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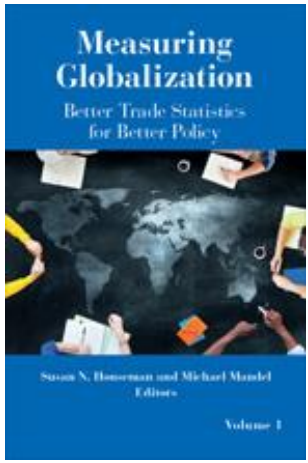

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Producing an Input Price Index

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This chapter is designed to address the need—and especially the feasibility—of producing what is referred to as an input price index (IPI) at the U.S. Bureau of Labor Statistics (BLS).[1] The current interest in this set of proposed price indexes grew out of concerns that the BLS does not directly measure price decreases associated with the dramatic rise in offshoring (or its corollary, onshoring) in its industrial price programs.[2] These new price indexes would help alleviate unease that current estimates of several key indicators of the U.S. economy—including gross domestic product (GDP), productivity, and inflation—may be inadequate.

Currently, the BLS has three price indexes that cover the production (or supply) of goods: 1) the U.S. Import Price Index (MPI), 2) the U.S. Export Price Index (XPI), and 3) the Producer Price Index (PPI). The MPI only covers goods that are being imported, the XPI only covers the export of goods, and the PPI only covers goods and services that are produced domestically. Thus, a good that is domestically produced and repriced by the PPI, and subsequently has its production sent overseas, will no longer be tracked in the PPI. Correspondingly, the MPI will not begin to price that particular item until after it has become an import. Therefore, neither program will directly show the price change that occurs when the item goes from domestic production to foreign (or vice versa).

In order to address this limitation, the BLS would need to develop an entirely new set of "input" price indexes, which would directly price goods and services that are inputs into the production function of a domestic company. Indeed, the BLS itself recognized the need for this type of series over 30 years ago when the old "wholesale price index" was transformed into the more comprehensive and systematic output-based producer price indexes. At that time, the BLS actually piloted a

"buyers'" index, but, primarily because of budget limitations, this earlier effort at an input price index was never extended.

This chapter will detail the problem in the current methodology for price indexes that an import price index would be designed to overcome, as well as review some of the evidence on the need for these data. Finally, the chapter will discuss the practical aspects and limitations of attempting to produce such an index. These include surveying the data sources necessary for drawing a sample of establishments and items to reprice, evaluating possible sources for appropriate weights in an input price index, determining a proper index estimation formula, and verifying the publication structure necessary to support the different uses of these series.

THE PROBLEM

An example of how the BLS constructs an import price index and a producer price index will help to illuminate the problem described above. Let us look at how both indexes would reflect price changes in the manufacturing of furniture. Table 10.1 contains prices for four different chairs. All chairs that are being produced domestically sell for $10, while all imported chairs sell for $5. Chair A is only produced domestically, while Chair D is only imported. During the year, the remaining two chairs shift from domestic production to being imported—Chair B in March and Chair C in May.

The PPI tracks only Chair A for the entire period, and Chairs B and C for the months that they are domestically produced. The MPI tracks only chair D for the entire period, and chairs B and C only for the months they are imported. Thus, both the PPI and the MPI for chairs would reflect no change during the entire reference period.[3]

Is there a way to combine the two indexes to reflect the impact of a switch from domestic production to importing the same chairs? Since the indexes are always unchanged, no amount of recombining or reweighting will produce anything other than a series showing unchanged prices. The only way to construct a price index that would show the price decline resulting from the offshoring of chairs B and C would be to directly track the price changes of items as they move from

Table 10.1 Tracking Prices When Sourcing Shifts

		Jan. '09	Feb. '09	Mar. '09	Apr. '09	May '09	June '09
Chair A	Domestic ($)	10	10	10	10	10	10
Chair B	Domestic ($)	10	10				
Chair B	Imported ($)			5	5	5	5
Chair C	Domestic ($)	10	10	10	10		
Chair C	Imported ($)					5	5
Chair D	Imported ($)	5	5	5	5	5	5
PPI (%)		100.0	100.0	100.0	100.0	100.0	100.0
MPI (%)		100.0	100.0	100.0	100.0	100.0	100.0
Combined index (%)		100.0	100.0	100.0	100.0	100.0	100.0
Input index (%)		100.0	100.0	85.7	85.7	71.4	71.4

SOURCE: Author's construction.

domestic to foreign and vice versa. This is not possible under the methodology (and concepts) currently in use in the bureau's two industrial price programs.[4]

WHY AN INPUT PRICE INDEX IS IMPORTANT

Although the BLS was aware of the potential data gaps between XPI, MPI, and PPI, the shifts over time between domestic and foreign production may have been gradual enough that it was not evident that the limitation of the indexes could be introducing biases into the nation's economic data. This potential gap in BLS data, however, became more serious as the proportion of the U.S. economy tied to the global economy expanded, and especially in conjunction with the growing perception that U.S. jobs were being lost to foreign competition and foreign workers.

The potential shortcomings in the BLS indexes were highlighted in an article in *BusinessWeek* (Mandel 2007) and subsequently in a study funded by the Sloan Foundation and the Bureau of Economic Analysis (BEA).[5] As the article and the study point out, an accurate estimate of the trend in prices paid by domestic U.S. establishments for inputs of both goods and services is crucial to a number of broad and critical measures

of the economy, such as GDP and productivity. For example, in order to properly estimate GDP by industry (as constructed by the BEA) and by industry productivity estimates (as constructed by the BLS), the producers of these economic data must subtract input costs. Although these data are usually readily available on a current dollar basis, in order to convert these nominal values to a constant dollar basis—that is, to an inflation-adjusted basis, also referred to as a real (as opposed to a nominal) basis—they must be adjusted by changes in price levels. However, the appropriate price measures paralleling these input values are not currently being produced by the BLS. Consequently, the BEA and BLS must make use of whatever price data are available. Generally, this has required the agencies to make use of the PPI price indexes or the import price indexes.

The argument has been made that using these next-best sources may lead to significant mismeasurements in the economy. For example, the *BusinessWeek* story estimated that the increase in real GDP from 2003 to mid-2007 may have been overestimated by $66 billion.

As evidence of this, the article's author, Mandel, points out the apparently contradictory behavior of consumer prices for furniture—which had been falling—at the same time that the indexes for domestic producer prices as well as import prices for this category had both been moving higher. Conversely, the article also infers that the lack of an input price index may lead to a significant overestimate of productivity in U.S. industry. A rise in a nation's productivity is considered the key factor in an economy's ability to improve that nation's standard of living, as it is presumed that increases in real hourly earnings should move in conjunction with gains in productivity. If, in fact, GDP and productivity are being overestimated, this implies that the gains from trade (i.e., the terms of trade) are being underestimated and that, in real terms, the value of imports is greater than currently measured.

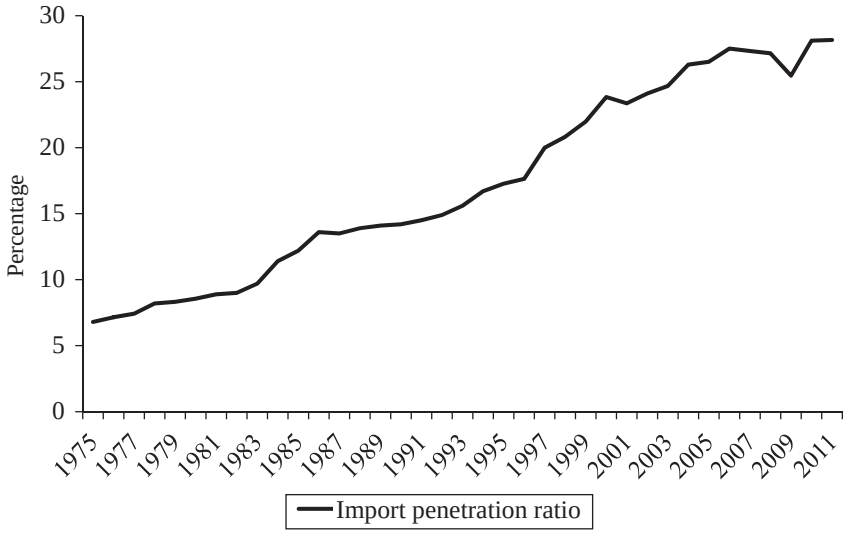
A growing body of literature—much of it in conjunction with the original 2009 conference and a second conference in 2013—has looked into the increasing role of imports in intermediate inputs in the U.S. economy, the current price index methodology used in the BLS, and their implications in U.S. estimates of GDP and productivity. For example, Kurz and Lengermann (2008) note that foreign inputs accounted for one-third of growth in the manufacturing sector between 1997 and 2005. Houseman et al. (2011) further explore the subject and find that

as a result of the mismeasurement of the shift from domestic to low-cost foreign suppliers, the growth in real value-added in manufacturing may have been overstated by between 0.2 and 0.5 percentage points from 1997 to 2007. Along similar lines, Feenstra et al. (2009) attribute a substantial portion of the apparent acceleration in productivity gains after 1995 to gains in the terms of trade and to tariff reductions. Additional work on this topic has been conducted by Houseman, Bartik, and Sturgeon (Chapter 5, this volume), who raise concerns over potential overestimates of productivity in the computer sector. In looking at Japanese data, Fukao and Arai (Chapter 7, this volume) conclude Japan also has "a relatively large offshoring bias." Using data from 38 economies, Inklaar (Chapter 6, this volume) finds evidence of systematic bias as a result of offshoring for the advanced economies. In related work, Nakamura and Steinsson (2009) find limitations in the import and export price indexes associated with "product replacement bias." Finally, Nakamura et al. (Chapter 2, this volume) see the need for a large increase in data collection by statistical agencies as well as changes in their price index methodology that would allow for more direct comparisons of closely related items from different sources.

In order to provide additional evidence of the growing need for a set of input price indexes that incorporate both domestic and foreign sourcing, I analyzed the most recent available data on the role of imports in domestic supply. In 1975, imports, as measured in current dollars, represented less than 7 percent of inputs into manufacturing. By 2007 the figure had climbed to almost 28 percent (see Figure 10.1). Equally important is that between 1997 and 2007 the percentage of imports in inputs increased by an average of more than 0.40 percent a year, whereas in the previous decade the percentage had increased by less than 0.25 percent a year. This point is interesting because it implies that there is an acceleration in companies' shifting their products from domestic sourcing to foreign sourcing, making the need for additional data more critical.[6]

Indeed, globalization may be happening so quickly that the ability of traditional measures to capture these shifts has become increasingly problematic. For example, the household wood furniture manufacturing industry—the industry highlighted in the *BusinessWeek* article—recorded a dramatic increase during the past decade in the value of imports, which jumped from $13.2 billion in 1999 to $27.0 billion in

Figure 10.1 Imports as a Percentage of Domestic Supply Manufacturing Sector



NOTE: There is a break in the series in 1998. Data prior to 1998 are based on the Standard Industrial Classification (SIC) code for manufacturing. More recent data are based on the North American Industry Classification System (NAICS).
SOURCE: Bureau of Economic Analysis.

2007. The article also points out that, according to official statistics, productivity went up 23 percent and output rose 3 percent between 2000 and 2005 (Mandel 2007). Interestingly, in 2006 the preliminary estimate from the Annual Survey of Manufactures (ASM) for the household wood furniture sector recorded an increase in the value of domestic production, up from $13.0 billion in 1999 to $13.5 billion in 2006 (U.S. Census Bureau 2013). However, when the final figures were revised the following year, the number was adjusted substantially downward, to only $8.6 billion. This may be due in part to the difficulty of properly (and in a timely manner) coding companies to the correct North American Industry Classification System (NAICS) number when they shift from being a manufacturer to being essentially a wholesaler. The key point is that economic data tasked with reflecting current trends must be flexible enough to allow for continual changes in the composition of the economy.[7] Ideally, an input price index will facilitate this

flexibility, as it allows for rapid capturing of changes in suppliers (and prices) of inputs.

EARLIER ATTEMPTS TO CONSTRUCT INPUT OR BUYERS' PRICE INDEXES

The seminal 1961 report of the NBER Price Statistics Review Committee, the so-called Stigler Report (Stigler 1961), made a number of recommendations surrounding the wholesale price indexes—the name given to the industrial price series then being produced by the BLS. One of the recommendations called for the creation of a set of conceptually rigorous input and output price indexes. A second recommendation was that the bureau should rely on buyers' prices and not on sellers' prices. The report included a study that suggested that buyers' prices were more likely than list prices to reflect the prices of actual transactions.

Using Buyers' Prices

In response to the Stigler Report and subsequent studies, the then-BLS commissioner as well as others expressed concerns that the cost of collecting buyers' prices would outweigh the potential benefits because of potential problems such as buyers' prices from an invoice sometimes not reflecting real transaction prices, difficulties capturing retroactive price adjustments based on cumulative volume, and financial assistance given by sellers to buyers for advertising and other expenses.[8] The BLS did, however, agree that the project had merit on a case-by-case basis in order to facilitate analysis of price trends in industries where transaction pricing was especially problematic.

A more detailed study looking into the advantages of buyers' prices was subsequently published in Stigler and Kindahl (1970), which pointed out the differences in price trends between buyers' and sellers' prices. Because much of the concern with the then-named BLS wholesale price index (WPI) focused on the use (or potential misuse) of so-called list prices, BLS economists began working with the sellers who were participating in the price survey to encourage the reporting of actual transaction prices. In doing so, they made substantial progress in

some industries in improving the quality of the received prices. In addition, the bureau also began the process of evaluating specific products where buyers' prices should be collected because of the unavailability of transaction prices from sellers. As a result of this study, in January 1972 the newly renamed PPI began publishing a commodity index for aluminum ingots using buyers' prices from a selected sample of reporters.

Building on this work, in 1974 the bureau attempted a systematic sampling approach to obtaining buyers' prices. This project was undertaken with the goal of determining the feasibility and cost of collecting prices directly from buyers in order to either calculate price indexes or evaluate the quality of the transaction prices being reported by sellers. The project identified product areas where sellers refused to provide transaction data, or the quality of current transaction data was questionable, and where there were homogeneous products frequently purchased by buyers in consistent quantities. The project focused on titanium forgings instead of aluminum ingots because the PPI was able to create a sampling frame and document the typical transaction characteristics of buyers in this product area. Even after significant resources had been spent on this project, pricing issues remained, and an effective process had not been identified to refine and systematically sample from the frame. As a result, the project was dropped, and the program switched its focus back to obtaining good transaction prices from sellers even in these more difficult cases. No further work was done on buyers' prices, and in 1980, the BLS introduced indexes calculated using sellers' transaction prices from the systematic sample for the primary aluminum industry output index. When this occurred, the buyers' price commodity index for aluminum ingots was dropped.

Input/Output (and Other) Price Indexes

Also in response to the Stigler Report, the BLS began examining a more systematic approach to creating input and output price indexes (as well as other indexes) for industries. For example, in the early 1960s the PPI built output industry-sector price indexes (ISPI) for some industries by combining the judgmentally sampled data collected for the commodity indexes using different classification structures and weighting. Finally, in the mid-1970s, the PPI began a comprehensive revision in

order to plan and implement many improvements that had been recommended over the years, including in the Stigler Report. The long-term goal of the revision was to expand the PPI's coverage to include every industry in the private economy and to publish a system of price indexes that included the following:

- Industry output indexes
- Industry input indexes
- Detailed commodity indexes
- Industry-based stage-of-processing indexes

In the late 1970s the Bureau began systematically sampling industries, and starting in 1980 it began introducing industry *output* indexes on a regular basis. Throughout the years, the PPI continued expanding the number of industry output indexes, and as of 2013 it covered 98 percent of domestic goods manufacturers and 72 percent of in-scope domestic service industries.

While the practical work focused on an output price index, work did proceed on the theory of an input price index, culminating in a BLS working paper by Archibald (1975). Furthermore, as an attempt to fulfill the recommendations of the Stigler report, and as a component of the stage of processing indexes, the bureau did publish a set of input price indexes from 1988 to 2003. These indexes were calculated by reweighting output prices using input weights. This allowed the use of output price indexes at a great level of detail. However, these indexes did not include imports, nor did they directly account for substitution from a buyer's perspective. Thus they assumed that sellers' prices are a good proxy for buyers' prices and that prices for imports and domestic production move similarly. The BLS discontinued these series in 2003, but the method is still used in the BEA and BLS for constructing input price indexes where necessary.[9]

CURRENT USES AND USERS OF THE DATA

The fundamental question facing the BLS, of course, is, "Can the Bureau produce an input price series that will meet the needs of its

primary users?" In order to answer this question, one must first delve into the intricacies of the construction of the outputs of the two primary potential users of these data, the Office of Productivity and Technology (OPT) at the BLS, and the Industry Sector Division (ISD) of the BEA.

The Office of Productivity and Technology at the Bureau of Labor Statistics

We will start with the OPT, which produces three sets of estimates of multifactor productivity (MFP), or output per unit of combined inputs. First, OPT publishes multifactor productivity estimates for the broad private business and private nonfarm business sectors of the economy. These sectors represent 74 percent of U.S. GDP. In calculating these series, outputs are measured on a value-added basis, and consequently the multifactor productivity measure only shows the returns to labor and capital.[10] The value of material inputs does not enter into these calculations. However, staff does use detailed price indexes to deflate inputs of capital expenditures. Physical capital, as measured by the OPT, consists of 42 types of equipment and software, 21 types of nonresidential structures, nine types of residential capital, inventories (manufacturing available for three stages of fabrication), and land. Deflation of each capital expenditure category is actually done at the detailed five- or six-digit input-output (I-O) level.

Second, the OPT also publishes annual multifactor productivity measures for total manufacturing and 18 broad three-digit NAICS manufacturing industries, comparing sectoral output (total output excluding intraindustry or intrasector transactions) to a broad set of inputs, including capital, labor, energy, materials, and business services (KLEMS) inputs. Consequently, MFP measures in this set of manufacturing industries reflect the return on each of these inputs to production. (Note that on a value-added basis, manufacturing represented 12 percent of GDP in 2012.) In the manufacturing sector of the economy and in individual industries, intermediate purchases constitute the largest component of inputs. The nominal dollar and constant dollar values of energy, materials, and services used by the OPT are obtained from the BEA.

Finally, the OPT publishes more detailed annual multifactor productivity measures for 86 four-digit NAICS manufacturing industries, plus air transportation and line-haul railroads. These productivity mea-

sures also compare industry sectoral output to a broad set of combined inputs. The OPT publishes estimates of intermediate purchases, capital, and labor for each of the detailed manufacturing industries. The index of intermediate purchases for each industry is constructed by combining separate quantities (or constant dollar costs) of electricity, fuels, materials, and purchased services. In order to deflate nominal dollar cost inputs for each industry, weighted deflators for materials and for services are calculated by combining detailed price indexes using weights derived from the cost of commodities consumed by each industry, as shown in the detailed benchmark I-O tables produced by the BEA. I-O commodities from the benchmark I-O tables generally relate to the primary products of six-digit NAICS industries, or occasionally a combination of industries. For materials commodities that are heavily imported, the OPT's Division of Industry Productivity Studies (DIPS) combines PPIs and import price indexes using weights from the BEA's import matrix. DIPS also uses PPIs in creating weighted deflators for deflating the annual fuel purchases of each industry.

The OPT also uses PPIs to deflate capital expenditures. Price deflators for each equipment asset category are constructed by combining detailed PPIs with weights from the BEA capital flow tables at roughly the six-digit level. For the DIPS detailed manufacturing industry measures, physical capital consists of 25 categories of equipment, two categories of structures, three categories of inventories, and land.[11] Since industry MFP calculations are based on annual data, the nominal input values are adjusted by annual PPIs (representing the average of 12 monthly price indexes).

The Industry Sector Division at the Bureau of Economic Analysis

The Industry Sector Division at the BEA is responsible for producing the annual industry accounts and the benchmark input-output accounts. These accounts, which shed critical light on the relationships between U.S. industries, take a value-added approach to, and are consistent with, the BEA's flagship GDP estimates. Although the BEA does not publish detailed annual real I-O estimates, it does publish annual price and quantity indexes for 65 detailed industries, including 19 manufacturing industries, which do require data on the real value of inputs.

As the BLS does in its work, the BEA attempts to make its adjustments at the most detailed level possible. For example, at the BEA, the effort to construct updated values for intermediate inputs of goods and services entails making adjustments to approximately 3,500 different items, of which roughly 2,300 represent categories of goods. Ideally, like the BLS, the BEA would like to have a level of detail that lists input price indexes *by industry* for each of the 1,179 six-digit NAICS categories. In practice, however, since the cost of producing that many separate price indexes could prove prohibitive, like the BLS, the BEA would accept a set of product-based input price indexes. In addition, at a minimum, category definitions should be consistent with the 12 expense categories recently added to the Census Bureau's Annual Survey of Manufactures (ASM) forms (most of which are services inputs). While the BEA currently only produces annual estimates of GDP by industry, there has been growing interest in providing these estimates on a quarterly basis.

In sum, although superficially the level of publication required to produce the currently published set of economic data is comparatively high, in actuality the detail necessary to properly support these estimates may be considerably more disaggregated.

Limitations

It is important to point out that the construction of an input price index by itself may not directly alleviate the potential mismeasurement issues associated with the problem noted. This is worthy of note because GDP can be estimated using two different methods: It can be constructed by measuring final sales (Method 1) or it can be estimated using a value-added approach (Method 2).[12] The current methodology in the United States focuses on the former of these two approaches, illustrated in the following equations:

(10.1) $Y = C + I + G + (X - M)$ (Expenditures/Final Sales Approach)

(10.2) $Y = \Sigma\,(S_i - C_i)$ (Production, or Value-Added, Approach),

where S_i represents total sales for industry i, and C_i represents the input costs for the same industry.

As mentioned earlier, in order to calculate real—or constant dollar—GDP, all of these values must be adjusted for inflation using appropriate price indexes. Under Method 1, the adjustments for inflation do not take into account adjustment for inflation that is due to offshoring. This is because an *input price index* does not play a role in the computation, since the formula still relies on the current *import price index*, with its associated potential limitations. Fixing the potential problem could entail shifting the construction of GDP to Method 2.[13]

In order to further illuminate why the BLS cannot construct an import price index that directly registers these price changes, it helps to review the current methodology. The procedure for producing import price indexes starts out with a very robust frame from which to draw a sample. It includes nearly the entire set of transactions of all merchandise brought through U.S. Customs and Border Protection and into the United States. It breaks transactions out by individual shipments, product categories, and of course, companies. A sample of specific companies and the items they imported is then drawn from this frame, and the BLS attempts to collect prices on a monthly basis for these items. Note, however, that the sample only consists of goods that are already being imported. It is not practical to ascertain from an importer (who in many cases may only be an intermediary) whether in the past he sourced an item domestically. It would also be hard to get information in the reverse situation, asking an importer who no longer imports whether the sampled good is now produced domestically and, if so, what the price is. Presumably, constructing an input price index may potentially provide some indication of the magnitude of any differences in price trends being missed by import prices or producer prices as sourcing shifts from one to the other. This might be possible if, as the pricing data is being collected, the respondent is able to report whether the item was bought domestically or from a foreign source. From a practical standpoint, however, it is not clear how this information could be properly and effectively incorporated into the producer or import price index production process.

It should also be pointed out that an input price index will not alleviate problems arising when goods and services that had been previously produced in-house are now shifted to being outsourced (either domestically or to a foreign source). This, too, is considered a growing phenomenon, but unless data on prices associated with the in-house cost of

producing an item can be directly compared with the outsourced price, it is not clear how the BLS could evaluate shifts in prices associated with this phenomenon.

STEPS TO PRODUCE AN INPUT PRICE INDEX

While there is little dispute over the potential advantages of adding an input price index to the family of price indexes produced by the BLS, there are the fundamental questions of both the feasibility and the cost of producing a usable and comprehensive set of indexes.

Developing a Sample

From a practical standpoint, the first and perhaps the biggest hurdle in developing an input price index is developing a frame from which to draw a sample of establishments. While U.S. manufacturing only accounts for approximately one-seventh of the value-added output of the U.S. economy, I determined that, in part because of data availability, this would be the first sector where I would attempt to develop a sample. An earlier work (Alterman 2009) cited the Economic Census produced by the U.S. Census Bureau, which that agency conducts every five years (in years ending in "2" and "7"). In that survey, all U.S. manufacturing firms are asked to include detailed data on their cost of materials, parts, and supplies consumed in the reference year.

In addition, the less comprehensive but timelier ASM, which is based on a sample of 50,000 manufacturing establishments, includes a limited amount of data on purchases, providing one category for total cost of materials, parts, containers, packaging, and other expenses.

One shortcoming of these surveys is that, while data on capital expenditures are also collected, they are only split three ways: into expenditures on 1) motor vehicles, 2) computers, and 3) other. Another potential shortcoming is the timeliness, or lack thereof, of these sources of data. Since the detailed data are only collected once every five years, it may be that by the time the BLS is able to draw a sample and initiate these establishments into a market basket, the establishments or the

products that they buy may be out of date and no longer reflective of their current market.

Although much of the focus has been on the manufacturing sector, the service sector represents nearly two-thirds of GDP. Unfortunately, currently the amount of detailed cost data collected by census for the service industry surveys is more limited. In general, the collection forms include some detailed data on purchased services, but only limited data on purchased equipment and materials.[14] Interestingly, while the census collects very little detailed data on material costs in the noncensus years for manufacturing industries, the level of detailed data collected on the cost of business services, though limited, is roughly the same, whether it is for the Service Annual Survey or the quinquennial Census of Service Industries. In general, the surveys break out the purchases of business services into five categories: 1) computer services, 2) communication services, 3) advertising and related services, 4) professional and technical services, and 5) repair and maintenance services.

Until recently, BLS staff have only been able to access the manufacturing data from the Economic Census while on-site at the Research Data Center at Census Bureau headquarters in Suitland, Maryland. In April 2012, however, the BLS and the Census Bureau signed a memorandum of understanding (MOU) that allowed the BLS to bring these data in-house, thus allowing the bureau to more readily determine whether these data can be used to develop an appropriate sample.[15] The first data sets were transmitted to the BLS in mid-December 2012 and included information on the detailed cost of materials for over 67,000 individual establishments (primarily manufacturers but also including some mining and agricultural companies) that reported information as part of the 2007 Economic Census. The data set represented a subset of the roughly 328,000 U.S. establishments that are coded by the census as manufacturing establishments and included breakouts of the cost of materials for approximately 1,340 individual eight-digit material codes.[16]

The first question that needs to be addressed in drawing a sample is, of course, "What do you want to publish?" Presumably one could construct an input price index either by including all inputs for a given industry, or by including only inputs of a specific material. After discussions with staff from the BEA as well as the OPT, it was determined that from a practical standpoint it would be best to, at least initially,

construct input price indexes that were product-specific. In the 2009 paper, I stated that a full set of input material price indexes covering material inputs to manufacturers would require sampling and pricing roughly 15,000 individual items and calculating and publishing indexes for 600 six-digit categories.[17] Subsequently, these numbers have been further refined for this exercise.

In attempting to draw a sample, the program would start off with several assumptions:

- The sample would, if possible, use the standard BLS methodology, involving a multistage stratified probability-proportionate-to-size (PPS) method.
- A published price index should contain a minimum of 25 repriceable items.
- Because of refusals, out-of-scopes, nonresponses, and deterioration rates, the bureau would need to oversample.
- A cap would be placed on the maximum number of price quotes requested from any individual establishment.
- The sample would only include establishments coded as manufacturers. However, data requested would also include materials produced by mining and agricultural industries, including a large value for crude petroleum purchases by the petroleum refinery industry.
- Purchases of capital expenditures were beyond the scope of this project.
- The sampling process also would set minimum dollar criteria for a given establishment's annual expenditure on cost of materials.

In accessing the detailed census data, it was apparent that there were some complications with the underlying data. For example, although the census collects the cost of materials by eight-digit material codes, which are roughly based on an NAICS structure, these eight-digit codes do not necessarily aggregate to a specific six-digit NAICS. In fact, of the 473 six-digit NAICS codes in manufacturing, only about one-half had eight-digit material codes mapped to them. In the other cases, the eight-digit material codes were apparently sufficiently broad that they cut across six-digit NAICS industries.[18] This creates a number of prob-

lems. For example, it would be difficult to construct a set of indexes at higher levels of aggregation. Also, it would be hard to match up input data with the corresponding domestic output or import data, which would be useful for data verification. Another potential problem with the data stems from the high proportion of the reported values for a given establishment that are not coded to any specific materials category. Approximately one-quarter of the reported value is coded to a "not elsewhere specified" type code.

The strategy used to construct a sampling algorithm for an input price index draws heavily on the algorithms used in the bureau's Producer Price Program and especially on the methodology from the bureau's International Price Program (IPP), which in addition to the import price indexes also produces a set of export price indexes. Like the detailed data collected in the Economic Census, the U.S. Customs and Border Protection (formerly the U.S. Customs Service) database provides a very detailed breakout (through a 10-digit Harmonized System code) of the value of imports by establishment. The customs data are also broken out by month, which permits the BLS not only to sample by detailed product areas but also to sample only those imports of a given company that are consistently traded over time. Unfortunately, the Economic Census data only reflect annual figures, so in using these data there is no way to assess the consistency of a company's purchases over the course of a year.[19]

Although many of the basic methodological challenges associated with producing these new indexes are similar to the issues successfully addressed in the Bureau's current price index programs, there are additional questions that must be addressed. For example, given the once-every-five-years time frame for the Economic Census, are the data too far outdated for reliable use by the time any sample drawn from this census is used to initiate establishments and items into a survey? One possible alternative would be to rely upon the somewhat smaller ASM, which is conducted in every noncensus year. However, while this survey does collect information on an establishment's cost of materials, the ASM does not collect data by eight-digit material categories.[20] Thus, any establishment-specific information on the value of their individual purchases would have to be collected as part of the process of initiating those potential respondents into the program. Of course, the current procedure in drawing an item sample for the producer price

indexes already relies heavily on using data supplied by establishments. However, it is unclear whether establishments would have available the same level of detail for their purchases as they have for their sales.

In any event, we did attempt to draw a sample using the data from the 2007 Census of Manufactures. The algorithm relied primarily on the sampling criteria and sample rotation developed for the import price indexes. As did that algorithm, the formula for the proposed input price index made several assumptions:

- A sample would be drawn—and establishments and their selected items initiated into the program—every two years.
- Prices collected from each sample would be collected for four years.
- Each index would consist of data drawn from two samples. (For example, a sample would be drawn in Year One and a separate sample would be drawn in Year Three. The index for Year Four would include data from both the samples drawn in Year One and those drawn in Year Three.)
- In order to draw a sample large enough to support publishing an index, a given product area would need to be sampled for 30 quotes. (Since an index consists of two overlapping samples, this would imply that a given published index would consist of the remaining data available from what had been 60 potential items.)
- Establishments with a cost-of-materials value (for a specific category) of more than $1 million would be treated as being consistent with a maximum burden of six for that category. Where an establishment/category did not meet this threshold, the category would have a maximum quote burden of two.
- Each sample would consist of approximately 2,500 establishments and approximately 15,000 quotes. (Note that the sample could also be staged, which would result in 1,250 establishments being initiated every year.)
- The samples would be drawn to support the publication of any six-digit category with a value of over $3 billion. All product areas, however, would be sampled and would be used in higher stages of aggregation.

Although the eight-digit cost-of-materials codes do not fully nest to six-digit categories, the sample was drawn as if they did. There were a total of 373 six-digit groupings, of which about 100 would be potentially publishable. These 100 six-digit cost-of-materials groups each had a minimum dollar value of $3 billion in 2007. Publication assumptions could, of course, be adjusted depending on the exact requirements of the end users of these data at the BEA and the OPT.

The selection of the actual item that the Bureau would need to reprice on a periodic basis would normally be done by a BLS field economist during a so-called initiation visit to the establishment. This procedure is one that is already done by staffers when collecting data for the bureau's PPI and IPP programs, and it involves a number of trade-offs. Ideally, the selection would be based on a probability proportionate to the value of a given item a company purchases within the selected category. In theory, if a company buys a certain amount of various types of steel, the field economist, using data supplied by the respondent, would be able to select a specific steel product that the BLS would attempt to collect data on. In practice, however, these procedures would likely have to take into account the fact that the selected item may not be purchased on a regular basis, or the respondent may not have any data available on how much of each different type of steel the company purchased in a given period. Since the BLS already has experience in dealing with these types of issues in its current programs, developing an appropriate fallback procedure does not necessarily present a problem. However, it does lead to what is perhaps the key issue to be faced, which is the ability of the program to reprice the same item month after month, quarter after quarter, or year after year, from the same source.

Pricing

Maintaining a constant set of items to reprice over time may prove the most intractable barrier to constructing a comprehensive set of input price indexes. Whereas on the output side companies tend to ship their goods (or offer their services) every month, it is not clear whether they buy the same item on a regular basis, especially for capital equipment such as computers. This may place a heavier burden on the imputation method chosen for valuing prices in missing periods.[21] Alternatively, the BLS may have to use an altogether different approach, such as com-

bining prices from different respondents (in cases where the item specifications are identical). A related question is how to handle changes in the pricing specifications. Here are some factors to consider:

- What is our general approach toward quality adjustment when a buyer switches products or suppliers? That is, in an ideal situation where we can get the exact information that we desire, what would we ask for?
- What are the acceptable fallbacks if we can't obtain the desired information?
- What if, in fact, the buyer uses multiple suppliers? Do we select a specific supplier or use some sort of average?
- If we select one, how and when do we switch to a price from a different supplier?
- Should the price include or exclude transportation costs?
- If other services are bundled with the product (e.g., installation), how do we handle those situations?
- Do we want to include government purchases?
- If so, how would we sample for them, since they wouldn't be included in data at the Census Bureau?
- How do we coordinate requests for buyers' prices with requests for sellers' prices within the same firm?

Eventually, though, the bureau will need to attempt to collect information from a sample of representative companies. A final decision on some of these issues will probably entail balancing the requirements of a price index with the reality of the bureau's sometimes limited ability to collect data from private industry through voluntary surveys.

The BLS determined that a critical first step in this process would be to get feedback from a representative group of establishments on their buying practices, their ability and willingness to voluntarily supply data to the BLS, and their receptivity to, and interest in, the bureau's effort to produce these price index series.[22] To that end, in May 2012, staff at the BLS set up a focus group with members of the Institute for Supply Management (ISM) in conjunction with that organization's annual meeting. Founded in 1915 as the National Association of Purchasing Agents, ISM is considered one of the largest and most

respected supply management associations in the world and boasts a total membership of nearly 40,000. Prior to the meeting, the focus group members were sent a set of questions designed to elicit input on the feasibility of the bureau's effort to produce a new set of indexes. In general, the focus group participants indicated that their establishments would almost certainly have the data available that the BLS would need to construct these indexes, and they did not believe cooperation issues would be any different from what the bureau currently experiences with establishments.

Estimation Formula

With one exception, as opposed to the questions associated with sampling and repricing, the issues surrounding the estimation formula are comparatively easy. Weights can either be derived from the sampling frame, from the respondents themselves, or from some combination thereof. One concern with using the weights derived from the sampling frame is the age of the data. Since the detailed data are collected only once every five years, the data may be out of date by the time they are actually used in the calculation of the indexes. A comparison of these values from one census to the next may shed light on the volatility of these figures.

There are various considerations involved in what actual formula to use, such as choosing between arithmetic and geometric mean formulas, but these do not present intractable barriers. One interesting aspect of the formula relates to theoretical differences between the price index formula for the output from a production function and the price index formula for inputs into a production function. The theory assumes that a firm will attempt to maximize profits by minimizing costs while maximizing revenue. On the output side, theory tells us that an establishment will attempt to shift sales to its goods or services that over time are becoming relatively more expensive compared to its other outputs. On the input side, the firm would attempt to shift costs toward its expense categories that are becoming relatively cheaper. Consequently, all else being equal, the price index of firms' outputs would tend to show at least no decline in the relative quantity of the more expensive goods being sold, while on the cost side, the index should in theory reflect at least no increase in the purchase of goods or services that are more expensive. What is interesting, however, is that these assumptions are

based on partial equilibrium models where the model is only looking at one side of the equation. But of course one establishment's sales are another establishment's purchases, and in a general equilibrium model, there is no a priori theory of exactly what constitutes the correct direction of substitution.[23]

One notable issue in estimating these indexes relates to how one goes about constructing industry-specific price indexes. Note that in calculating GDP, Method 2 relies on collecting data for both outputs and inputs by industry. While a product-based input price index would use every establishment's purchases of a specific good (or service), an industry-specific input price index would only use goods or services purchased by establishments in that specific industry. For example, presumably all establishments must purchase energy, be it electricity, gas, petroleum products, or other forms. Would the BLS attempt to calculate a separate energy index for each industry, or would it combine all energy data into one generic input energy index? For now the approach is based on practical consideration—i.e., do we have enough data for separate energy series, or does each of the different energy series trend nearly the same? Of course, a proxy for an industry-specific input price index could be constructed using individual product-level price indexes but aggregating them using the proportions appropriate for a particular industry's purchasing patterns.

Developing a Pilot

A longer-term effort to produce input price indexes can be broken down into four phases, based on availability of data. This effort will require additional approvals and funding as well. The four phases include

1) Input indexes covering manufacturers' material costs,
2) Input indexes covering manufacturers' capital equipment costs,
3) Input indexes covering manufacturers' business services costs, and
4) Input indexes covering service industries' material, capital equipment, and business services costs.

Ideally, each phase would start with a pilot prior to going into production. For each pilot, the BLS would conduct research and develop

the methodology, procedures, and systems associated with each of the following steps:

- Obtain permission from the Office of Management and Budget.
- Select a set of industries for the pilot.
- Evaluate the data sources that are available for a sampling frame. Because of the availability of detailed cost data from the quinquennial Census of Manufactures, the first phase would focus on input indexes of cost of materials for manufacturing industries.
- Develop the collection materials and procedures and train staff.
- Select a sample of establishments for the pilot.
- Conduct the pilot test and evaluate the results.
- Based on the results of the pilot, finalize resource and data requirements for developing and maintaining an input price index, including publication goals, required sample size, expected burden, and estimated time frame for publication.

SUMMARY

There has been a long-standing interest in both producing an input price index and obtaining prices from buyers. The dramatic growth in imports as a source of domestic supplies has also served to underscore the increasing need for these data. There would be, however, a significant cost to developing these new series data, and it would take some time to put them into production. As resources permit, the bureau will continue its research on this topic.

Notes

1. This paper was the result of combining works from two related conferences. The first conference was called "Measurement Issues Arising from the Growth of Globalization" and was held November 6–7, 2009, in Washington, D.C. The second conference was "Measuring the Effects of Globalization," held February 28–March 1, 2013, also in Washington, D.C. I would like to thank Mike Horrigan, John Greenlees, Steve Paben, Maureen Doherty, Ted To, Mina Kim, Jenny FitzGerald, and David Friedman for their contributions and comments. I would also like to thank Shawn Klimek and Lynn Riggs at the U.S. Census Bureau for their assistance in gaining access to census data. All views expressed in this paper are those of the author and do not necessarily reflect the views or policies of the U.S. Bureau of Labor Statistics or the U.S. Census Bureau.
2. Note that the Consumer Price Index is designed to pick up these price changes but is only used to adjust estimates of domestic consumption.
3. This assumes that the prices of chairs A, C, and D do not decrease in response to the change in the price of Chair B resulting from the switch from domestic production to being imported. The bureau, however, has conducted an analysis of PPI data that provides some evidence that prices from domestic producers are influenced by the degree of import penetration in their industry. See Doherty (2012).
4. Note that the PPI does currently construct output price indexes for wholesalers and retailers; these indexes presumably include data on both imported and domestically produced goods. However, these indexes are only gross margin indexes, and as such they only represent the difference between their selling price of a good and the acquisition price for that same item. In addition, the data collected do not delineate between import goods and domestic goods.
5. Information on the Sloan Foundation study, and the subsequent conference, can be found here: http://research.upjohn.org/cgi/viewcontent.cgi?article=1006&context=externalpapers. A summary of the conference was included in the February 2011 issue of the *Survey of Current Business*.
6. If the rate of change was consistent over time, it might have been easier to model a "discount" factor to apply to import prices in order to adjust for this shift.
7. Price indexes, for example, must take into account ongoing shifts in the market basket of items being priced, as some products are discontinued and new items enter into consumption.
8. Actually, prior to the Stigler Report, the PPI had done some work in evaluating the use of buyers' prices. In 1942, the PPI did a study of buyers' prices for eight selected items of steel mill products for six time periods and compared them to list prices. The results of the study showed that the buyers' prices moved differently from list prices for short periods of time but that longer-term list and invoice prices were comparable.
9. Note that the bureau does have extensive experience with constructing price indexes that, in theory, are input price indexes, since both the import price indexes and the Consumer Price Index are constructed from buyers' prices.

10. Labor input for private business and private nonfarm business estimates include labor composition effects. These labor composition effects reflect the fact that the hours worked are adjusted for changes in the composition of workers over time.
11. Note that the BLS makes use of product-specific data in constructing deflators for a set of input price indexes for a given industry's material costs. Ideally, an input price index would be industry-specific, but that may prove cost-prohibitive.
12. There is also a third approach, commonly referred to as the Income Approach, which is not directly relevant to this discussion.
13. In practice, Method 1 is actually more effective at measuring total domestic consumption. Indeed, the deflator for "C" uses the CPI, which does include imported consumer goods. However, Method 1 is not as effective in estimating domestic production. Note, however, that even if the BLS had a complete set of input price indexes, Method 2 might still have some data problems, as information currently collected on purchases by industry and related information may not be as timely or as detailed as the data currently collected for Method 1.
14. For example, in contrast to the forms for the furniture manufacturing industry, the collection form for the parallel furniture wholesale sector does not provide the same level of detail on material costs, while the collection form for the retail furniture industry does not collect *any* information on the cost of materials.
15. "Memorandum of Understanding between the U.S. Bureau of Labor Statistics and the U.S. Census Bureau 61-12-MOU-06," signed on April 12, 2012. Under the terms of the agreement, the BLS does not have access to firms consisting of only one establishment, as their information is considered to fall under the purview of Title 26 of the United States Code, comprising federal tax regulations, and cannot be made available to the BLS.
16. Note that a company can consist of more than one establishment and that the data set analyzed at the BLS only included data from approximately 19,000 multiestablishment manufacturers (referred to as "enterprises"). However, these multiestablishment enterprises were estimated to account for roughly 93 percent of materials that were purchased by all manufacturers in 2007. The published data from the census Web site puts the total cost of "materials, parts, containers, packaging, etc., used" in 2007 at approximately $2.63 trillion (U.S. Census Bureau 2013). For comparison purposes, in 2007 the United States exported goods valued at $1.15 trillion and imported goods worth $1.97 trillion. In 2007 domestic manufacturers shipped products with a gross value of $5.34 trillion.
17. For comparison purposes, the BLS's International Price Program collects prices for approximately 25,000 items and publishes 1,050 series, whereas the BLS's Producer Price Program includes approximately 100,000 quotes and publishes 9,500 series.
18. It should be noted that in the new 2012 NAICS manual, the number of six-digit NAICS industries has been reduced to 364. One follow-up project would be to attempt to revise the eight-digit material codes so they accord more readily to six-digit NAICS codes.
19. The BLS price indexes come out monthly, which enables researchers to know how sporadic trade is. This helps in developing a repriceable market basket of items.

20. As part of the MOU signed by the Census Bureau, the BLS also requested access to the detailed multiestablishment data from the Annual Survey of Manufactures. These data were delivered during the second quarter of Fiscal Year 2013 and are being analyzed by the BLS in order to assess the survey's utility in drawing a sample for an input price index.
21. In constructing a sample for the import price index, the International Price Program has the advantage of accessing the universe of import transactions from the U.S. Customs and Border Protection agency, which allows for drawing a sample only of those items and importers who trade consistently over the course of a year.
22. Data collection for all BLS price programs is conducted on a voluntary basis.
23. For further elucidation, see Kim and To (2009).

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