

## Methodological Problems with the Consumer Price Index<sup>1</sup>

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A new Manual on the Consumer Price Index<sup>2</sup> has been prepared by a group of international experts and recommends many “new” practices instead of just endorsing current CPI practices. In this note, I would like to try and explain why there was a need to recommend changes to existing CPI practices.

First, we need to look at the “standard” methodology for a “typical” CPI. This methodology is based on the fixed base Laspeyres price index. Thus, a base period basket of consumer purchases is priced out at base period prices and then the same basket is priced out at the current period prices. The target CPI is defined to be the ratio of these two costs. This formula has the virtue of being easily explained to the public. The next step is to put the Laspeyres formula into price relative and expenditure share format; i.e., the Laspeyres index can be rewritten as the sum of base period expenditure shares on the commodities in the domain of definition of the index times the corresponding price relatives. The Laspeyres formula has the virtue of being consistent in aggregation right down to the lowest level of aggregation. At this point, some approximations to this theoretical target are introduced:

- It is recognized that it is impossible to get accurate expenditure shares for the base period down to the finest level of commodity aggregation so we settle for getting base period expenditure weights at the level of 100 to 1000 commodity groups.
- For each of the chosen consumption aggregates, a sample of representative prices for specific items is collected (typically from shops rather than from households) and either the unweighted arithmetic mean of the price ratios (Carli index), or the ratio of unweighted arithmetic means (Dutot index) or the unweighted geometric mean of the price ratios (Jevons index) is used to aggregate these item prices into an elementary price index. This elementary price index will then be used as a price relative for the each of the 100 to 1000 commodity classes in the final Laspeyres formula. It is recognized that this two stage procedure is not completely consistent with the Laspeyres methodology (which requires weighting at each stage of aggregation), but from the viewpoint of the (unweighted) stochastic approach to index number theory, if the sample of item prices is large and representative enough in each elementary category, it is felt that the resulting elementary index price relatives will be sufficiently accurate to insert into the

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<sup>1</sup> This is the written text of a talk presented at the joint UNECE/ILO Meeting on Consumer Price Indices, held at the Palais des Nations, Geneva, December 4-5, 2003.

<sup>2</sup> *Consumer Price Index Manual: Theory and Practice*, The International Labour Organization, Geneva, forthcoming, April, 2004.

Laspeyres formula at the final stage of aggregation. Indeed it can be shown that if the target index is a Laspeyres index and sampling is with probability proportionate to base month expenditure shares the sample Carli index between a current and base period month can be used as an estimator for the Laspeyres index.

The above “standard” CPI methodology dates back to the work of Mitchell and Knibbs and other pioneers who introduced it about 80 or 90 years ago and it is still used today.

Before I outline some of the problems with the above standard methodology, I would like to outline what index number theory gives us as *target index concepts*.<sup>3</sup> First of all, it should be noted that most of the *theoretical literature* on index numbers centers on the case where complete price and quantity information is available for *two* periods where it is desired to compare the level of prices in one of the periods with those of the other period. This is called *bilateral* index number theory as opposed to *multilateral* index number theory, which deals with many periods instead of just two. However, multilateral approaches can readily be built up using bilateral index number theory. In the theoretical chapters of the new Manual, it is noted that there are 4 main approaches to bilateral index number theory:

1. fixed basket approaches and symmetric averages of fixed baskets;
2. the stochastic approach to index number theory;
3. test approaches and
4. the economic approach.

Approaches 3 and 4 will be familiar enough to many price statisticians and expert users of the CPI but perhaps a few words about approaches 1 and 2 are in order.

The Laspeyres index is an example of a fixed basket index. The problem from a theoretical point of view is that it has an equally valid “twin” between the same two periods under consideration, the Paasche index. If we have two equally valid estimators for the same concept, then statistical theory tells us to take the average of the two estimators in order to obtain a more accurate estimator. However, there is more than one way of taking an average so the question of the “best” average to take of the Paasche and Laspeyres indexes is not trivial. The new Manual suggests that the two “best” averages that emerge are the Fisher ideal and the Walsh price indexes.

The unweighted stochastic approach to index number theory is also an easy one for price statisticians to follow: we have lots of independent item price relatives between two periods so some sort of average of them ought to be a pretty good estimator for the amount of inflation between the two periods. Moreover, this approach has the advantage

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<sup>3</sup> Of course, the target index may not be achievable by a statistical agency but it is necessary to have some sort of theoretical target so that procedures can be adjusted so as to come closer to the target concept. Having a target concept is also necessary so that the index that is actually produced by a statistical agency can be evaluated from the perspective of how close the actual index comes to the theoretical ideal. The Laspeyres index is an example of a target index concept.

of giving us a standard error for the estimated aggregate price change. Unfortunately, this straightforward stochastic approach neglects one key variable: namely, the *economic importance* of each price relative. Thus to get a more accurate stochastic approach to index number theory, it is necessary to bring into the picture *expenditure weights* for each item. When this is done, the Törnqvist Theil formula emerges as being “best” from the viewpoint of weighted stochastic approaches to index number theory.

It turns out that the test and economic approaches to bilateral index number theory also end up endorsing the Fisher, Walsh and Törnqvist Theil price indexes as being “best” from their perspectives as well.<sup>4</sup> *Thus all four approaches to bilateral index number theory lead to the same three formulae as being best.* Which formula should then be used by a statistical agency as their target index? It turns out that for “typical” time series data, it will not matter much, since the three indexes approximate each other very closely.

There is one additional theoretical result from index number theory that should be mentioned here and that is the problem of defining the price and quantity of an item that should be used for each period in a bilateral index number formulae. The problem is that a household may make purchases of an item during the period under consideration at more than one price. Similarly, the sales of an item by an outlet during a period can be at a number of different prices so the question arises, what price would be most representative of the sales of this item for the period? The answer to this question is obviously the *unit value* for the item for the period since this price will match up with the quantity sold during the period to give a product that is equal to the value of sales.<sup>5</sup>

Now we can return to the problems with the standard CPI methodology. In my opinion, there are *6 main problem areas* with the standard methodology:<sup>6</sup>

(1). At the final stage of aggregation, the standard CPI index is *not* a true Laspeyres index since the expenditure weights pertain to a base *year* which is different from the base *month* (or quarter) for prices. Thus the expenditure weights are chosen at an annual frequency whereas the prices are collected at a monthly frequency. To be a true Laspeyres index, the base period expenditures should *coincide* with the base period for the prices. In fact, the actual target index used by many statistical agencies at the last stage of aggregation is a *Young index*, which is a weighted version of the unweighted

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<sup>4</sup> These three index number formulae are all examples of superlative index number formulae.

<sup>5</sup> Note that the Manual does *not* endorse taking unit values over *heterogeneous* items at this first stage of aggregation; it endorses only taking unit values over *identical* items in each period.

<sup>6</sup> These problems are not ranked in order of their importance; they all seem important to me.

Carli index.<sup>7</sup> Both the Young and Carli indexes have definite upward biases compared to theoretical target indexes.<sup>8</sup>

(2). At the elementary (or first) stages of aggregation, the Carli, Jevons or Dutot indexes are used. The Carli has a definite upward bias but all three indexes suffer from being unweighted indexes. Until relatively recently, when scanner data has become more readily available, it was thought that the biases that might result from the use of unweighted indexes were not particularly significant but recent evidence points to *a very significant bias problem* at lower levels of aggregation compared to results that are generated by the preferred target indexes mentioned above (i.e., the Fisher, Walsh and Törnqvist Theil price indexes). In any case, the standard statistical agency practice at lower levels of aggregation is simply not consistent with the Laspeyres index as a target index (since the Laspeyres index requires proper weighting at all levels of aggregation).

(3). The third major problem area with the standard CPI methodology is that although statistical agencies generally recognize that there is a problem with the treatment of quality change and new goods, it is difficult to work out a coherent methodological treatment of these problems in the context of a fixed base Laspeyres index. In fact, there is a considerable amount of controversy on how to integrate hedonic regression methodology into a cost of living framework. The theoretical and “practical” chapters in the Manual devote a lot of attention to these methodological problems. I would say that the problems created by the disappearance of old goods and the appearance of new models are now much more severe than they were when the traditional CPI methodology was developed some 80 years ago (where the problem was mostly ignored). For many categories of consumption, approximately 50% of the items that were priced at the beginning of the year are simply no longer available by the end of the year. Thus there is a tremendous problem of *sample attrition* which impacts on the overall methodology; i.e., at lower levels of aggregation, it becomes necessary (at least in many categories of consumption) to switch to chained indexes or to hedonic indexes rather than use fixed base indexes. Thus if the Carli formula is used at the elementary level, the upward bias generated by the use of chained Carli indexes can be enormous.

(4). A fourth major problem area with standard CPI methodology is related to the first problem area and that is the *treatment of seasonal commodities*. The use of an annual basket or the use of annual expenditure shares is justified to a certain extent if one is interested in the longer run trend of inflation but if the focus is on short term month to month inflation (as is the focus of central banks), then it is obvious that the use of annual weights can lead to misleading signals from a short run perspective, since monthly price changes for commodities that are out of season (i.e., the seasonal weights for the

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<sup>7</sup> This index is an expenditure share weighted average of price ratios where the numerator price is the price of the commodity in the current month and the denominator price is the price of the same commodity in a base month. The expenditure shares typically pertain to a base *year* (which is necessarily different from the base *month* for prices). Thus the Young index involves *three* periods: a base year (for expenditures), a base month (for prices) and a current month (for prices). The Carli index is simply an evenly weighted average of the price ratios. Hence, if the base year expenditure shares were all equal, the Young index would collapse down to a Carli index.

<sup>8</sup> The theoretical target indexes would be the Fisher, Walsh or Törnqvist Theil indexes.

commodity class are small for the two months being considered) can be greatly magnified by the use of annual weights. The problem of seasonal weights is a big one: in Canada, approximately 7% of the basket is not available at all at certain months of the year. Moreover, at least a third of the major commodity classes are subject to large seasonal fluctuations in weights. There are solutions to these seasonality problems but the solutions do not appeal to traditional CPI statisticians since they involve the construction of *two* indexes: one for the short term measurement of inflation and another (more accurate) longer term index that is seasonally adjusted.

(5). A fifth problem with standard CPI methodology is that the problems of measuring complex services are generally neglected. In fact, a typical CPI will collect many more goods prices than services prices and will have many more commodity classes for goods rather than services. In a way, this just reflects the historical origins of existing CPI theory. As mentioned above, CPI theory has essentially remained unchanged for 80 years but 80 years ago, goods were much more significant than services, and hence, there was not much focus on the problems involved in measuring services. It is only over the last 30 or 40 years that the shift to services has caused service expenditures to exceed those on goods in many countries. However, if one looks at published CPI categories, there will generally be many more goods categories than services categories.<sup>9</sup> In addition to inertia, there are some serious conceptual problems involved in measuring the prices of many services. Some examples of difficult to measure services are: expenditures on insurance, gambling, financial services, advertising services, telecommunication services (with complex plans), entertainment services and rental housing. In many cases, statistical agencies simply do not have appropriate methodologies to deal with these difficult conceptual measurement problems and so in many cases, these service sector outputs are either not measured at all or deflated with a very rough and ready deflator.

(6). A final problem with existing CPI methodology is that it tends not to recognize that more than one CPI may be required to meet the needs of different users. For example, some users may require information on the month to month movement of prices in a timely fashion. This requirement leads to a Laspeyres type CPI along the lines of existing CPI's, where current information on weights is not necessarily available. However, other users may be more interested in a more accurate or representative measure of price change and may be willing to sacrifice timeliness for increased accuracy. Thus the Bureau of Labor Statistics in the U. S. is providing, on a delayed basis, a superlative index that uses current period weight information as well as base period weight information. This is an entirely reasonable development, recognizing that different users have different needs. A second example where multiple indexes would be useful occurs in the context of the treatment of owner occupied housing. Researchers have made solid cases for at least three different treatments of owner occupied housing: the acquisitions approach (just price out purchases of new dwelling units), the rental equivalence approach (impute a rent for the dwelling) and the user cost approach (work out all of the anticipated or actual costs of owning the house for the reference period including depreciation and the opportunity cost of the capital tied up in owning the

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<sup>9</sup> Detailed consumer price indexes for approximately 160 commodities are available from Statistics Canada on a monthly basis. Of these 160 consumer price indexes, only about 40 are devoted to service prices.

dwelling). However, these three approaches to the treatment of owner occupied housing will usually give quite different numerical results in the short run. Since all three approaches have strong support, it would be reasonable for a statistical agency to pick one approach for their flagship index but make available the other two treatments as “analytical series” for interested users. A third example where multiple indexes would be useful occurs in the context of seasonal commodities. The usual CPI is a month to month index and it is implicitly assumed that all commodities are available in each month. As we have noted in (4) above, this assumption is not warranted: some 5 to 10 % of all commodities are generally not available in all months. In this context, a month to month CPI will not be as “accurate” as a year over year CPI that compares the prices of commodities in this month with the corresponding commodities in the same month a year ago. Hence again, the need for multiple indexes emerges to cater to the needs of different users.

Many of the above problem areas are addressed in the new CPI Manual.<sup>10</sup> It is my hope that the frank discussion of these problem areas will stimulate the interest of academic economists and statisticians to address these measurement problems and to provide new solutions that can be used by statistical agencies. I also hope that public awareness of these problem areas will lead to a willingness on the part of governments to allocate additional resources to statistical agencies so that economic measurement will be improved. In particular, there is an urgent need to fill in some of the gaps that exist in the measurement of service sector outputs.

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<sup>10</sup> Many of these problems have also been addressed in the *Amended Draft Resolution Concerning Consumer Price Indices* which was passed by the Seventeenth International Conference of Labour Statisticians in Geneva, December 3, 2003.