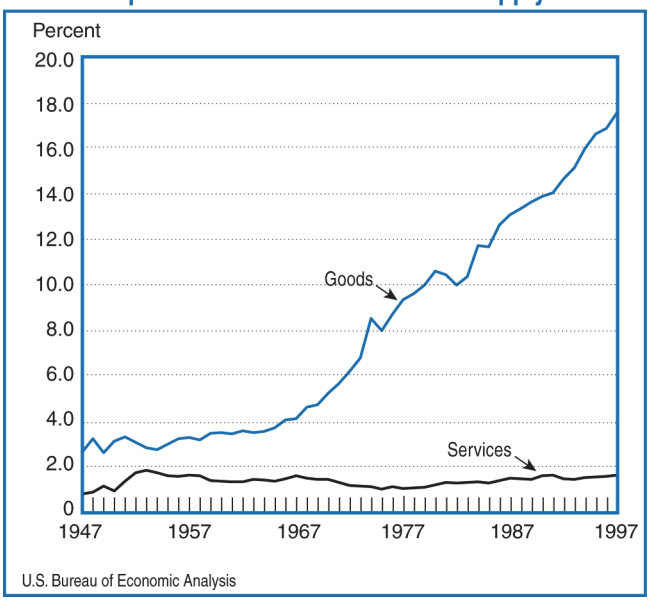
3. Consists of utilities; wholesale trade; retail trade; transportation and warehousing; information; finance, insurance, real estate, rental, and leasing; professional and business services; educational services, health care, and social assistance; arts, entertainment, recreation, accommodation, and food services; and other services, except government.

The new time series of I-O accounts also provides important insights into the impact of globalization on the U.S. economy. One measure of this impact is the changing share of the domestic supply of goods and services that is accounted for by imports (chart 4).[6] The newly released data show a sharp increase beginning in the 1970s in imported goods as a share of the total domestic supply of goods. The average share for all years in 1947–1969 was 3.4 percent. This value jumps to 7.8 percent in the 1970s, 11.7 percent in the 1980s, and 15.6 percent for 1990–1996. Over this same period, imported services as a share of the total domestic supply of services was essentially unchanged, averaging 1.4 percent for 1947–1970 and 1.3 percent for 1970–1996.

Another measure of the impact of globalization is the value of exports as a share of total domestic output

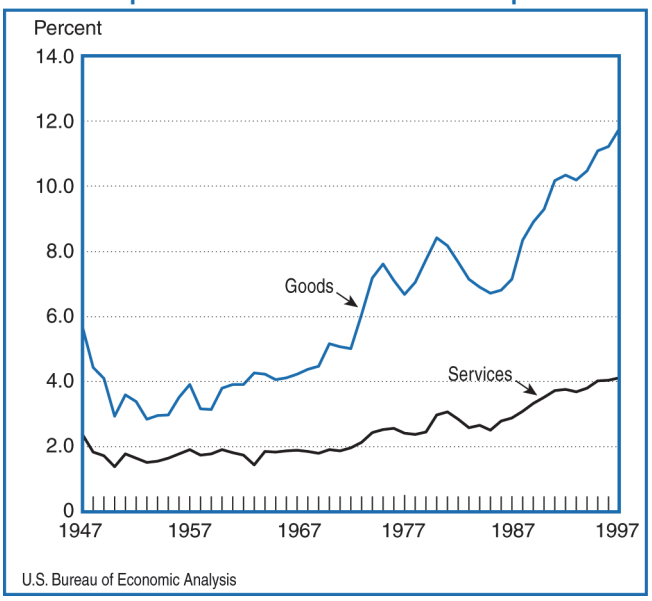
6. Domestic supply is the total amount of a good or service available for use by industry and government as intermediate inputs or by industry, government, and consumers as final consumption. Domestic supply for a good or service is calculated as domestic output plus imports less exports less change in private inventories.

Chart 4. Imports as a Share of Domestic Supply



(chart 5). In this case, both goods and services have shown notable increases over the historical period. For goods, the export share has more than doubled, from 3.8 percent in 1947–1969 to 6.5 percent in the 1970s, 7.6 percent in the 1980s, and 10.6 percent for 1990–1996. The services export share has also shown growth over the historical period, averaging 1.8 percent in 1947–1969 and rising to 2.3 percent in the 1970s, 2.9 percent in the 1980s, and 3.8 percent for 1990–1996. Goods exports make up the majority of exports throughout the historical time period; however, services exports have grown steadily in importance. Services exports averaged $7,444 million for 1947–1969 and accounted for 28.1 percent of total exports. By the 1990–1996 period, services exports averaged $282.5 billion and accounted for 39.0 percent of total exports.

Chart 5. Exports as a Share of Domestic Output



Expansions and Contractions

The revised historical GDP by industry statistics include value-added quantity indexes and price indexes that are calculated in a fully-integrated framework.

This section examines expansions in 1949–1953, 1954–1957, 1957–1963, 1963–1969, 1970–1973, 1975–1979, 1982–1990, and 1990–1997 and contractions in 1973–1975 and 1979–1982 (table 2). These time periods correspond closely to the expansion and contraction periods based on the business cycles identified by the National Bureau of Economic Research (NBER).

Expansions

The growth in real GDP in all expansion periods reflects growth in the private services-producing industries and the manufacturing sector. In all expansion periods, the private services-producing industries contributed more to real GDP growth than private goods-producing industries. All services industries included within the private-services producing sector contributed to growth during these periods.

The finance, insurance, real estate, rental and leasing industry group was the largest contributor to

Table 2. Contributions to Percent Change in Real Gross Domestic Product by Industry Group
Average Annual Rates of Change for Expansions and Contractions

[Percentage points]

	1949–53	1954–57	1957–63	1963–69	1970–73	1973–75	1975–79	1979–82	1982–90	1990–97
Gross domestic product[1]	**6.4**	**3.8**	**3.6**	**4.9**	**4.7**	**–0.4**	**4.7**	**0.1**	**4.1**	**3.0**
Private industries	**5.50**	**3.65**	**3.45**	**4.28**	**4.63**	**–0.48**	**4.24**	**–0.11**	**3.71**	**2.95**
Agriculture, forestry, fishing, and hunting	0.16	0.00	0.06	0.04	0.01	0.26	0.01	0.23	0.03	0.04
Mining	0.11	0.09	0.00	0.02	–0.01	–0.28	–0.07	–0.17	0.10	0.03
Utilities	0.12	0.08	0.07	0.11	0.07	0.04	–0.06	–0.01	0.08	–0.02
Construction	0.30	0.20	0.18	0.16	0.08	–0.30	0.19	–0.26	0.17	0.05
Manufacturing	2.04	0.83	0.77	1.54	1.58	–1.47	1.29	–0.68	0.85	0.64
Durable goods	1.37	0.32	0.38	1.00	1.16	–0.89	0.76	–0.61	0.58	0.48
Nondurable goods	0.67	0.51	0.40	0.54	0.42	–0.58	0.53	–0.07	0.27	0.15
Wholesale trade	0.23	0.32	0.32	0.36	0.63	0.28	0.48	0.18	0.34	0.39
Retail trade	0.37	0.32	0.17	0.27	0.39	0.02	0.30	–0.14	0.35	0.37
Transportation and warehousing	0.51	0.20	0.15	0.14	0.20	–0.02	0.18	–0.20	0.16	0.16
Information	0.31	0.26	0.25	0.25	0.19	0.16	0.38	0.15	0.16	0.16
Finance, insurance, real estate, rental, and leasing	0.70	0.59	0.78	0.76	0.71	0.69	0.77	0.65	0.51	0.54
Professional and business services[2]	0.30	0.30	0.27	0.30	0.30	0.01	0.39	0.06	0.53	0.30
Educational services, health care, and social assistance	0.21	0.25	0.23	0.19	0.22	0.15	0.15	0.06	0.18	0.11
Arts, entertainment, recreation, accommodation, and food services	0.10	0.08	0.07	0.08	0.16	0.02	0.15	0.00	0.13	0.10
Other services, except government	0.05	0.13	0.10	0.07	0.08	–0.03	0.09	0.02	0.12	0.08
Government	**1.02**	**0.22**	**0.47**	**0.67**	**0.09**	**0.20**	**0.17**	**0.11**	**0.36**	**0.08**
Addenda:										
Private goods-producing industries[3]	2.61	1.11	1.01	1.75	1.67	–1.79	1.42	–0.89	1.15	0.75
Private services-producing industries[4]	2.89	2.54	2.44	2.53	2.96	1.32	2.82	0.78	2.56	2.20

1. The estimates of gross domestic product are percent changes.
2. Consists of professional, scientific, and technical services; management of companies and enterprises; and administrative and waste management services.
3. Consists of agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing.
4. 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.

growth in 1954–1957 (0.59 percentage point), 1957–1963 (0.78 percentage point), 1975–1979 (0.77 percentage point), and 1990–1997 (0.54 percentage point). Despite the strong contributions of the services sector, durable-goods manufacturing was the largest contributor to growth in 1949–1953 (1.37 percentage point), 1963–1969 (1.00 percentage point), 1970–1973 (1.16 percentage point), and 1982–1990 (0.58 percentage point).

Contractions

In both sustained contraction periods, the private services-producing industries contributed to growth in real GDP, while private goods-producing industries subtracted from growth. In 1973–1975, the finance, insurance, real estate, rental, and leasing industry contributed 0.69 percentage points to the 0.4 percent decline in real GDP. That contribution was more than offset by the manufacturing sector (–1.47 percentage points). Within manufacturing, the nondurable-goods industry was the primary contributor to this decline.

In 1979–1982, the finance, insurance, real estate, rental, and leasing industry was again the leading contributor to the 0.1 percent growth in real GDP, contributing 0.65 percentage point. Manufacturing subtracted 0.68 percentage point from growth, primarily driven by a large decline in the contribution of durable-goods manufacturing.

Appendix: Methodology for Revised and Newly Available Statistics

Current-dollar estimates

The preparation of the time series of current-dollar I-O accounts used a five-step process. First, the 1947–1992 benchmark tables were updated to incorporate major definitional changes introduced during NIPA comprehensive revisions through the 2010 revision. Second, the benchmark accounts were converted to a 2002 NAICS industry and commodity basis to be consistent with the available time series of annual I-O and GDP by industry accounts as of May, 2010. Third, annual updates of the benchmark tables were prepared for all years between benchmarks. Fourth, the 2002 NAICS time series of annual I-O accounts for 1947–1996 was converted to a 2007 NAICS basis. Fifth, the major definitional and statistical improvements from the 2013 comprehensive revision of the IEAs were incorporated.

The benchmark accounts between the years 1947 and 1992 included industry descriptions that remained similar over time despite changes in the SIC during this period. Yet, these tables were not comparable because the benchmarks were not updated to reflect changes in definitions and other statistical revisions that were incorporated into the NIPAs. Consistency of these tables can be thought of as having three distinct periods: the 1947–1967 period, during which definitions remained relatively consistent through the publication of industry-by-industry "transactions" tables;[7] the 1972–1982 period, during which the United Nations recommended make-use format and industry classification based on the 1972 standard industrial classification (SIC) were adopted; and the 1987–1992 period, which was tabulated on the 1987 SIC.

Step 1. Update of historical benchmark tables to reflect consistency with NIPAs

The first step was to make the historical benchmark I-O accounts consistent in both definition and statistical vintage with the May 2010 release of the IEAs.[8] To ensure consistency of final expenditures at the most detailed level possible, "bridge" tables between the I-O accounts and the published NIPA category detail for personal consumption expenditures (PCE) and private fixed investment in equipment and software (PES) were required. PCE bridge tables were available for 1967–1997 and PES bridges for 1972–1997. Bridges for other years were backcasted. Bridges for all years were modified to follow a consistent structure across all years that matched published NIPA data. Major definitional and statistical changes introduced into these tables included:

- Government treated as a producer selling services to industries and households
- Statistical revisions to autos and trucks
- Statistical revisions to housing and housing services
- Changes to the output of insurance and banking
- Statistical revisions to non-profits
- Capitalization of purchased and own-account software

Step 2. Conversion to 2002 NAICS

The conversion of benchmark I-O accounts from SIC to NAICS required concordances based on the definitions and content of those industries and commodities for the respective year. However, the only

7. The tables showed the total supply of goods and services flowing between industries and final uses. The industry columns included production inputs plus comparable imports as well as secondary products of other industries that were primary to the industry. The industry rows showed the distribution of the total supply to industries and final uses. The row sum and the column sum for respective industries were identical.

8. For additional details, see Matthew M. Donahoe, Edward T. Morgan, Kevin J. Muck, and Ricky L. Stewart, "Annual Industry Accounts: Advance Statistics on GDP by Industry for 2009 and Revised Statistics for 1998–2008, Comprehensive Revision," SURVEY 90 (June 2010): 14–20.

available concordance between SIC and NAICS was for the year 1997. This concordance was updated to capture changes in industry structure over time by aggregating the most detailed SIC-based benchmark data available to a roughly three-digit NAICS level of detail. The conversion of make tables focused primarily on conversion of primary production with modification made after to adjust for secondary output. The conversion of the use tables relied on a two-step process: (1) detailed inputs that represented greater than 75 percent of industry output were assigned directly to the converted NAICS output from the make table; (2) inputs that reflected less than 75 percent of the industry output were distributed to two or more related industries.[9] These tables were then rebalanced to historical GDP by industry controls consistent with the results from the 2010 comprehensive revision of the IEAs for the respective benchmark years between 1947–1997 and to available NIPA final expenditure detail for each period using a biproportional scaling procedure.

Step 3. Annual updates of the benchmark accounts.

The benchmark Make and Use tables were interpolated to develop a series of unbalanced tables between benchmark tables spanning 1947–1997. A set of indicators were developed to extrapolate industry and commodity output, intermediate inputs, and final expenditures. Table 3 provides a summary list of indicators by industry. The modified Denton proportional first difference method was used for interpolation.[10] Unbalanced use tables were subject to adjustments to satisfy historical GDP by industry and NIPA final expenditure controls through the use of a biproportional scaling procedure.

Step 4. Conversion to 2007 NAICS

The conversion of the historical I-O accounts from a 2002 NAICS basis to a 2007 NAICS basis affected three sectors: (1) information (NAICS 51), (2) professional, scientific, and technical services (NAICS 54), and (3) administrative and support and waste management and remediation services (NAICS 56). Table 4 presents detailed 2002 NAICS industries matched to 2007 NAICS for the affected industries.

Beginning with the make table, output adjustments were constructed using a published concordance from the 2007 NAICS manual as well as analyst judgment.[11] Analyst judgement based on industry expertise was a critical component in this step because the working-level detail in the historical I-O tables is substantially less detailed than the working-level detail for 1997-forward. As a result, adjustments in the historical period reflect anecdotal information combined with industry expertise.

For example, important reclassifications affected Internet service providers (ISPs) within the information sector. Under 2002 NAICS, subsector 518 was defined as "Internet Service Providers, Web Search Portals, and Data Processing Services" but was redefined under 2007 NAICS to "Data Processing, Hosting, and Related Services." ISPs under 2007 NAICS were reclassified to subsector 517, "Telecommunications." This change reflects the fact that in the early 2000s, Internet service

9. The downside to this method is that 100 percent of the original input structure was not converted to a NAICS basis. However, the upside to this approach was it resulted in a more manageable input structure to review for consistency over time.

10. In the case of exports, imports, and change in business inventories, the interpolated values were scaled to the NIPA published levels. Exports and imports were adjusted on a net exports basis (extrapolated net export total was adjusted to the NIPA level by scaling both exports and imports excluding duty and the rest of the world adjustment).

11. For additional details on the concordance, see *North American Industry Classification System, United States, 2007.*

Table 3. Major Sources of Data Used as Indicators for Interpolation

Source	Description
Annual survey of manufactures (ASM)	An NBER researcher developed a time series of ASM value of shipments on a 1987 four-digit SIC basis for the period 1958–1994. These SIC shipments were converted to a NAICS basis and used for extrapolation. For 1947–1957 Census and ASM value of shipments data obtained and converted to NAICS for extrapolation of manufacturing.
Annual I-O accounts	Annual I-O tables were developed for the years 1968–1987 at a summary I-O code level. These tables were converted to a NAICS basis using appropriate concordances. While conversion to NAICS was rough, the values provided reasonable extrapolators for some industries.
GDP by industry estimates of gross industry output	Industry output on a NAICS basis was estimated for 1987–1997. These values were used as extrapolators for this period.
NIPA PCE and fixed investment estimates	For some commodities most of the supply flows to a set of PCE and/or fixed investment categories. In these cases PCE/ and/or investment categories served as extrapolators.
Statistical Abstract	Numerous series on industry production were available relatively consistently over the period.
NIPA foreign trade and Balance of Payments	NIPA table 4.2.5. Exports and Imports of Goods and Services by Type of Product
	BEA balance of payments "Table 1. U.S. International Transactions"
Exports and imports of goods	An NBER researcher developed a time series of exports and imports on a 1987 four digit SIC basis for the period 1958–1994. These SIC trade data were converted to a NAICS basis and used for extrapolation of exports and imports of goods. These data are available on the CD-ROMs "NBER Trade Database, Disk 1: U.S. Imports, 1972–1994," and "Disk 3: U.S. Exports, 1972–1994," which can be ordered from the NBER at 617–868–3900 or by e-mail at orders@nber.org.

I-O Input-output
NAICS North American Industry Classification System
NBER National Bureau of Economic Research
NIPA National income and product accounts
PCE Personal consumption expenditures
SIC Standard Industrial Classification

was largely provided by dedicated ISPs using dial-up technology (for example, AOL, Prodigy, and CompuServe). However, by the latter half of the decade, Internet service was largely provided by telecommunications companies using broadband technology. The adjustment was wedged to zero in 1992 based on the fact that ISPs were not separately identified in the 1992 benchmark and likely did not exist then.

The second phase of this step was to adjust the affected transactions in the use table. Several options were considered, ranging from simply incorporating the adjustments solely into the gross operating surplus to distributing the adjustments across all elements of the use table. The preferred method was to preserve the existing I-O ratio and to distribute the adjustments to that industries' intermediate inputs and the gross operating surplus. Preserving the I-O ratio after adjusting output provided a "control" for total intermediate inputs, with the gross operating surplus derived residually. The initial, prebalanced, commodity distribution of the intermediate inputs was estimated using existing shares (that is, all commodities were multiplied by a single scalar).

Step 5. Update for definitional and statistical revisions from the 2013 comprehensive revision

The final step in this process was to update the converted 2007 NAICS-based I-O statistics to reflect the major definitional and statistical improvements from the 2013 comprehensive revision of the IEAs. Among the most significant improvements incorporated in the 2013 revision was the recognition of R&D expenditures as capital investment. Other improvements that were incorporated into the historical estimates included the capitalization of entertainment, literary, and other artistic originals; the expansion of the capitalization of the ownership transfer costs of residential fixed assets; and the use of an improved measure of transactions for defined benefit pension plans.[12]

R&D. Updating the historical time series to include the capitalization of R&D expenditures required several types of adjustments across many industries. R&D capital includes both R&D developed in-house (also known as own-account production) as well as purchases of R&D.[13] The process for developing adjustments for the historical period is summarized in the box "Adjustments to Capitalize Historical R&D."

Entertainment originals. The capitalization of entertainment, literary, and other artistic originals was somewhat unique because all of this newly recognized capital was considered "own-account" investment. The nature of these assets and the methodology used to estimate them facilitated the adjustments to output and value added in the make and use tables. For example, the recognition of theatrical movie originals added $10.5 billion to both output and value added for the industry group motion picture and sound recording industries.

Residential fixed assets. The expansion of the capitalization of the ownership transfer costs of residential fixed assets had no effect on gross output; rather these costs were reclassified from intermediate expenses to fixed investment with a resultant increase in value added.

Defined benefit pensions. The final adjustment to

12. For additional detail on the definitional changes, see Strassner and Wasshausen, 20–22.

13. For additional details see Marissa J. Crawford, Jennifer Lee, John E. Jankowski, and Francisco A. Moris, "Measuring R&D in the National Economic Accounting System," SURVEY 94 (November 2014): 1–15.

Table 4. 2002 NAICS Matched to 2007 NAICS

2002 NAICS code	2002 NAICS title (and specific piece of the 2002 industry that is contained in the 2007 industry)	2007 NAICS code	2007 NAICS title
516110	Internet Publishing and Broadcasting	**519130**	Internet Publishing and Broadcasting and Web Search Portals
517110	Wired Telecommunications Carriers	**517110**	Wired Telecommunications Carriers
517211	Paging	**517210**	Wireless Telecommunications Carriers (except Satellite)
517212	Cellular and Other Wireless Telecommunications	**517210**	Wireless Telecommunications Carriers (except Satellite)
517510	Cable and Other Program Distribution	**517110**	Wired Telecommunications Carriers
517910	Other Telecommunications	**517919**	All Other Telecommunications
518111	Internet Service Providers—*broadband Internet service providers (for example, cable, DSL)*	**517110**	Wired Telecommunications Carriers
518111	Internet Service Providers—*Internet services providers providing services via client-supplied telecommunications connection*	**517919**	All Other Telecommunications
518112	Web Search Portals	**519130**	Internet Publishing and Broadcasting and Web Search Portals
541612	Human Resources and Executive Search Consulting Services—*executive search consulting services*	**561312**	Executive Search Services

NAICS North American Industry Classification System

NOTE. 2007 NAICS codes in bold indicate pieces of the 2007 industry from more than one 2002 NAICS industry; 2002 NAICS codes in italics indicate the 2002 industry split to two or more 2007 NAICS industries.

the historical estimates was to change the recording of the transactions associated with defined benefit pension plans from a cash-accounting basis to an accrual-accounting basis. These improvements had been published historically on an SIC basis as part of the comprehensive revisions of the national economic accounts. These improvements for compensation were converted from an SIC basis to a 2007 NAICS basis using a series of conversion matrices that had been developed previously for constructing historical NAICS-based GDP by industry that were incorporated directly into the historical use tables. The final step after all necessary adjustments had been made to output and value added was to balance the use table using the adjusted output and published NIPA final demand as control values.

Real estimates

Real estimates (chain-type quantity indexes) for value added by industry were calculated using the double-deflation method, which calls for real value added to be computed as the difference between real gross output and real intermediate inputs within a Fisher index-number framework.[14] These revised statistics for real value added mark a substantial improvement from the previously published statistics, which were prepared using a modified double-deflation method for the 1987 forward and a single-deflation method for years before 1987. Price indexes used to deflate current-dollar gross output and intermediate inputs in 1947–1996 were primarily derived from prices developed by Dale W. Jorgenson, Mun Ho, and Jon D. Samuels. These historical price indexes include separate estimates for both domestically produced and imported commodities and reflect a number of different data sources and methods over the full historical time period.[15] Domestic commodity prices for 1958–1996 largely reflect Bureau of Labor Statistics (BLS) producer price indexes with selected adjustments. For years prior to 1958, the domestic commodity prices reflect a mixture of prices derived using data from BLS and from BEA's NIPAs.[16] Import prices for the period 1977–1996 reflect BLS import price indexes. For years prior to 1977, import prices primarily reflect prices developed by Ho that were derived largely from unit value indexes for imports prepared by the Census Bureau.[17] Gross output by commodity was deflated with the domestic commodity prices, while intermediate inputs by industry were separately deflated. Domestic intermediate inputs were deflated with the domestic commodity prices while imported intermediate inputs were deflated with the prices for imported commodities.

For more information on previously published statistics, see the box on page 9.

14. For details on the Fisher index number framework for computing real value added by industry, see the technical appendix in Brian C. Moyer, Mark A. Planting, Mahnaz Fahim Nader, and Sherlene K.S. Lum, "Preview of the Comprehensive Revision of the Annual Industry Accounts: Integrating the Annual Input-Output Accounts and the Gross Domestic Product by Industry Accounts," SURVEY 84 (March 2004): 38–51.

15. For more information, see Dale W. Jorgenson, Mun S. Ho, and Jon D. Samuels, "Data Appendix" to "The Impact of Information Technology on Postwar U.S. Economic Growth," *Telecommunications Policy* (online, November 2015).

16. For more information, see Dale W. Jorgenson, Frank M. Gollop, and Barbara M. Fraumeni, *Productivity and U.S. Economic Growth* (Cambridge, MA: Harvard University Press, 1987).

17. Mun S. Ho, "The Effects of the External Linkages on U.S. Economic Growth," PhD thesis (Cambridge, MA: Harvard University Press, 1989).

Adjustments to Capitalize Historical R&D

For own-account R&D, equal magnitude adjustments were made to both output and value added; the recognition of own-account investment has no impact on intermediate inputs. Own-account estimates for R&D, including the historical estimates that are published as part of the NIPAs, were constructed at a pseudo-industry level. For example, in NIPA table 5.6.5., Private Fixed Investment in Intellectual Property Products by Type, R&D type is defined by the industry that "owns" the R&D. Moreover, it is reasonable to assume that own-account R&D owned by "Pharmaceutical and medicine manufacturing" was also performed by the same industry. Unfortunately, the industry-level detail at which these estimates were developed do not always align with the industry-level detail that we are working with in the historical I-O time series. For example, estimates of own-account R&D for "other" manufacturing needed to be disaggregated further to broadly match three-digit 2007 NAICS detail.

For purchased R&D, conceptually no adjustments to output should be necessary; however, in reality there is not enough existing output to adequately cover the newly recognized final demand. As a result, additional output was imputed for the R&D-producing industry (NAICS 5417) for the historical period. Adjustments were also necessary for value added to reflect the reclassification of purchased R&D from an intermediate input to final demand. These adjustments were loaded directly on to the existing gross operating surplus, reflecting a return to the R&D capital. Unlike own-account R&D, the industry allocation of the imputed gross operating surplus for purchased R&D is allocated to the purchasing industry—not to the producing industry. Information from NIPA table 5.6.5 and BEA's fixed assets accounts was used to make these historical adjustments for purchased R&D.

Previously Published Historical Statistics

Benchmark input-output accounts are available on the Bureau of Economic Analysis Web site for 1947 forward and are generally available every 5 years—for years ending in "two" and in "seven." However, these benchmark input-output accounts are not consistent with one another.

Definitional and statistical improvements introduced in the benchmark input-output accounts have not been carried backward to previously published benchmark tables. Annual gross domestic product by industry statistics are available on the Bureau of Economic Analysis Web site, on a North American Industry Classification System basis, also beginning with 1947.

Previously published annual gross domestic product by industry statistics were compiled with distinct methodologies for two separate periods: 1947–1987 and 1987–1996. The 1996 end year marked a break from the more recent period beginning with 1997 because 1997 was the first year that the economic census data were collected on a North American Industry Classification System basis; previously, the data had been collected on a Standard Industrial Classification system basis.

Previously published estimates that were based on the Standard Industrial Classification were first converted to a North American Industry Classification System basis in 2004, covering 1987–1997; the remaining historical period estimates for 1947–1986 were converted in 2005.[1]

Input-output accounts have been prepared by Bureau of Economic Analysis at regular intervals beginning with the 1958 table and have been an integral part of the benchmarking of the national economic accounts.[2] In 1972, Bureau of Economic Analysis began preparing of annual input-output tables, which were updates of the most recently available benchmark table. The first annual table was prepared for 1966 and for every year after that with the exception of 1988–1995.[3] Prior to this release, annual input-output tables availability on the Bureau of Economic Analysis Web site were limited to 1997-forward. Prototype historical (pre-1997) annual input-output tables have been developed previously, but they were never integrated with the published historical gross domestic product by industry statistics.

1. For additional details, see Robert E. Yuskavage and Yvon H. Pho, "Gross Domestic Product by Industry for 1987–2000: New Estimates on the North American Industry Classification System," SURVEY 84 (November 2004): 33–41, and Robert E. Yuskavage and Mahnaz Fahim-Nader, "Gross Domestic Product by Industry for 1947–86: New Estimates Based on the North American Industry Classification System," SURVEY 85 (December 2005): 70–80.

2.Benchmark tables are available for 1947, 1958, 1963, 1967, 1972, 1977, 1982, 1987, 1992, 1997, 2002, and 2007; however, only the 2007 table is a fully integrated component of the national income and product accounts and the industry economic accounts. The 1947 table was originally prepared by the Bureau of Labor Statistics. BEA revised the 1947 table to be consistent with the national income and product accounts and with the definitions of BEA's 1958 I-O table.

3. Annual I-O tables were discontinued between 1988 and 1995.