Industrial Production and Capacity Utilization - G.17

History of the Industrial Production Index[1]

Almost from its founding the Federal Reserve Board has reported on current business conditions. The first issue of the *Federal Reserve Bulletin*, in May 1915, included digests of business conditions in the twelve Federal Reserve Districts. By 1919, the *Bulletin* included monthly "data relative to the physical volume of trade," published both in actual amounts (tons, feet, and so on) and as indexes. By 1922, the tables on the physical volume of trade contained more than 100 series that measured the current activity of business. From these monthly physical volume data, Federal Reserve staff developed aggregate production indexes to study trends in business activity in a more compact and coordinated form. Since 1922, the Federal Reserve's monthly indexes of production have evolved by incorporating new data and techniques.

The evolution of the monthly index of production reflects a number of stages. In the pioneer stage during and after World War I, the economics profession built on the work of Wesley Mitchell at the War Industries Board, and articles on production indexes appeared in academic journals. By December 1922, the Federal Reserve had developed "The Index of Production in Selected Basic Industries." It was seasonally adjusted by the ratio-to-moving-average method and was available by the 25th day following the reference month. In 1927, "A New Index of Industrial Production" was published. This index used value-added weights for combining manufacturing series and value produced for minerals. Moving seasonal factors were introduced, and daily average output was used instead of output per month. This index gained wide national acceptance.

During the 1930s, Frederick Mills, Arthur Burns, and Solomon Fabricant at the National Bureau of Economic Research (NBER) studied and developed production data for manufacturing from the *Census of Manufactures* (COM); the NBER researchers found that the available physical volume data, used in production indexes up to that time, understated the growth of output in manufacturing because the data did not cover new, rapidly expanding industries. The Federal Reserve staff used the broader annual NBER production indexes to benchmark the monthly production indexes in the revision of 1940. At that time, the staff also began to use monthly production-worker hours with productivity adjustments to estimate output in industries for which monthly physical product data were lacking. To maintain continuity in the index, the new broader monthly index was linked to the older index that was based solely on physical indicators. The index was seasonally adjusted by the ratio-to-freehand-curve method.

Important developments occurred after World War II. In the 1953 revision, the number of series in the index was expanded from 100 to 175 series, monthly indexes were benchmarked to comprehensive annual indexes of output, and value-added weights were used for both the mining and manufacturing series. In 1959, the coverage of the index was expanded to include electric and gas utilities, along with manufacturing and mining to bring the coverage of the index into closer accord with recommendations made by the United Nations. Market groups were introduced for consumer goods, equipment, and materials. Computerized computation began.

In the 1960s, the staff found that electric utilities had and were willing to supply data on monthly sales of electric power to industry classified by Standard Industrial Classification (SIC) category. In 1971, kilowatt-hour series were introduced to replace or supplement many of the production-worker-hours series in the index; the total number of series increased to 227. At that time, the market groups were refined further, and the staff developed supplementary gross value of products series for comparison with gross value aggregates, such as shipments, foreign trade, and GNP final expenditure categories. In 1985, intervention analysis was included as part of seasonal adjustment, and the number of series

rose to 252.

The primary purpose of the 1990 revision was to include the latest available benchmark and annual information on the levels of the 250 basic series that made up the index. In addition, the value-added weights used to combine the series were updated: 1982 weights were used for 1982–86, and 1987 weights were used for the period since 1987. To improve consistency with other measures of output, the revised index for office and computing machines incorporated the price deflator (based on a combination of matched-model and hedonic components) developed jointly by IBM and the BEA for use in the National Income and Product Accounts. In April 1990, the statistical release for capacity utilization (G.3) was merged into the release for industrial production (G.12.3) to form a new combined release (G.17).

In the 1993 revision, the 1987 weight and comparison base was maintained, and the broad structure of the major market and industry groups remained basically the same. The detailed industry structure, however, was modified to conform to the 1987 SIC, and many refinements to the compilation of individual series were made. The introduction of new series increased the number of individual series to 255.

Quarterly production data in physical units were introduced to maintain the representation of physical product measures. (Currently, the number of IP series that are based on quarterly production data represent about 4.5 percent of the total industrial production index in value added terms.) A cubic spline generally is used to interpolate monthly values from the quarterly figures.

Beginning with the 1993 revision, an annual or historical revision was issued each year, usually in the fall; the total number of individual series continued to expand. The most important improvement for the revision issued in January 1997 (the 1996 revision) was the introduction of new chain-type aggregation methods from 1977 onward, a significant modification in the index. As before, however, the contribution of an individual industry to total output was based on the value added by that industry. The sources of these figures are the same as those used for the periodic updating of weights for the earlier measures.[2] The newly introduced aggregation method, a version of the Fisher-ideal index number, was more firmly rooted in economic theory and eliminated a source of upward bias in the previous estimates. For the weights used in aggregating the IP and capacity indexes, a refinement to the scheme first used in the 1996 revision was introduced in the 2000 revision. In the 1996 revision, annual chain weighting was introduced into the aggregation method used to construct IP from 1977 to the present. With the 2000 revision, the annual unit value-added measures used to aggregate IP were linearly interpolated to the monthly frequency, and the IP index became a chain-type index with monthly weights.

Although the introduction of a chain-type index formula followed a similar reformulation of the featured measure of real output published by the BEA, the Federal Reserve introduced a method in which weights were estimated through the most current periods, even though comprehensive data on value added lag a few years. The Federal Reserve also addressed the problem of the aggregation of ratios, such as capacity utilization. As a result, the aggregation of capacity and capacity utilization was done with a generalization of the method introduced in the 1990 revision of those series.[3] (The background of capacity utilization is described here.)

Another significant development in the late 1990s was the incorporation of new real output measures for high-technology industries in the IP index.[4] In the 1997 revision, a new monthly measure of semiconductor output was introduced from 1992 onward; the measure was further refined in the 1998 revision and followed the earlier introduction of an improved annual benchmark index for the industry from 1977 onward.[5] Following the introduction of a new output index for semiconductors in the 1998 revision, new or improved high-technology output measures were introduced for computers (1999 revision) and communications equipment (2000 revision). These initial efforts at improving the measurement of high-technology goods were followed up by annual improvements in the measures for

at least one of these product categories.

The fundamental strategies used to estimate output and prices for these high-technology categories were similar. First, data on prices and shipments for numerous technologically distinct products were obtained from private market research firms. The shipments data were often either worldwide shipments or shipments to the United States. In that case, these data were transformed to an estimate of U.S. production, either based on adjustment estimates from foreign trade data or based on annual data on U.S. production by manufacturer or by detailed product class.

This basic approach was also applied to the measurement of pharmaceutical production.[6] Specifically, the 2000 revision introduced a new method for estimating the production of pharmaceutical preparations. The new production index was a chain-type quantity index developed principally from data provided by IMS-Health on the prices and quantities of shipments to dispensers of prescription and non-prescription drugs in the United States for about 500 product classes. Information from the Census Bureau's *Current Industrial Reports* (CIR) was the basis for the adjustment of these data to estimates of actual U.S. production.

Changes to other individual IP series in the late 1990s and 2000s also involved the use of very detailed product data, including the revised production measures for coal, completed commercial aircraft, and motor vehicles. For motor vehicles, the monthly production indexes for autos and light trucks were improved to capture shifts in the mix and relative values of different models produced on a more timely basis. This change was introduced in the 1999 revision and reviewed in an article in the March 2000 issue of the *Federal Reserve Bulletin*.[7] The article explained that the monthly indicator for the production of autos and light trucks from 1992 forward became an annually-weighted Fisher quantity index; the calculations use monthly data on the number of assemblies by model and the annual list price for each model at the start of the new model year. Before the change, the monthly indicator for the production of autos and for light trucks was the simple count of units assembled.

A method used to estimate the initial IP figures, where appropriate, that accounts for changes in the number of temporary employees who work in the industrial sector was introduced in 2001 and refined in 2002 and again in 2009. With limited data available, the compilation of the initial IP estimate for a given month relies heavily on the hours worked by production workers in the manufacturing sector. However, this approach had ignored the use of temporary workers in manufacturing, which surged in the 1990s.[8] At the Federal Reserve's request, the *Survey of Plant Capacity* (SPC) included questions on temporary help from 1998 through 2006. The data from this report and the 1999 *Current Population Survey* were used to model the share of temporary help employment that was sited at manufacturing establishments. This adjustment to manufacturing employment is allocated by industry based on the SPC information and on the relative rates of change in hours for directly employed workers.[9]

The monthly processing of the source data for industrial production and the monthly compilation of the index were streamlined and significantly improved in the 1990s and 2000s. Seasonal adjustment procedures incorporated regression-based holiday and other calendar effects; the monthly electric power data used in IP were automatically adjusted for systematic influences of the weather.[10] In addition, the statistical tables in the monthly G.17 release were revised with its February 2001 publication, and new, high-technology-related aggregates for production and capacity were introduced. Another important refinement was the compilation of the seasonally adjusted aggregates from the seasonally adjusted individual series; this improvement was introduced in the 1993 annual revision. Prior to that, the aggregates were independently seasonally adjusted and, as a result, did not always equal the sum of the seasonally adjusted individual series.

The most significant change to IP and the related measures of capacity and capacity utilization since 2000 was the reclassification to a NAICS basis from an SIC basis, which was the cornerstone of the 2002 annual revision.[11] Individual and aggregate series for production and capacity indexes were reclassified back to 1972 on a NAICS basis, which made them the first major economic indicators

issued with substantial history on a NAICS basis.[12] The issuance of these revised indicators marked a major advance within the statistical community. The historical continuity afforded by consistent time series data is particularly important to economists concerned about low frequency events, such as business cycles, where each observation is quite important.[13]

The key to developing historical NAICS indexes, therefore, was to determine the share of each SIC industry that should be assigned to each of its corresponding NAICS industries. The Census Bureau took care of this problem for 1997 by publishing industry-level statistics, such as shipments and value-added, on both an SIC and a NAICS basis in the COM. The underlying establishment-level data for 1997 were dual-coded. For many industries, however, the shares derived from the 1997 data would not accurately reflect the industrial distribution of activity in earlier years. To develop this information, historical plant-level data, or microdata, in the Census Bureau's Longitudinal Research Database were used. Historical SIC-to-NAICS shares for industry-level COM variables (value added, shipments, and the like) were calculated that assigned a NAICS industry code to each establishment in the microdata files of the historical censuses back to 1963.

Along with the reclassification to NAICS, the 2002 revision featured a modification to the composition of the IP market groups. The market groups apportion production on the basis of how it is used: as a consumer good, as an investment good, as an intermediate input for businesses outside of the industrial sector, or as an intermediate input for businesses within the industrial sector. Previously, only about 25 industries were disaggregated based on detailed product and end-use statistics so that their output could be assigned to multiple market groups. With the 2002 revision, when appropriate, *all* industries in the IP index have their output allocated to multiple market groups. Market group shares for the industries represented by individual series in the industrial production index were derived using relationships in the 1992 input-output (I-O) tables issued by the BEA. In addition, input-output methods were used to classify the industries in the IP index into four stages of processing—crude, primary, semifinished, and finished. IP indexes for these stages replaced the primary and advanced processing aggregates that were previously published.

Another significant change to IP in the 2000s was the discontinuance of its use of survey data of industrial electric power use at the end of 2005.[14] The survey, discussed a bit earlier, was initiated in the 1960s to collect data on electricity use—which tends to be highly correlated with production in capital-intensive industries—as an alternative indicator of output. These survey data were used directly as the production indicators for some industries (particularly those with highly automated assembly operations and a diverse product mix) for which product-based data were unavailable. However, by 2004, the electric power usage covered by the survey had dropped nearly 40 percent from its peak in 1993, and several regions and industries had significant gaps. The 20 industry indexes that previously relied on electric power use data were recalculated using production-worker hours as the underlying source data for the period 1997 forward.

Another change in methods for the IP indexes was the establishment of a method for estimating the production of an industry for which only shipments data were available. The procedure was first developed and implemented for the machine tool industry in the 2004 annual revision.[15] The use of the procedure, which adjusts shipments by an estimated the change in inventories at manufacturers, was extended considerably in the subsequent three years. In total, about 30 industrial production indexes are now computed from shipments data augmented by a model-based estimate of their inventory swings.

Beginning with the annual revision issued in March 2008, the date of annual revisions began being targeted for the end of March. This timing allowed for the inclusion of data from *Annual Survey of Manufactures* (ASM)—often issued by the Census Bureau around the end of a year&mdesh;and from annual benchmark releases for the BLS *Current Employment Survey*—issued in early February—as soon as possible after their availability. The 2010 release of the annual revision to the G.17 was

delayed until June of that year in order to incorporate the 2008 ASM.

Also beginning in 2008 after the release of the annual revision, the monthly G.17 releases were based on a six-month reporting window: One month of new data is reported, and the previous five months of data are revised. Previously, the monthly releases were issued with a four-month reporting window, which covered one month of new data and revisions to the previous three months of data. The six-month window allowed for the inclusion of additional data that otherwise would not be incorporated into IP until the next annual revision.

Initially introduced in the 2002 annual revision, the weights that allocate individual IP indexes into multiple market groups were updated in the 2009 annual revision.[16] The weights for 2002 were updated using estimates for the 2002 input-output tables; years subsequent to 2002 were assumed to have weights identical to those for 2002. The weights for the period up through 1997 were still computed from the 1997 tables, and the weights between 1997 and 2002 were linear combinations of the 1997 and 2002 weights.

In 2011, a long-time source of production data for IP, the Census Bureau's CIR program, was eliminated because of budget constraints. The data from that program—both monthly and quarterly—had been used for about 2 percent of industrial production. Initially, production worker hours replaced the CIR data as the production indicator for the indexes. However, quarterly estimates of utilization rates from the Census Bureau's *Quarterly Survey of Plant Capacity* (QSPC) were combined with estimates of an capital services and price deflators to form quarterly production indicators to replace CIR data for both communications equipment (at the time of the 2012 annual revison) and computer servers (2014 annual revision).

The QSPC was established in 2007 as a higher frequency replacement for the annual *Survey of Plant Capacity*. The Federal Reserve was a major supporter of the new survey because it was looking for a substitute for the data from the discontinued electric power use survey and the capacity utilization results from the SPC were useful proxies for output indicators.

Improving the methods used to estimate the indexes for computers, communications equipment, and semiconductors was a focal point of the improvements to the index since the technology boom in the mid-1990s. While improvements to the computer indexes had primacy early in that period, more of the work in recent years has been done for communications equipment. Even so, much of the production in those two categories had moved abroad by 2014 leaving only semiconductors, particularly microprocessors, as having a large domestic presence. One noteworthy innnovation for a smaller category of semiconductors, memories, was introduced in the 2014 annual revision: A price index from the Bank of Japan was used to interpolate domestic quarterly price indexes to a monthly frequency and to extend the quarterly indexes beyond their last available date. This use took advantage of memories being essentially a commodity that has a global price.

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[1] The historical portion of this section is based on the "History of the Index," a chapter in *Industrial Production—1986 Edition, with a Description of the Methodology* (Board of Governors of the Federal Reserve System, 1986).
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[2] Annual value added are reported in the quinquennial *Census of Manufactures* and the *Annual Survey of Manufactures* of the Bureau of the Census. Value added for electric and gas utilities are computed from annual revenue and expense data reported by the Department of Energy and the American Gas Association. Value-added data for mining industries are available only every five years from the *Census of Mineral Industries*. Estimates of unit value added for intervening years are derived from related final product prices, either a producer price index from the Department of Labor's Bureau of Labor Statistics or a spot price for selected commodities such as crude, oil, gold, or silver. Annual

data on the total value of production (shipments plus inventory change, including the value of excise taxes) required for the gross value of product aggregates are derived from these same resources.
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[3] The generalized method is discussed more fully in the article in the February 1997 *Federal Reserve Bulletin*.
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[4] The Federal Reserve's effort to improve the measurement of high-technology industry output was featured in a speech by former Chairman Alan Greenspan, "The Challenge of Measuring and Modeling a Dynamic Economy," at the Washington Economic Policy Conference of the National Association for Business Economics, Washington, D.C., March 27, 2001.
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[5] The benchmark quantity index for the semiconductor industry was constructed based on newly available quality-adjusted price indexes for selected semiconductor components developed by the BEA. See Grimm, Bruce T. "Price Indexes for Semiconductors, 1974–1996," *Survey of Current Business*, February 1998, pp. 8–24.
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[6] The basic research that underlay the development of the new measures was presented at conferences and workshops sponsored by NBER's Committee on Research on Income and Wealth.
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[7] Charles Gilbert, Norman Morin, and Richard Raddock, "Industrial Production and Capacity Utilization: Recent Developments and the 1999 Revision," p. 192.
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[8] In the IP methodology up to this point, the effect of the use of temporary workers would be indirectly captured, to some extent, in the updating of near-term productivity estimates.
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[9] When overall manufacturing employment is declining (increasing), no adjustment is made to industries where production-worker hours are increasing (decreasing).
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[10] Staff research indicated that the usual seasonal adjustment techniques did not adequately capture the influence of the weather on electric power usage for numerous industries. The new adjustment procedure uses data on heating and cooling degree days to model the effects of weather more accurately in those industries.
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[11] Carol Corrado, "Industrial Production and Capacity Utilization: The 2002 Historical and Annual Revision," *Federal Reserve Bulletin*, vol. 89, April 2003, pp. 153–76, contains a description of the reclassification methods and results.
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[12] Kimberly Bayard and Shawn Klimek, "Creating a Historical Bridge for Manufacturing Between the Standard Industrial Classification System and the North American Industry Classification System," *2003 Proceedings of the American Statistical Association, Business and Economic Statistics Section [CD-ROM]* (2004), pp. 478–84, contains a description of the methodology used to reclassify historical data from an SIC basis to a NAICS basis.
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[13] John Stevens, "Overhauling Industrial Production: The 2002 Historical and Annual Revision," *2003 Proceedings of the American Statistical Association, Business & Economic Statistics Section*

[CD-ROM] (2004), pp. 4072–8, contains a description of the conversion of the IP, capacity, and utilization data from an SIC-basis to a NAICS-basis.
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[14] Kimberly Bayard and Charles Gilbert, "Industrial Production and Capacity Utilization: The 2005 Annual Revision," *Federal Reserve Bulletin*, vol. 92, 2006, pp. A39–A58.
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[15]Charles Gilbert and Kimberly Bayard, "Industrial Production and Capacity Utilization: The 2004 Annual Revision," *Federal Reserve Bulletin*, vol. 91, Winter 2005, pp. 9–24.
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[16]Anne Hall, "Industrial Production and Capacity Utilization: The 2009 Annual Revision," *Federal Reserve Bulletin*, vol. 95.
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