Alternative Weighting of the Hospital Market Basket Input Price Index
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<u>Abstract</u>

The inpatient hospital prospective payment system (IPPS) input price index, or market basket, represents a weighted average of hospital input prices. The cost shares (weights) currently incorporated in the index are 2002-based; 1997 weights were used in the prior rebasing. Since the Medicare Modernization Act (P.L. 108-173, Section 404) requires the hospital market basket weights be rebased more frequently than every five years, this paper investigates the influence of annual changes to these weights on the IPPS market basket input price index. Results show small differences when compared to the historical market basket index. Further, because the hospital input price index is constructed as a Laspeyres price index, it is possible other price formulations, namely Paasche, Fisher, and Tornqvist, may lead to different results. Employing the same source data as the published hospital input price index, results using these alternative formulations closely match the Laspeyres outcomes.

I.   Background of the Hospital Market Basket Price Index

The market basket concept, developed by Freeland, Anderson, and Schendler (1979), measures changes in the prices of goods and services used to produce hospital care. Later, as required by the 1983 amendment to the Social Security Act (Section 1886(b)(3)(B)(iii)), the market basket was included as part of the inpatient prospective payment system (PPS) to determine the annual update of Medicare payments to hospitals. This system of updates went into effect on October 1, 1983 (P.L. 98-21). The components or expenditure categories that make up the current market basket are listed on Table 1.

Hospital data from the Medicare Cost Reports are used in conjunction with data from the Bureau of Economic Analysis' (BEA) input-output (I-O) tables to create the index. Based on this data, cost categories are selected and their respective weights are calculated. Price or wage proxies, most of which are developed and published regularly by the Bureau of Labor Statistics (BLS), are then matched to their respective cost category. Together, the weights and price proxies are used to construct the hospital input price index.

Periodically, the Centers for Medicare & Medicaid Services (CMS) recalculates, or rebases, the weights to account for any changes in the composition of hospital costs. The last such rebasing was published in the August 12, 2005 **Federal Register** (70 FR 47387).

Medicare's diagnosis-related group-based (DRG) hospital payment rates are updated using the IPPS market basket. These updates are constructed from the base-period weights and quarterly forecasts of the year-over-year four-quarter moving average of the price proxies. These forecasts are produced for CMS by Global Insight, Incorporated (GII). The fiscal year (FY) 2008 update of the hospital input price index was 3.3 percent (72 FR 48173).

This paper proceeds as follows. In Section II, the Laspeyres price formulation, as well as alternative price indexes, namely the Paasche, Fisher, and Tornqvist, are presented. In Section III, the data used in this study are discussed. Results appear in Section IV. Section V contains some final thoughts.

II. Formulations of Various Price Indexes

This section presents formulas for the Laspeyres, Paasche, Fisher, and Torqvist price indexes. Note that each summation symbol represents the aggregate of the N detailed components i which make up the aggregate.

A. Laspeyres price index

The Laspeyres price (LP) index is based on a fixed-weight, or fixed market basket of goods and services from a base or previous period. It is a weighted average of market basket component price relatives where the weights are the shares of the components in the base or previous period. Laspeyres price indexes identify changes in expenditures due to changes in prices, holding base- or previous-period weights (or quantities) unchanged.[1]

Laspeyres price indexes with base-period weights are portrayed as follows:

$$(1a) \qquad LP = \frac{\sum_i^N p_{i,t} \times q_{i,0}}{\sum_i^N p_{i,0} \times q_{i,0}}, \quad \text{for } t = 0, \ldots, T$$

In equation (1a), $p_{i,t}$ represents the current-period price of the i-th of N components under the aggregate. $p_{i,0}$ and $q_{i,0}$ are the base-period price and quantity, respectively, of the i-th component in the base period.

If the weights (or quantities) vary during the time period, Laspeyres chain relatives are formed, where:

$$(1b) \qquad LP = \frac{\sum_i^N p_{i,t} \times q_{i,t-1}}{\sum_i^N p_{i,t-1} \times q_{i,t-1}}, \quad \text{for } t = 0, \ldots, T$$

In equation (1b), $p_{i,t-1}$ and $q_{i,t-1}$ are the price and quantity, of the i-th of N components in the previous period. The Laspeyres are chained forwards (or backwards) and then are applied to a particular index level to form the index. In this case, base-period prices and quantities are not necessary.

Note that Laspeyres price indexes can overstate inflation because they do not adjust for any substitutions that may have been made in response to relative price changes and for quality improvements.[2]

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[1] A description of the Laspeyres price index, as well as the Paasche, Fisher, and Tornqvist price indexes appear in the System of National Accounts (United Nations 2008).

[2] There are two types of substitution, cross-component and within-component substitution. Cross-component substitution occurs when, say, an increase in hospital wage rates leads to the use of fewer labor services and to the increased use of another expenditure component (a substitute), one with a relatively smaller price change, maybe medical instruments. (Wages and medical instruments are two of the expenditure components that make up the hospital market basket. These, along with the other market basket components are listed on Table 1.) In the case of the Laspeyres price relative, the weights do not change, they are held constant from the previous or base period.

B. Paasche price index

The Paasche price (PP) index is based on a fixed-weight or fixed market basket of goods or services from the current period. It is a weighted average of market basket component price relatives where the weights are the shares of the components in the current period. Paasche price indexes differ from Laspeyres price indexes; the former identify changes in expenditures due to changes in prices, holding current, as opposed to base period quantities, unchanged (United Nations 2008). Paasche price indexes (PP) are portrayed as follows:

$$\text{(2a)} \qquad PP = \frac{\sum_{i}^{N} p_{i,t} \times q_{i,t}}{\sum_{i}^{N} p_{i,0} \times q_{i,t}}, \quad \text{for } t = 0, \dots, T$$

In equation (2a), $p_{i,t}$ and $q_{i,t}$ represent the current-period price and quantity of the i-th of N components under the aggregate, while $p_{i,0}$ is the base-period price of the i-th component under the aggregate.

Given varying weights (or quantities), Paasche chain price relatives are formed, whereby:

$$\text{(2b)} \qquad PP = \frac{\sum_{i}^{N} p_{i,t} \times q_{i,t}}{\sum_{i}^{N} p_{i,t-1} \times q_{i,t}}, \quad \text{for } t = 0, \dots, T$$

In equation (2b), $p_{i,t-1}$ is the previous-period price of the i-th component under the aggregate. This equation is the Paasche chain relative. The Paasche are chained forwards (or backwards) and then are applied to a particular index level to form the Paasche index. In this case, base-period prices are not necessary.

Paasche price indexes tend to understate inflation because they more heavily weight items purchased more extensively today, presumably because, in response to inflation, prices for such items rose more slowly than prices for items purchased in the base or previous period (United Nations 2008). If the relative price of a particular market basket item rises, there may be substitution to another, relatively less

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Therefore, in this example, the substitution away from labor due to an increase in wage rates is not reflected in the wage share; hence, hospital prices are overstated.

Substitution can also occur within a component. An increase in the pay of physician's assistants may induce hospitals to use more nurse practitioners, registered nurses (RN), licensed practical nurses (LPN), or other staff. Since nurse practitioners, RNs, LPNs, and other related staff are in the same market basket component as physician's assistants, this is within-component substitution. As shown on Table 1, the price proxy for hospital wages is the employment cost index (ECI) for wages and salaries for civilian hospital workers. BLS publishes ECIs for all hospital workers, but specific ECIs for physician's assistants, nurse practitioners, RNs, LPNs, and so on, are not available. Therefore, although some within-component substitution may exist, it is immeasurable due to difficulties in differentiating employment cost differences among these different hospital employees.

Hospitals may respond in other ways than by substituting lower priced inputs. Since, under PPS, Medicare hospital reimbursements per DRG do not change, hospitals which produce care at below the DRG rate have an incentive to maximize the difference between reimbursements and costs. They can do this by not only substituting lower priced inputs, but also by increasing productivity, by increasing their output price, or by a combination of any or all of the three. (These possibilities are outlined in Arnett, et al. (1985) and a payment framework constructed for PPS skilled nursing facilities (SNF) (Office of the Actuary 2000). The PPS SNF framework contains features applicable to PPS hospitals.)

expensive, item. Under the Laspeyres formulation, the original item remains in the index, thus the effect of the price increase of the original item is included in the Laspeyres price index. Under the Paasche formulation, the new item is counted in place of the relatively more expensive original item. Therefore, the Laspeyres price index is higher than the Paasche price index.

   C. Fisher price index[3]

The Fisher price (FP) index is a geometric mean of the Paasche and Laspeyres price indexes and is depicted as:

$$FP = \sqrt{PP \times LP}$$

(3a) $$FP = \sqrt{\frac{\sum_{i}^{N} p_{i,t} \times q_{i,t}}{\sum_{i}^{N} p_{i,0} \times q_{i,t}} \times \frac{\sum_{i}^{N} p_{i,t} \times q_{i,0}}{\sum_{i}^{N} p_{i,0} \times q_{i,0}}} \quad , \text{ for } t = 0, \ldots, T$$

In equation (3a), $p_{i,0}$ and $p_{i,t}$ are the base- and current-period prices, while $q_{i,0}$ and $q_{i,t}$ are the base- and current-period quantities of the i-th of N components under the aggregate.

If the weights (or quantities) vary, Fisher chain relatives are formed. Fisher chain relative prices are depicted by the following equation:

(3b) $$FP = \sqrt{\frac{\sum_{i}^{N} p_{i,t} \times q_{i,t}}{\sum_{i}^{N} p_{i,t-1} \times q_{i,t}} \times \frac{\sum_{i}^{N} p_{i,t} \times q_{i,t-1}}{\sum_{i}^{N} p_{i,t-1} \times q_{i,t-1}}} \quad , \text{ for } t = 0, \ldots, T$$

$p_{i,t-1}$ and $q_{i,t-1}$ are the previous-period prices and quantities of the i-th of N components under the aggregate. The Fisher prices are chained forwards (or backwards) and then are applied to a particular index level to form the index. Again, base-period prices and quantities are not necessary.

In theory, if the Paasche index tends to understate inflation, while the Laspeyres index tends to overstate inflation, the Fisher index, which is a geometric average of the Paasche and Laspeyres, more accurately reflects price changes (United Nations 2008).

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[3]This index is also referred to as the Fisher Ideal index. Fisher called it "ideal" because it "is at least equal in accuracy and is probably slightly superior in accuracy to any of the others" (Fisher 1922, p. 360). (Note that Fisher also credits Walsh (1901) and Pigou (1912) for this formula (p. 241).)

D. Tornqvist price index[4]

The Tornqvist price (TP) index is a weighted geometric average of the component price relatives using current- or previous-period shares as weights (United Nations 2008).

$$(4a) \qquad TP = \prod_i^N \left(\frac{p_{i,t}}{p_{i,0}} \right)^{s_{i,0}}, \quad \text{for } t = 0, \ldots, T$$

In equation (4a), $p_{i,t}$ and $p_{i,0}$ are current- and base-period prices of the i-th of N components under the aggregate, while $s_{i,0}$ is the base-period share.

As with the Laspeyres, Paasche, and Fisher relatives, given varying weights (or quantities), Tornqvist chain price relatives are formed using:

$$(4b) \qquad TP = \prod_i^N \left(\frac{p_{i,t}}{p_{i,t-1}} \right)^{\frac{s_{i,t} + s_{i,t-1}}{2}}, \quad \text{for } t = 0, \ldots, T$$

In equation (4b), $p_{i,t-1}$ and $s_{i,t-1}$ are previous-period prices and shares of the i-th of N components under the aggregate. As with the other price relatives mentioned, the Tornqvist price relatives can be chained forwards (or backwards) and applied to a particular index level to form the index. Again, base-period prices and quantities are not necessary.

As with the Fisher index, the Tornqvist lies between the Laspeyres and Paasche results.[5]

III. The Data

A. Detailed weights

During the most recent hospital market basket rebasing, the hospital weights were rebased to FY2002.[6] The FY2002 rebased weights were mainly developed from these data sources: (1) the FY2002 Medicare Cost Reports; (2) the 1997 I-O tables, published by BEA (more recent I-O numbers were not available at the time); and (3) the 1997 Business Expenses Survey (BES), published by the Census Bureau.

The Medicare Modernization Act of 2003 (P.L. 108-173, Section 404), or MMA, required that the hospital market basket weights be rebased more frequently than every five years. As published in the **Federal Register** (70 FR 47405), CMS examined the hypothetical movement of the hospital market basket index under rebasing scenarios of one to five years, between FY1997 and FY2002. Price

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[4]Diewert (1976) showed the Fisher and Tornqvist indexes are "superlative"—good approximations of the "exact" indexes. In practice, differences between the Fisher and Tornqvist indexes are expected to be small. (Fisher placed the various price indexes into categories. "Superlative" is his highest classification (Fisher 1922, p. 247).)

[5]Fisher indexes have two advantages over the Tornqvist. First, they are easier to interpret. Second, Fisher indexes have a "dual" property: (1) it is possible to produce Fisher price and quantity indexes and (2) it is also possible to reproduce the original indexes from the price and quantity indexes. This is not true of the Tornqvist. Therefore, the Fisher price index is a better approximation of the "exact" index.

[6]This rebasing was discussed in the August 12, 2005 **Federal Register** (70 FR 47387).

movements using hypothetical FY1998 weights for all years, then hypothetical FY1999 weights for all years, and so on were calculated using the most recent available data at that time.[7]

After comparing the results, few differences in the movement of the hospital market basket were found, suggesting that market basket rebasings more frequent than every five years does not lead to any significant changes in the results. This stability of these various price outcomes is attributed to the stability of the weights. These weights, which appeared in the August 12, 2005 **Federal Register** (70 FR 47406), are reproduced on Table 2.

In this paper, the impact of annual changes in these weights on the hospital market basket is examined. Further, these weights are used to construct other price formulations, specifically Paasche, Fisher, and Tornqvist price indexes.

        B.   Detailed prices

Recall, the price companion for each weight is referred to as a price proxy. With one exception, the price proxies are price indexes published by BLS. A list of these proxies appeared in the **Federal Register** (70 FR 47389) and are reproduced in Table 1. Note that each of the price proxies must be rebased to the appropriate base year. If FY2002 is chosen as the base year, a given price proxy is divided by its FY2002 value.

The weights and prices are applied to the price formulations presented in Section II to produce the results, which are reported in the next section.

IV. Results

The Laspeyres hospital market basket price index published on the CMS website uses FY2002 weights and holds these weights constant across time. This historical market basket data are compared against Laspeyres price indexes where the weights are allowed to change. Outcomes using the Paasche, Fisher, and Tornqvist price formulations are also shown.

Annual percent changes in hospital input prices by base period and by index formulation are presented on Table 3. Historical market basket data show that, using equation (1a) and 2002 weights, the Laspeyres hospital input price index increases an average of 3.3 percent per year during FY1997-FY2002[8] (Table 3, line 1). The results are almost the same when 1997 weights are used (line 2) or when the weights are allowed to vary (equation (1b); Table 3, line 3). The stability of these results is attributed to the stability of the weights of the individual cost categories that make up the hospital input price index, likely reflecting the lack of substitution among the various inputs in response to input price changes.

FY1997-FY2002 variable weight results for the Paasche, Fisher, and Tornqvist price formulations (equations (2b), (3b), and (4b)) also appear on Table 3 (lines 4-6). There are some very small differences in percent changes among the formulations, but these are not discernable at the one-decimal level.

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[7]The FY1998 weights for wages, benefits, professional liability insurance, drugs, and blood and blood products (which are part of "miscellaneous products") were based on the FY1998 Medicare Cost Reports, while the weights for all of the other components were aged from FY1997 to FY1998 using the price proxies. The FY1999 weights for wages, benefits, professional liability insurance, drugs, and blood and blood products were based on the FY1999 Medicare Cost Reports and the weights for all of the other components were aged from FY1997 to FY1999. The FY2000 and FY2001 weights were similarly constructed.

[8]Quarterly historical and (forecast) PPS hospital market basket data are published on the CMS website (http://www.cms.hhs.gov/MedicareProgramRatesStats/downloads/mktbskt-pps-hospital-2002.pdf, accessed June 23, 2008). Note: (1) the third quarter data also reflect annual fiscal-year data; and (2) annual growth rates shown on Table 3 are calculated from hospital market basket index levels.

Tornqvist growth rates also differ slightly from the Laspeyres, Paasche, and Fisher growth rates, but these differences are not very large.

These findings show that growth rates in hospital input prices do not vary even when using Paasche, Fisher, or Tornqvist formulations. Further, these outcomes match results from the historical market basket data.

V. Conclusion.

The MMA requires that the hospital market basket weights be rebased more frequently than every five years. Do more frequent rebasings lead to conspicuous changes in the index? This is not the case; irrespective of the set of weights, approximately the same results appear. Again, the stability of these results is attributable to the stability of the weights of the expenditure categories that make up the index. That is, the weights are relatively stable over five-year periods, reflecting little substitution among the expenditure categories that make up the index, meaning changes in the market basket are attributable to changes in the hospital input prices and not changes to the weights. Further, compare the current Laspeyres hospital price index against Paasche, Fisher, and Tornqvist price indexes. Employing the same source data as the published index, the results for the alternative formulations closely match the Laspeyres outcomes. Therefore, using a Paasche, a Fisher, or a Tornqvist formulation will not lead to appreciable changes to the results.

More practical matters support the use of the Laspeyres. First, as noted in Section II, the Paasche, Fisher, and Tornqvist price indexes partly rely on current-period weights. Unfortunately, these weights are based on data which are not immediately available; it may take two or three years to obtain reliable Medicare Cost Report data and five years to obtain BEA I-O data. Furthermore, once these data are available, the rebasing process may take one to two years to complete (70 FR 47407), meaning two separate rebasings would need to be conducted simultaneously. Second, as mentioned in Section I, Medicare's DRG hospital payment rates are updated using forecasts of the market basket. These forecasts are constructed from base-period weights and quarterly forecasts of the individual price proxies. Using Paasche, Fisher, and Tornqvist price indexes and would require contemporaneous as opposed to base-period weights, hence, forecasts of the weights as well as the price proxies.

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Table 1.--Hospital Market Basket Price Proxies,
FY2002

Market basket component	Price proxy
Hospitals	
Compensation	
Wages	ECI Wages and Salaries, Civilian Hospital Workers
Benefits	ECI Benefits, Civilian Hospital Workers
Professional fees	ECI Compensation, Professional, Specialty, &Technical Workers
Utilities	
Electricity	PPI Refined Petroleum Products
Fuel, oil, coal, etc	PPI Commercial Electric Power
Water and sewerage	CPI-U Water & Sewerage Maintenance
Professional liability insurance	CMS Professional Liability Insurance Premium Index
All other	
All other products	
Drugs	PPI Prescription Drugs
Food-direct purchase	PPI Processed Foods & Feeds
Food-away from home	CPI-U Food Away From Home
Chemicals	PPI Industrial Chemicals
Medical instruments	PPI Medical Instruments & Equipment
Photo supplies	PPI Photographic Supplies
Rubber and plastics	PPI Rubber & Plastic Products
Paper products	PPI Converted Paper & Paperboard Products
Apparel	PPI Apparel
Machinery and equipment	PPI Machinery & Equipment
Miscellaneous products	PPI Finished Goods, less Food and Energy
All other services	
Telephone	CPI-U Telephone Services
Postage	CPI-U Postage
All other: labor intensive	ECI Compensation, Private Service Occupations
All other: nonlabor intensive	CPI-U All Items

Source: 70 FR 47389.

Table 2.--Hospital Market Basket
Comparison Weights from Hypothetical Market Baskets,
Base Years FY1997 and FY2002

	Actual 1997	Hypo-thetical 1998	Hypo-thetical 1999	Hypo-thetical 2000	Hypo-thetical 2001	Actual 2002
Hospitals	100.000	100.000	100.000	100.000	100.000	100.000
Compensation	61.656	60.830	60.920	59.717	60.057	59.993
Wages	50.686	50.248	49.684	49.127	49.029	48.171
Benefits	10.970	10.582	11.236	10.590	11.028	11.822
Professional fees	4.965	5.184	5.198	5.452	5.438	5.510
Utilities	1.219	1.242	1.208	1.258	1.329	1.251
Electricity	0.688	0.691	0.665	0.676	0.681	0.669
Fuel, oil, coal, etc	0.181	0.183	0.175	0.203	0.277	0.206
Water and sewerage	0.351	0.369	0.367	0.378	0.371	0.376
Professional liability insurance	1.142	1.076	1.020	1.123	1.247	1.589
All other	31.018	31.667	31.654	32.451	31.929	31.657
All other products	20.311	20.602	20.637	21.032	20.701	20.336
Drugs	5.416	5.560	5.890	5.954	5.938	5.855
Food-direct purchase	1.771	1.762	1.703	1.736	1.699	1.664
Food-away from home	1.122	1.164	1.162	1.199	1.172	1.180
Chemicals	2.301	2.263	2.112	2.296	2.240	2.096
Medical instruments	2.086	2.083	2.019	2.019	1.939	1.932
Photo supplies	0.206	0.208	0.201	0.198	0.192	0.183
Rubber and plastics	2.107	2.123	2.056	2.110	2.057	2.004
Paper products	1.866	1.931	1.880	2.006	1.953	1.905
Apparel	0.425	0.433	0.423	0.428	0.406	0.394
Machinery and equipment	0.625	0.628	0.608	0.610	0.580	0.565
Miscellaneous products	2.386	2.448	2.582	2.476	2.524	2.558
All other services	10.707	11.065	11.017	11.418	11.228	11.321
Telephone	0.497	0.504	0.489	0.488	0.464	0.458
Postage	1.269	1.284	1.277	1.298	1.269	1.300
All other: labor intensive	3.800	3.991	4.004	4.176	4.136	4.228
All other: nonlabor intensive	5.142	5.286	5.246	5.457	5.359	5.335

Source: 70 FR 47406.

Table 3.--Hospital Market Basket
Annual Percent Changes in Various Price Indexes,
FY1998-FY2002
(in percent)

	Line	1998	1999	2000	2001	2002	Average 1998-2002
Current mkt basket							
Laspeyres	1	2.5%	2.5%	3.3%	4.2%	3.8%	3.3%
1997 weights							
Laspeyres	2	2.5%	2.5%	3.3%	4.2%	3.8%	3.2%
1997-2002 weights							
Laspeyres	3	2.5%	2.5%	3.3%	4.2%	3.7%	3.2%
Paasche	4	2.5%	2.5%	3.3%	4.2%	3.8%	3.2%
Fisher	5	2.5%	2.5%	3.3%	4.2%	3.7%	3.2%
Tornqvist	6	2.6%	2.5%	3.3%	4.2%	3.8%	3.3%