

# Producing an Input Price Index

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## *Introduction*

This paper is designed to address the need--and especially the feasibility--of producing what is referred to as an input price index, at the U.S. Bureau of Labor Statistics (BLS).<sup>ii</sup> The current interest in this set of proposed price indexes arose over 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.<sup>iii</sup> 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, the US. Import Price Index (MPI), the U.S. Export Price Index (XPI), and 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 has subsequently has its production sent overseas, will no longer be tracked in the PPI. Correspondingly, the MPI index 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, 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, BLS itself recognized the need for this type of series over thirty 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 due primarily to budget limitations, this earlier effort at an input price index was never extended.

This paper will detail the problem in the current methodology for price indexes this index would be designed to overcome, as well as reviewing some of the evidence on the need for these data. Finally, the paper will discuss the practical aspects and limitations of attempting to produce such an index. These will 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 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 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 only tracks Chair A for the entire period, and Chairs B and C for the months that they are domestically produced. The Import Price Index (MPI) only tracks 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.<sup>iv</sup>

**Table 1**

		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-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

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 associated from the offshoring of chairs B and C would be to construct a price index that would directly track the price changes of items as they move from 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.<sup>v</sup>

### ***Why an Input Price Index is Important***

Although 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 in the Nation's economic data. This potential gap in BLS data, however, became more serious as the proportion of the U.S. economy tied into the global economy expanded and especially in conjunction with the growing perception that U.S. jobs are being lost to foreign competition and foreign workers. The potential shortcomings in the BLS indexes were highlighted in an article in *Business Week* in the summer of 2007, and subsequently in a study funded by the Sloan Foundation and the Bureau of Economic Analysis (BEA).<sup>vi</sup> As the article and the study pointed 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 constructed by BEA, and industry productivity estimates constructed by 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, that is inflation-adjusted basis (also referred to as real, as opposed to 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 BLS. Consequently, BEA and BLS must make use of whatever price data are available. Generally this has required the agencies to make use of the PPI output price indexes and/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 magazine story estimated that the increase in real GDP from 2003 to mid-2007 may have been overestimated by \$66 billion.

As some evidence, the article also pointed out the apparent contradictory behavior of consumer prices for furniture--which have been falling--at the same time the indexes for domestic producer prices as well as import prices for this category have both been moving higher. Conversely, the article also inferred 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 its 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 BLS, and for their

implications in U.S. estimates of GDP and productivity. Kurz and Lengermann (2008) note that foreign inputs accounted for one-third of growth in the manufacturing sector between 1997 and 2005. Subsequently, Houseman, Kurz, Lengermann and Mandel (2011) argue 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 0.2 to 0.5 percentage points from 1997 to 2007. Feenstra, et al (2009) also attributes a substantial portion of the apparent acceleration in productivity gains after 1995 to gains in the terms of trade and tariff reductions. Additional work on this topic has also been conducted by Houseman, Bartik and Sturgeon (2013), who raise specific concerns over potential over-estimates of productivity in the computer sector. In looking at Japanese data, Fukai and Arai (2013) conclude that Japan also has “a relatively large offshoring bias,” while Inklaar (2013), using data from 38 economies, 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, Diewert and Nakamura (2013) see the need for a large increase in data collection by the statistical agencies as well as changes in their price index methodology that would allow more direct comparisons of closely related items from different sources.

In order to provide additional evidence for the growing need for a set of input price indexes which 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 Chart A.] Equally important, between 1997 and 2007, the percent of imports in inputs increased by an average of over 0.4 percent a year, while in the prior decade, the percent 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.<sup>vii</sup>

Indeed, globalization is perhaps 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 Business Week article-- recorded a dramatic increase in the value of imports during the past decade, jumping from \$13.2 billion in 1999 to \$27.0 billion in 2007. Despite this increase, in 2006 the preliminary estimate from the Annual Survey of Manufactures for the household wood furniture sector recorded an increase in value of domestic production, up to \$13.5 billion. 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 NAICS (North American Industry Classification System) number when they shift from being a manufacturer to being essentially a wholesaler. The key point is that economic data that is tasked with reflecting current trends, must be flexible enough to allow for continual changes in the composition of the economy.<sup>viii</sup> Ideally an input price index will facilitate this 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, made a number of recommendations surrounding the Wholesale Price Indexes, which

was the name of the industrial price series then being produced by 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 buyer's prices and not on seller's prices. The report included a study which suggested that buyer's prices were more likely than list prices to reflect 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, due to 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.<sup>ix</sup> 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 buyer's prices was subsequently published in Stigler and Kindahl (1970), which pointed out the differences in price trends between buyers' and sellers' prices. As much of the concern with the then BLS Wholesale Price Index 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 and 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 due to 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 ingot using buyers' prices from a judgmentally 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 because the PPI was able to create a sampling frame and document the typical transaction characteristics of buyers in this product area. After significant resources were 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 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 when indexes calculated using sellers' transaction prices were introduced from the systematic sample for the Primary Aluminum industry output index, the buyers' price commodity index for aluminum ingot 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 for industries as well as other indexes. For example, in the early 1960's 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 1970's, 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 every industry in the private economy and to publish a system of price indexes that included;

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

In the late 1970's the Bureau began systematically sampling industries and starting in 1980 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 now covers 98 percent of in-scope 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 Robert Archibald in 1975.

Furthermore, as an attempt to fulfill the recommendations of the Stigler report, and as a component of its 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 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. These series were discontinued in 2003, but the method is still used in BEA and BLS for constructing input price indexes where necessary.<sup>x</sup>

### ***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 BLS, and the Industry Sector Division of BEA.

#### **BLS**

We will start with 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, which are then compared to just two inputs, capital and labor.<sup>xi</sup> The value of material inputs is excluded from these calculations. However, staff does use detailed price indexes to deflate capital expenditures. Physical capital, as measured by OPT,

consists of 42 types of equipment and software, 21 types of nonresidential structures, 9 types of residential capital, inventories (manufacturing available for 3 stages of fabrication), and land. Deflation of each capital expenditure category is actually done at the detailed 5 or 6 digit-I/O level.

Secondly, OPT also publishes annual multifactor productivity measures for total manufacturing and 18 broad three-digit NAICS manufacturing industries, comparing sectoral output (total output excluding intra-industry or intrasector transactions) to a broad set of inputs, including capital, labor, energy, materials and business services (KLEMS) inputs. [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 OPT are obtained from BEA.

Finally, OPT publishes more detailed annual multifactor productivity measures for 86 four-digit NAICS manufacturing industries, plus air transportation and line-haul railroads. These productivity measures also compare industry sectoral output to a broad set of combined inputs. 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 (Input-Output) tables produced by BEA. I/O commodities from the benchmark I/O tables generally relate to the primary products of 6-digit NAICS industries, or

occasionally a combination of industries. For materials commodities that are heavily imported, OPT's Division of Industry Productivity Studies (DIPS) combines PPIs and import price indexes using weights from BEA's import matrix. DIPS also uses PPIs in creating weighted deflators for deflating annual fuels purchases of each industry.

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 the roughly 6-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.<sup>xii</sup> Since industry MFP calculations are based on annual data, the nominal input values are adjusted by annual PPIs (average of 12 monthly price indexes).

## BEA

The Industry Sector Division at 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, BEA's flagship GDP estimates. Although BEA does not publish detailed annual real I-O estimates, they do 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 in the work at BLS, BEA attempts to make their adjustments at the most detailed level possible. For example, at BEA, the effort to construct updated values for intermediate inputs of goods and services entails making adjustment to approximately 3,500 different items, of which roughly 2,300 represent categories of goods. Ideally, and like BLS, BEA would like input price indexes *by industry* for each of the 1,179 six-digit NAICS level of detail. In practice, since the

cost of producing that many separate price indexes could be prohibitive, like BLS, 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 Manufacturing (ASM) forms (most of which are services inputs). While 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 important to note because GDP can be estimated using two different methods: It can be constructed by using measuring final sales (Method 1) or it can be estimated using a value added approach (Method 2).<sup>xiii</sup> The current methodology in the U.S. focuses on the former.

1.  $Y = C + I + G + (X - M)$  (Expenditures/Final Sales Approach)
2.  $Y = \sum (S_i - C_i)$  (Production, or Value-Added Approach)

Where  $S_i$  represents Total Sales for industry  $j$ , and  $C_i$  are 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 due to offshoring, as an *input price index* does not play a role in the computation as 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.<sup>xiv</sup>

In order to further illuminate why the Bureau's 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 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 Bureau 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) if whether in the past he sourced an item domestically. It would also be hard to get the reverse, asking an importer who no longer imports, if whether the sampled good is now produced domestically and if so, what is the price. 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 prices index production process.

It should also be pointed out that an input price index will not alleviate problems arising when goods and services which 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 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 BLS, there is the fundamental question of both feasibility and 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, it was determined that, due in part to data availability, this would be the first sector where we would attempt to develop a sample. Earlier work (Alterman, 2009) cited the Economic Census produced by the U.S. Census Bureau, which that agency conducts every 5 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, etc.

One shortcoming of these surveys is that, while data on capital expenditures are also collected, they are only split three ways: a) motor vehicles, b) computers and c) 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 and/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 2/3 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.<sup>xv</sup> Interestingly, while the Census collects very little detailed data on material costs in the non-Census years for manufacturing industries, the level of detailed data collected for 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 5 categories: computer services, communication services, advertising and related services, professional and technical services, and repair and maintenance services.

Until recently BLS staff have only been able to access the manufacturing data from the Economic Census while onsite at the Research Data Center at Census in Suitland, Maryland. In April 2012, however, BLS and the Census Bureau signed a Memorandum of Understanding (MOU) that allowed BLS to bring these data in-house, thus allowing the Bureau to more readily determine if these data can be used to develop an appropriate sample.<sup>xvi</sup> The first datasets were transmitted to 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 dataset represented a subset of the roughly 328,000 U.S. establishments that are coded by Census as manufacturing establishments and included breakouts of the cost of materials for approximately 1,340 individual 8-digit material codes.<sup>xvii</sup>

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 all inputs for a given industry, or by inputs of a specific material. After discussions with staff from BEA as well as 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, it was stated that a full set of input material price indexes covering material inputs to manufactures would require sampling and pricing roughly 15,000 individual items and calculate and publish indexes for 600 6-digit categories.<sup>xviii</sup> Subsequently, these number have been further refined for this exercise.

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

1. The sample would, if possible, use the standard BLS methodology, using a multi-stage stratified probability-proportionate-to-size (PPS) method.
2. A published price index should contain a minimum of 25 repriceable items.
3. Due to refusals, out-of-scopes, non-response and deterioration rates, the Bureau would need to oversample.
4. A cap will be placed on the maximum number of price quotes requested from any individual establishment.
5. 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.

6. Purchases of capital expenditures were out-of-scope of this project.
7. 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 are some complications with the underlying data. For example, while the Census collects the cost of materials by 8-digit material codes which are roughly based on a NAICS structure, these 8-digit codes do NOT necessarily aggregate to a specific 6-digit NAICS. In fact, of the 473 six-digit NAICS codes in manufacturing, only about one-half had 8-digit material codes mapped to them. In the other cases, the 8-digit material codes were apparently sufficiently broad that they cut across six-digit NAICS industries.<sup>xix</sup> This creates a number of problems. For example, it would be difficult to construct a set of indexes that aggregated upward. 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 is due to 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 detail in the Economic Census, U.S. Customs and Border Protection (formerly the U.S. Customs Service) database provides a very detailed (by 10-digit Harmonized System code) breakout of the value of imports by establishment. The Customs data are also broken out by month, which permits BLS to not only sample by detailed product areas, but also sample only a given company's imports that are

consistently traded over time. Unfortunately, the Economic Census data only reflect annual figures so, using these data, there is no way to assess the consistency of a company's purchases over the course of a year.<sup>xx</sup> In contrast to the IPP methodology, the current PPI methodology does not draw a sample in the National Office that includes detailed product category samples. This step in the PPI is conducted when establishments are approached and initiated into the Program.<sup>xxi</sup> 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 outdated for reliable use by the time any sample drawn from it 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 every non-Census year. However, while this survey does collect information on an establishment's cost of materials, the ASM does not collect data by 8-digit material categories.<sup>xxii</sup> 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 if 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. Similar to 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 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 that 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 over \$1.0 million would be treated as 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 2.
- Each sample would consist of approximately 2,500 establishments and approximately 15,000 quotes. (Note that the sample could also be staged so roughly 1,250 establishments would be initiated every year.)
- The samples would be drawn to support the publication of any six digit category with a value of over \$3.0 billion. All product areas, however, would be sampled and would be used in higher stages of aggregation.

Although the 8-digit cost of materials codes do not fully nest to 6-digit categories, the sample was drawn as if they did. There were a total of 373 6-digit groupings, of which about 100 would be potentially publishable. These 100 6-digit cost of materials groups each had a minimum

dollar value of \$3.0 billion in 2007. Publication assumptions could, of course, be adjusted depending on the exact requirements of the end users of these data at BEA and 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 involves a number of tradeoffs. Ideally the selection would be based on a probability proportionate to the value of a given item a company purchases within the selected category. Ideally, if a company buys a certain amount of varying 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 BLS already has experience with these types of issues in its current programs, developing an appropriate fallback procedures does not necessarily present a problem. However, it does lead in 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. While on the output side, companies tend to ship their goods (or offer their services) every month, it is not clear if 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.<sup>xxiii</sup>

Alternatively, the BLS may have to use an altogether different approach, such as combining prices from different respondents (in cases where the item specifications are identical). A related question is how to handle changes in the pricing specifications. What is our general approach towards quality adjustment when a buyer switches products and/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 Census? How do we coordinate requests for buyers' prices with requests for sellers' prices within the same firm? Eventually, however, 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.

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 BLS, and their receptivity to, and interest in, the Bureau's effort to produce these price index series.<sup>xxiv</sup> 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 with 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 BLS would need to construct these indexes, and they did not believe cooperation issues would not be any different from what the Bureau currently experiences with establishments.

### Estimation formula

With one exception, compared 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 questions associated with the 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, versus the index formula for the price index 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. In contrast, the firm would attempt to shift costs towards its expense categories that are becoming relatively cheaper. Consequently, all else equal, 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 purchases of goods or services that are more expensive. What is interesting, however, is 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.<sup>xxv</sup>

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, etc. 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 do 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,
- 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, BLS would conduct research and develop the methodology, procedures, and systems associated with each of the following activities:

- 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. Due to 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.

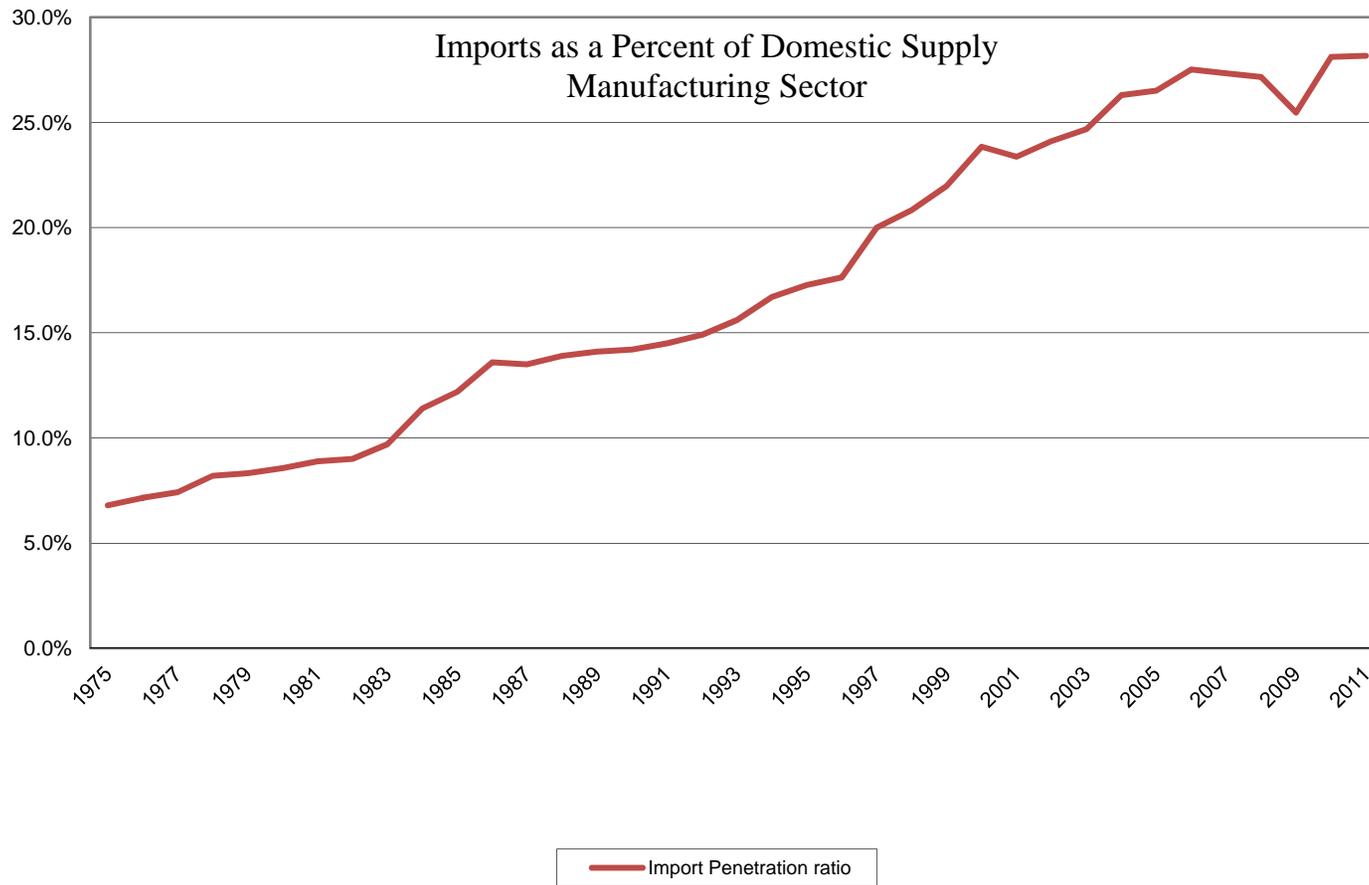
- Based on the results of the pilot, finalize resource and data requirements for developing and maintaining an input price index, including publication goals, required sample size, expected burden and estimated timeframe for publication.

## ***Summary***

There has been a longstanding interest in both producing an input price indexes and in 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.

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**Chart A:**

There is a break in the series in 1998. Data prior to 1998 is based on SIC classification of manufacturing . More recent data is based on NAICS classification.

Source: Bureau of Economic Analysis

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<sup>i</sup> William Alterman is an economist with the U.S. Bureau of Labor Statistics. This paper was the result of work from two related conferences. The first was “Measurement Issues Arising from the Growth of Globalization” Conference held November 6-7, 2009 in Washington, DC. The second was “Measuring the Effects of Globalization” Conference held February 28<sup>th</sup> and March 1<sup>st</sup> 2013, also in Washington, DC. The author wishes 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 Census Bureau for their assistance in gaining access to Census data. All views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the U.S. Bureau of Labor Statistics or the U.S. Census Bureau.

<sup>ii</sup> The type of index is sometimes referred to as a Buyers’ Input Price Index.

<sup>iii</sup> Note that the consumer price index is designed to pick up these price changes, but is only used to adjust estimates of domestic *consumption*.

<sup>iv</sup> 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. 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).

<sup>v</sup> Note that the PPI does currently construct output price indexes for wholesalers and retailers, which presumably includes data on both imported and domestically produced goods. However, these indexes are only gross margin indexes, and 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.

<sup>vi</sup> “The Real Cost of Offshoring” [http://www.businessweek.com/magazine/content/07\\_25/b4039001.htm](http://www.businessweek.com/magazine/content/07_25/b4039001.htm)

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>, while a summary of the conference was included in the February 2011 Survey of Current Business.

<sup>vii</sup> 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.

<sup>viii</sup> Price indexes, for example, must take into account ongoing shifts in the market basket of items being priced as some products are discontinued while new items enter into consumption.

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<sup>ix</sup> 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 8 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 than list prices for short periods of time but longer term list and invoice prices were comparable.

<sup>x</sup>Note that the Bureau *does* have extensive experience with constructing price indexes that, in theory, are input price indexes, as both the import price indexes as well as the Consumer Price Index are constructed from buyers' prices

<sup>x<sup>i</sup></sup> Labor input for private business and private nonfarm business estimates include labor composition effects. The meaning of labor composition effects should be spelled out. What he means is that hours worked are adjusted for changes in the composition of workers over time.

<sup>x<sup>ii</sup></sup> Note that 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.

<sup>x<sup>iii</sup></sup> There is also a third approach, commonly referred to as the Income Approach, that is not directly relevant to this discussion.

<sup>x<sup>iv</sup></sup> 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.

<sup>x<sup>v</sup></sup> For example, in contrast to the forms for the furniture manufacturing industries, 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.

<sup>x<sup>vi</sup></sup> *Memorandum of Understanding Between the U.S. Bureau of Labor Statistics and the U.S. Census Bureau 61-12-MOU-06*, signed on 4/12/2012. Under the terms of the agreement, 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, Federal Tax Information, and cannot be made available to BLS.

<sup>x<sup>vii</sup></sup> Note that a company can consist of more than one establishment, and the dataset analyzed at BLS only included data from approximately 19,000 multi-establishment manufactures (referred to as *enterprises*). However, these multi-establishments enterprises were estimated to account for roughly 93 percent of materials that were purchased by all manufacturers in 2007. The published data from Census website puts the total cost of "Materials, parts, containers, packaging, etc. used" in 2007 at approximately \$2.63 trillion. [http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ASM\\_2008\\_31GS101&prodType=table](http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ASM_2008_31GS101&prodType=table) . For

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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.

<sup>xviii</sup> For comparison purposes the International Price Program collects prices for approximately 25,000 items and publishes 1,050 series while the Producer Price Program includes approximately 100,000 quotes and publishes 9,500 series..

<sup>xix</sup> It should be noted that in the new 2012 NAICS manual, the number of 6-digit NAICS industries has been reduced to 364. One follow-up project would be to attempt to construct a new mapping between 8-digit material codes and 6-digit NAICS codes.

<sup>xx</sup> Since the BLS price indexes are monthly, knowing how sporadic trade is helps in developing a repriceable market basket of items.

<sup>xxi</sup> Information on the universe of establishments from which to draw the sample is available from the Bureau's Quarterly Census of Employment and Wages. These data, however, only contain information on the number of employees in a given establishment, not the value of shipments.

<sup>xxii</sup> As part of the MOU with Census, BLS also requested access to the detailed multi-establishment data from the Annual Survey of Manufactures. These data were delivered during the second quarter of fiscal 2013 and are being analyzed by BLS in order to assess its utility in drawing a sample for an input price index.

<sup>xxiii</sup> 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 Customs Service, which allows for drawing a sample only of those items and importers who trade consistently over the course of a year.

<sup>xxiv</sup> Data collections for all BLS price programs are conducted on a voluntary basis.

<sup>xxv</sup> For further elucidation, see Kim and To (2009)