Assessing the Reliability of the 2005 CPI Basket Update in Canada Using the Bortkiewicz Decomposition*

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First draft: September 2007-12-10
Current draft: December 2007

Abstract: This paper uses the Bortkiewicz decomposition technique to analyze the relationship between price changes and shifts in consumer expenditures in Canada from 2001 to 2005. This technique has proved useful for analyzing the divergence between indexes and helps to asses the reliability of the 2005 Consumer Price Index basket update. In 2007, Statistics Canada moved from basket weights based on the 2001 Survey of Household Spending to a weighting pattern based on the 2005 Survey of Household Spending. Using the new updated 2005 basket of goods and services, the Paasche index for 2005 can be computed. Using this result, Bortkiewicz's decomposition relating the Paasche and Laspeyres indexes can be studied. The Bortkiewicz analysis yielded expected results: the Paasche index was 1.68% lower than the corresponding Laspeyres index for the "All-items" classification. This indicates that, on the whole, from 2001 to 2005 consumers responded to rising prices by substituting away from relatively more expensive commodities and towards relatively cheaper ones. Computer equipment and supplies contributed more than any other basic class to the negative divergence between the Laspeyres and Paasche indexes. This negative impact, however, was partially offset by rent and mortgage interest cost, which were both leading positive contributors to the divergence between the two indexes.

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*The comments made by colleagues and, particularly, Andy Baldwin, George Beelen, Tarek Harchaoui, John Mallon, and Jennifer Withington are acknowledged with thanks.

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Executive Summary

Statistical agencies periodically update the weights used in the construction of their Consumer Price Indexes (CPIs). In spring 2007, Statistics Canada updated its CPI basket to make use of its most recent consumer expenditure survey, the 2005 Survey of Household Spending (SHS), and replaced the weights that were based on the 2001 SHS. This update provided the opportunity to review some of the concepts, methods and data sources underlying the CPI.

As with most statistical agencies around the world, Statistics Canada uses expenditure weights from a prior period and price changes from more recent periods to compute an official CPI; such an index is a Laspeyres-type price index. At basket update time, it is possible to retrospectively calculate a Paasche price index using weights from the more recent consumer expenditure survey. In the 1920s, the economist Ladislaus Josephowitsch Bortkiewicz provided a useful framework for conducting an analysis between the Laspeyres and Paasche price indexes. The following paper uses Bortkiewicz's theorem and adaptations of it as part of a quality assurance exercise to confront the new 2005 weighting data against prior expectations and other data sources.

Specifically, this paper analyzes the divergence between the Laspeyres and Paasche indexes for the basket as a whole and for commodities at their lowest level of aggregation using Bortkiewicz's formula relating the two indexes. A Bortkiewicz analysis is conducted to help identify potential problems associated with the estimated weights applied to the individual elements within the new 2005 basket of goods and services. In the usual consumer context, when the correlation between price and quantity relatives is negative, Bortkiewicz illustrated that the Laspeyres price and quantity indexes will exceed the corresponding Paasche price and quantity indexes.

In practice, it is well known that the Laspeyres price index is generally greater than the Paasche price index. Under the "normal" economic condition that relative prices are negatively correlated with the corresponding relative quantities, the Laspeyres price index will apply a larger (lower) weight to a commodity with rising (decreasing) prices compared to the Paasche price index. When results indicate otherwise, there is the possibility that an error has occurred in the estimation of the applied weight(s) to the particular element(s) within the new basket of goods and services. The result of the Bortkiewicz decomposition yielded expected results as the Paasche index was 1.68% lower than the corresponding Laspeyres index for the "All-items" classification. This indicates that, on the whole, from 2001 to 2005 consumers responded to rising prices by substituting away from relatively more expensive commodities and towards relatively cheaper ones.

To conclude the quality assurance exercise of the new 2005 weighting data, a discussion and analysis comparing the CPI using the 2001 and 2005 weights is presented. Specifically, we determine how much the CPI would have differed if the 2005 basket had been employed from January 2006 through to April 2007. Had the new 2005 weights been employed in January of 2006 instead of May 2007, we find that between January

2006 and April 2007 the new series would have been on average 0.3 index points less than the published series which used the 2001 basket weights.

1. Introduction

Consumer Price Indexes (CPIs) are index numbers that measure pure changes in the prices of consumer goods and services purchased by the average household over a specified period of time. The CPI has become an essential statistic for monetary policy and is used in a wide variety of public and private contracts as the appropriate measure of price change for purposes of adjusting payments such as wages, rents, social security or other payments to maintain previous purchasing power in the face of changing consumer prices. The CPI is one of the most widely used statistics and plays a major role in the daily lives of Canadians. As a result, it is necessary for Statistics Canada to ensure sound quality assurance in the construction of the CPI. One means of ensuring quality assurance in the construction of the weights in Statistics Canada's updated 2005 basket of goods and services is to compare and contrast among competing forms of price indexes.[1]

In constructing any index, the first step is to decide on the form of index number to apply. Over the last two centuries there has been extensive literature written on the different mathematical formulas which can be used to construct a price index. Even though there has been no consensus on a single formula, progress has been made and the formulas used in practice have been narrowed down to a very small class. Two sound choices for a price index are the Laspeyres and Paasche indexes. Just like any price index, however, the Laspeyres and Paasche indexes have their limitations.

The emphasis of this paper is not to provide a detailed analysis of the various price index measures but rather to address the statistical relationship between them. In particular, the focus of this paper is to study the direction of divergence between the Laspeyres and Paasche index forms. This is achieved by examining Ladislaus Josephowitsch Bortkiewicz's formula relating the two indexes.[2] A good deal can be said about the direction of the divergence between these price indexes and the extent of divergence can be useful in identifying potential problem areas in the weighting of individual elements within the basket of goods and services.

Statistics Canada produces an annual Survey of Household Spending (SHS) which collects detailed information about expenditures for consumer goods and services,

[1] The term "weights" refers to the aggregate dollar expenditure on each commodity that is consumed by Canadian households. The term "basket" refers to a well defined set of elements (goods and services), which are consumed by a typical household. That is, the term "basket" is an aggregate of commodities.

[2] Ladislaus Von Bortkiewicz was a German statistician and economist born in St. Petersburg, Russia August 7, 1868. He studied law at the University of St. Petersburg and graduated in 1890 before going on to defend his doctorial thesis in 1893. Most of his career was spent as a professor of statistics and economics at the University of Berlin until his death on July 15, 1931. Bortkiewicz is best known for his modeling of rare-event phenomena by the Poisson distribution. He also made numerous contributions to mathematical statistics, particularly to the statistical analysis of radioactivity, the theory of runs and the distributional properties of extreme values. In addition, his work on population theory, actuarial science and political economy is also noteworthy. (Zabell (2006)).

changes in assets, mortgages and other loans, annual income, dwelling characteristics (e.g., type and age of heating equipment) and household equipment (e.g., appliances, communications equipment and vehicles). The most recent SHS was conducted from January to March 2006 for the 2005 calendar year.[3] The information from this survey is used to derive the underlying weights applied to the individual elements in the basket of goods and services, which in turn are used in the computation of the CPI.[4]

In spring 2007, much work was completed to update the basket of goods and services underlying the Canadian CPI. The new 2005 basket, based on the 2005 SHS, replaced the 2001 basket as of June 2007 with the release of the May CPI data. As part of the quality assurance procedures put in place by the Prices Division of Statistics Canada, significant work was undertaken to ensure the quality of the new expenditure weights. In light of this, a Bortkiewicz analysis was conducted to draw attention to weight shifts which might require further scrutiny. In the past, Bortkiewicz studies have proven useful in finding unusual weight changes between baskets updates, such as the discovery in 2004 of incorrect weights for mortgage interest costs in the original 2001 CPI basket.[5]

In order to understand and derive Bortkiewicz's formula relating the Laspeyres and Paasche indexes the ensuing section provides a brief summary of the two indexes.

2. Overview of the Laspeyres and Paasche Price Indexes

Price indexes are single numbers calculated from an array of prices and quantities over a specified period. While all price index formulas use price and quantity data, they integrate this data in various ways. A simple approach to measure a price index was suggested by Joseph Lowe in 1823.[6] Lowe suggested that price changes between two periods, 0 and 1, should be measured by tracking the price of a representative commodity basket; a set of goods and services purchased by a typical consumer represented by the quantity vector $q \equiv [q_1,\ldots.q_n]$. Using this fixed basket of goods and services the price index is computed by first determining the level of prices in period 1 and period 0 and then by taking the ratio of the value of the period 1 cost of the representative basket, $\sum_{i=1}^{n} p_i^1 q_i$, to the period 0 cost of the representative basket, $\sum_{i=1}^{n} p_i^0 q_i$. Thus prices vary but the quantities are held fixed when computing the value aggregates. Two natural choices for the fixed basket of goods and services exist: the base period commodity vector, q^0, and the current period quantity vector, q^1. These two options lead to two concrete choices for a price index, the Laspeyres (P_L) and Paasche (P_p) price index forms.

[3] See Statistics Canada (2006) for further information on the SHS. For statistical information on the most recent SHS publication see Statistics Canada (2007).

[4] In previous basket updates, the underlying weights applied to the food elements in the basket of goods and services were computed using detailed information on food expenditure provided by the Food Expenditure Survey (FES). However, the FES was last conducted in 2001 and as a result, 2005 expenditure estimates below the level of "Food" required an alternative derivation. To obtain 2005 basic class weights for food, SHS totals for "Food Purchased from Stores" and "Food Purchased from Restaurants" were used at an aggregate level and distributed among the basic classes using the proportions derived from the price-updated 2001 expenditures.

[5] The Daily (August 24, 2004).

[6] See Lowe (1823).

The Laspeyres and Paasche price indexes between two time periods, 0 and 1, can be expressed, respectively, as follows:[7,8]

$$(1)\ P_L = \frac{\sum_{i=1}^{n} p_i^1 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0}$$

$$(2)\ P_{P=} \frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^1}$$

where n represents the number of products (goods and services), q is the vector of quantities and p is the vector of prices. Note that the representative commodity basket (q) for the Laspeyres price index is the base period commodity vector, q^0. On the other hand, the current period commodity vector, q^1, serves as the reference basket for the Paasche price index. The Laspeyres price index determines the rate of inflation between two periods by answering the question, "What is the change in total expenditure required by the average household to purchase the base period basket of goods and services over two periods?" Similarly, the Paasche price index determines the rate of inflation by answering the question, "What is the average household's change in total expenditure necessary to purchase the current basket of goods and services over two periods?" The Laspeyres price index is a fixed-weighted or base-weighted index while the Paasche price index is a current-weighted price index. In practice, most CPIs are weighted averages of the percentage change in prices for a precisely defined set of consumer goods and services, where the weights for each good and service are determined by the relative sizes of the expenditure made on those goods and services by the average household.

Using simple algebraic manipulation we can weight the above two indexes in terms of expenditure shares. Let w_i^t represent the weighted expenditure share as follows:

$$(3)\ w_i^t \equiv \frac{p_i^t q_i^t}{\sum_{i=1}^{n} p_i^t q_i^t} \qquad \text{for } i = 1, \ldots, n \text{ and } t = 0,1$$

As previously mentioned, data from the SHS is used to compute the weights for each element in the basket. By multiplying the right-hand side of equation (1) by p_i^0/p_i^0 the Laspeyres price index can be expressed as a base period expenditure weighted index as follows:

[7] Note that the two periods could be expressed annually or monthly.
[8] For a detailed discussion on the Paasche and Laspeyres indexes see Diewert (2007b).

$$(4)\ P_L = \frac{\sum_{i=1}^{n} p_i^1 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0} * p_i^0 \Big/ p_i^0$$

$$= \frac{\sum_{i=1}^{n} \left(\frac{p_i^1}{p_i^0} \right) p_i^0 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0}$$

$$= \sum_{i=1}^{n} \left(\frac{p_i^1}{p_i^0} \right) w_i^0 \qquad \text{using the definition of } w_i^0 \text{ from equation (3)}$$

In this context, the Laspeyres price index is now interpreted as the arithmetic mean of price relatives, p_i^1/p_i^0, weighted by the base period expenditure shares. The Laspeyres index is often referred to as the base-weighted price index and is widely used around the world for calculating CPI's.[9] Using current period prices, a similar calculation can be carried out for the Paasche price index:

$$(5)\ P_P = \frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^1} * p_i^1 \Big/ p_i^1$$

$$= \frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} \left(\frac{p_i^0}{p_i^1} \right) p_i^1 q_i^1}$$

[9] Statistics Canada and other statistical agencies actually use a Lowe price index rather than a true Laspeyres price index for measuring inflation. The difference between the two indexes is simply that the quantity vector in the Lowe index pertains to annual weights in the base year while the quantity vector in the Laspeyres index refers to transactions in the base month (time t=0). That is, when the price indexes are computed monthly and annual quantities are used, the Laspeyres concept is actually a Lowe price index. For simplicity, we continue to refer to the base-weighted index as the Laspeyres index even though it is in fact a Lowe index. For a further discussion on the relationship between the Lowe and the Laspeyres index see Diewert (2007a).

$$= \frac{1}{\sum_{i=1}^{n}\left(\frac{p_i^0}{p_i^1}\right)w_i^1}$$ using the definition of w_i^1 from equation (3)

Taking the reciprocal of equation (5) a neater result is derived as follows:

$$(6)\ \frac{1}{P_P} = \sum_{i=1}^{n}\left(\frac{p_i^0}{p_i^1}\right)w_i^1$$

or,

$$(7)\ P_P = \left\{\sum_{i=1}^{n}\left(\frac{p_i^1}{p_i^0}\right)^{-1} w_i^1\right\}^{-1}$$

The Paasche price index can, therefore, be written as the harmonic average of the price relatives, p_i^1/p_i^0, weighted by the current period expenditure shares. The Paasche price index is often referred to as the current-weighted price index. In practice, statistical agencies require an index which they can publish frequently and produce in a timely manner.[10] For these reasons the Laspeyres price index is preferred to the Paasche price index because once a statistical agency determines the expenditure shares all that is required to calculate the index on an ongoing basis are current prices. The lack of information on current quantities, however, prevents statistical agencies from being able to produce the Paasche price index in a timely manner.

A potential bias occurs when using base period weights from a distant year to compute the CPI. When possible, consumers are likely to substitute away from products that become relatively more expensive and towards products that are relatively cheaper. As a result, using a fixed basket price index such as the Laspeyres fails to capture the substitution effect of consumers when prices change. In other words, when the relative price of commodity *i* increase (decreases) the relative quantity consumed tends to be reduced (increased).[11] Looking at the Laspeyres and Paasche price index equations, a commodity with a price relative (p_1/p_0) greater (less) than unity would likely have a greater (lower) weight in the Laspeyres price index compared to the Paasche price index since $p_0q_0 > p_0q_1$ ($p_0q_0 < p_0q_1$). In other words, under the "normal" economic condition that relative prices are negatively correlated with the corresponding relative quantities, the Laspeyres price index will apply a larger (lower) weight to a commodity with rising (decreasing) prices compared to the Paasche price index. Hence the Laspeyres price index will be larger (smaller) than the Paasche price index.[12] As a result, a price index

[10] For a discussion on the CPI as an index number see Diewert (1999).
[11] For a detailed discussion on the bounds of the Laspeyres and Paasche price indexes see Diewert (2006).
[12] In other words, if prices tend upwards over time and households substitute away from products that relatively increase in price and towards products that relatively decrease in price, the Laspeyres price index would be greater than the Paasche price index for the specific commodity.

like the Laspeyres, which makes of use of distant quantity weights, would tend to lead to an upward bias in the CPI compared to one that uses more current weights, such as the Paasche price index.[13]

In order to compare the Laspeyres and Paasche price indexes it is more informative to do so at low levels of aggregated commodities, such as the price index for chicken or beef.[14] At this level, one would expect that the Laspeyres index would be greater than the Paasche index due to the substitution effects discussed above. However, when looking at high levels of aggregated commodities, such as food, the relationship between the Laspeyres and Paasche price indexes may not hold because substitution effects may be negligible at such a level.

Statistical agencies regularly compare competing price indexes when replacing a basket and updating the applied weights to the commodities in order to asses the substitution bias of the price index series and to highlight probable errors that may have occurred during the updating process. The Laspeyres and Paasche price indexes provide different answers to the same questions and as a result, it is necessary to understand how they differ. The divergence between the two indexes can be measured and this is the discussion of the ensuing section. To fully understand the algebra in the proceeding section it is first necessary to define the quantity indexes that correspond to the Laspeyres and Paasche price indexes. Interchanging the vector of prices and quantities in equations (1) and (2) yields the Laspeyres and Paasche quantity indexes, respectively, as follows:[15]

$$(8)\; Q_L = \frac{\sum_{i=1}^{n} p_i^0 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^0}$$

$$(9)\; Q_P = \frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} p_i^1 q_i^0}$$

The Laspeyres and Paasche quantity indexes are thus evaluated at constant prices instead of at constant quantities. The Laspeyres quantity index compares consumers' expenditure at constant prices (referred to as a measure of consumers' expenditure in real terms), whereas the Paasche quantity index compares consumers' expenditure at current prices.

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[13] This of course is only true to the extent that households increase their purchases of commodities in which relative prices decline and decrease their purchases of commodities in which relative prices increase.

[14] For a discussion of the typical aggregation structure of a CPI see International Labour Office et. al. (2004).

[15] The quantity indexes are derived by substituting the price indexes into the product test: $V^1/V^0=\sum_{i=1}^{n}p_i^0q_i^0/\sum_{i=1}^{n}p_i^1q_i^1=P(p^0,p^1,q^0,q^1)Q(p^0,p^1,q^0,q^1)$. Substituting the Laspeyres price index into the product test results in the Paasche quantity index and substituting the Paasche price index into the product test results in the Laspeyres quantity index. For a detailed discussion see Diewert (2003).

3. Statistical Relationship between the Laspeyres and Paasche Price Indexes

"Laspeyres or Paasche? The Laspeyres calculation is simpler, since the denominator needs calculating only once. But a rise in prices tends to be overstated, since it does not take into account falls in demand or changes in output. Paasche, on the other hand, tends to understate the rise in prices because it uses current weights. In practice, neither all prices nor all quantities move in the same ratio and the relationship between the two systems depends on the correlation between the price and quantity movements, which is normally negative. An analysis that follows the normal laws of supply and demand." Walter R. Crowe (1965).

"The extent of the divergence [between the Laspeyres and Paasche price indexes]*, in whichever direction it is, depends partly on the strength of the correlation and partly on the dispersion of the price and quantity relatives as shown up in the coefficients of variation. Something can be said about this. In the classic problem of the purchasing power of money, for example, the level of either the Laspeyres or the Paasche price index is settled primarily by monetary factors while the divergence between the two forms depends more on the non-monetary influences working on the spread of price relatives about the 'norm'. The typical situation is that the two forms drift apart over time. The gap between them can grow very quickly in periods of great change." Roy George Douglas Allen (1975).*

The Laspeyres principle consists of using constant (base period) weights, while the Paasche principle, on the other hand, consists of using variable weights related to the current period. The problem with the Laspeyres and Paasche principles is that they are both equally plausible, but in general they will yield different results.[16] In situations where weights are changing rapidly the Laspeyres and Paasche price indexes can differ considerably. It is, however, not sufficient for a statistical agency to provide two different answers for a measure of inflation. Although not the focus of this report, a more accurate price index would be one that simultaneously accounts for the likelihood of both the Laspeyres and Paasche indexes. There are various ways to average the two indexes.[17] The Fisher ideal price index, however, which is equal to the square root of the product of the Laspeyres and Paasche price indexes (that is, the geometric average of the Paasche and Laspeyres formulas), emerges as perhaps the "best" evenly weighted average of the two price indexes.[18]

This section provides a discussion on the fundamental mathematical relationships that exist between the Laspeyres and Paasche indexes. Using equations (1), (2), (8) and (9) it can be illustrated that the ratio of the Paasche price index to the Laspeyres price index is equal to the ratio of the Paasche quantity index to the Laspeyres quantity index as follows:

[16] See Diewert (2006).
[17] For a discussion on the properties of symmetric averages see International Labour Office et. al. (2004).
[18] See Diewert (2006).

$$(10)\ \frac{P_P}{P_L} = \frac{Q_P}{Q_L} = \left(\frac{\sum_{i=1}^{n} p_i^0 q_i^0}{\sum_{i=1}^{n} p_i^1 q_i^0}\right)\left(\frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^1}\right)$$

From the above equation, it follows that the direction of divergence of the quantity index numbers is the same as that of the price index numbers. That is, if P_P is greater than P_L then Q_P will also be greater than Q_L and vice versa. Equation (10) can also be expressed to show that both indexes fail the factor reversal test as the Laspeyres price index is matched with the Paasche quantity index and conversely as follows:[19]

$$(11)\ P_L * Q_P = P_P * Q_L = \left(\frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^0}\right)$$

Using equation (11), Q_P can be expressed as a function of P_L and the current and base-year expenditures as follows:

$$(12)\ Q_P = \left(\frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^0}\right)\left(\frac{1}{P_L}\right)$$

To simplify, define the value aggregates in the two periods as follows:

$$(13)\ V^0 = \sum_{i-1}^{n} p_i^0 q_i^0;\quad V^1 = \sum_{i-1}^{n} p_i^1 q_i^1$$

Using the above definitions for the value aggregates, equation (12) can be re-written as follows:

$$(14)\ Q_P = \left(\frac{V^1}{V^0}\right)\left(\frac{1}{P_L}\right)$$

By substituting equation (14) into equation (10), the ratio of the Paasche price index to the Laspeyres price index can be expressed as follows:

[19] The factor reversal test requires the following: $P_L * Q_L$ and $P_P * Q_P = \sum_{i=1}^{N} p_i^1 q_i^1 / \sum_{i=1}^{N} p_i^0 q_i^0$. That is, the factor reversal test requires that the product of the price and quantity index should equal the ratio of value aggregates between the two periods. For a more detailed discussion see Diewert (2006b).

$$(15)\ \frac{P_P}{P_L} = \frac{Q_P}{Q_L} = \left(\frac{\left(\frac{V^1}{V^0}\right)\left(\frac{1}{P_L}\right)}{Q_L} \right) = \left(\frac{V^1/V^0}{P_L Q_L} \right)$$

Recall that w_i^0 was defined above as the base period expenditure share on commodity i (the base weights, item by item) as follows:

$$(16)\ w_i^0 \equiv \frac{p_i^0 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0} \qquad (20)$$

Using the above fundamental mathematical relationships between the Laspeyres and Paasche price indexes (equations (10) through (15)) the statistical relationship between the two indexes can be further examined by using the item-by-item distributions of, and covariance between the price and quantity relatives. The algebraic relationship between the Paasche and Laspeyres price indexes that follows is due to Ladislaus Josephowitsch Bortkiewicz's (1923) classical paper on the structure of price index numbers.[20] As noted by Schultz (1997), Bortkiewicz did not view his decomposition between the two indexes as a tool for analyzing numerical results provided by concrete index numbers, aside from an example given to illustrate his theorem. In addition, most of Bortkiewicz's followers used his idea in abstract studies; either to examine some general attributes of index formulae or to conjecture about the comparative results the formulae would provide, assuming given trends in price and quantity movements.[21]

To illustrate the Bortkiewicz theorem it is first necessary to define the covariance between the vector of price relatives, p^1/p^0, and the vector of quantity relatives, q^1/q^0, weighted by the vector of expenditure shares, w_i^0.[22] Using the notation consistent with the Laspeyres price and quantity indexes (equations (1) and (8), respectively), the weighted means of the price and quantity relatives is computed by weighting both the price and quantity relatives by the base period expenditure share, w_i^0, as follows:

$$(17)\ \frac{\overline{p_i^1}}{p_i^0} = \frac{\sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0}}{\sum_{i=1}^{n} w_i^0} = \frac{\sum_{i=1}^{n} p_i^1 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0} = P_L$$

[20] Several papers provide a discussion of the Bortkiewicz theorem. See Allen (1963), Allen (1975), Diewert (2007) and von der Lippe (2007).
[21] See Schultz (1997).
[22] For simplicity it has been assumed that we are comparing period one with period zero; however, this could be generalized by replacing period 1 with time t.

$$(18)\ \frac{\overline{q_i^1}}{q_i^0} = \frac{\sum_{i=1}^{n} w_i^0 \frac{q_i^1}{q_i^0}}{\sum_{i=1}^{n} w_i^0} = \frac{\sum_{i=1}^{n} p_i^0 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^0} = Q_L$$

The weighted means of the price and quantity relatives are simply equal to their corresponding Laspeyres price and quantity index. Therefore, the weighted covariance between the vector of price and quantity relatives using the base period vector of expenditure shares, w_i^0, as weights is as follows:

$$\begin{aligned}
(19)\ \sigma_{\mathrm{pqw}^0} &= \sum_{i=1}^{n} w_i^0 \left(\frac{p_i^1}{p_i^0} - P_L \right)\left(\frac{q_i^1}{q_i^0} - Q_L \right) \\
&= \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0}\frac{q_i^1}{q_i^0} - \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0} Q_L - \sum_{i=1}^{n} w_i^0 P_L \frac{q_i^1}{q_i^0} + \sum_{i=1}^{n} w_i^0 P_L Q_L \\
&= \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0}\frac{q_i^1}{q_i^0} - Q_L \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0} - P_L \sum_{i=1}^{n} w_i^0 \frac{q_i^1}{q_i^0} + P_L Q_L \sum_{i=1}^{n} w_i^0 \qquad \text{using} \sum_{i=1}^{n} w_i^0 = 1 \\
&= \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0}\frac{q_i^1}{q_i^0} - Q_L \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0} - P_L \sum_{i=1}^{n} w_i^0 \frac{q_i^1}{q_i^0} + P_L Q_L \qquad \text{using} \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0} = \mathrm{P_L} \\
&= \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0}\frac{q_i^1}{q_i^0} - Q_L P_L - P_L \sum_{i=1}^{n} w_i^0 \frac{q_i^1}{q_i^0} + P_L Q_L \\
&= \sum_{i=1}^{n} w_i^0 \frac{p_i^1}{p_i^0}\frac{q_i^1}{q_i^0} - P_L Q_L \qquad \text{using } \sum_{i=1}^{n} w_i^0 \frac{q_i^1}{q_i^0} = \mathrm{Q_L} \\
&= \sum_{i=1}^{n} \left(\frac{p_i^0 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0} \right)\left(\frac{p_i^1}{p_i^0} \right)\left(\frac{q_i^1}{q_i^0} \right) - P_L Q_L \qquad \text{using } w_i^0 \equiv \frac{p_i^0 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0} \\
&= \frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^0} - P_L Q_L
\end{aligned}$$

Finally, using the definitions for the value aggregates defined above in equation (13) the weighted covariance between the price and quantity relatives can be written as follows:

$$(20)\ \sigma_{\mathrm{pqw}^0} = \left(\frac{V^1}{V^0} \right) - P_L Q_L$$

Recall from equation (15) that the price ratio of the Paasche price index over the Laspeyres index was expressed as follows:

$$(21)\ \frac{P_P}{P_L}=\frac{Q_P}{Q_L}=\left(\frac{\left(\frac{V^1}{V^0}\right)\left(\frac{1}{P_L}\right)}{Q_L}\right)=\left(\frac{V^1/V^0}{P_LQ_L}\right)$$

By adding and subtracting one from the right hand side of this expression, the ratio of the Paasche price index to the Laspeyres price index can be written as follows:

$$\begin{aligned}(22)\ \frac{P_P}{P_L}&=\left(\frac{V^1/V^0}{P_LQ_L}\right)+1-1\\&=\left(\frac{V^1/V^0}{P_LQ_L}\right)+1-\frac{P_LQ_L}{P_LQ_L}\\&=\left(\frac{V^1/V^0-P_LQ_L}{P_LQ_L}\right)+1\end{aligned}$$

Notice that the numerator term in the ratio of the Paasche price index to the Laspeyres price index equation is the covariance, σ_{pqw^0}, between the price and quantity relatives which was derived above. Therefore, the ratio of the Paasche price index to the Laspeyres price index can be expressed as follows:

$$(23)\ \frac{P_P}{P_L}=1+\frac{\sigma_{pqw^0}}{P_LQ_L}$$

Bortkiewicz's (1923) finding was that a negative covariance coefficient (σ_{pqw^0}) between price and quantity relatives, which follows the normal laws of demand and supply, was a sufficient condition for $P_P/P_L<1$. That is, the sign of σ_{pqw^0} determines the direction of divergence between the Paasche and Laspeyres price indexes. The Paasche price index is larger (less) than the Laspeyres price index when σ_{pqw^0} is greater (less) than zero.

Covariance is not a very useful measure of the precision of a relationship between two variables as it is dependant on the units in which the two variables are measured. Correlation, on the other hand, is independent of the units in which the two variables are measured as it measures the linear relationship between two variables by normalizing the product of the deviations of the two variables by their standard deviations. As a result, the correlation coefficient between two variables x and y, r_{xy}, is bounded between -1 and +1 and is more useful in comparing the degree of relation between two variables. Using the following relationship between covariance (σ_{pq}) and correlation (r_{pq}):

$$(24)\ r_{pq}=\frac{\sigma_{pq}}{\sigma_p\sigma_q}$$

the ratio of the difference between the Paasche price index to the Laspeyres price index can be expressed as follows:

$$(25)\ \frac{P_P}{P_L} = 1 + \frac{r_{pqw^0}\sigma_{pw^0}\sigma_{qw^0}}{P_L Q_L} \qquad \text{using } \sigma_{pqw^0}=r_{pqw^0}*\sigma_{pw^0}\sigma_{qw^0}$$

$$\frac{P_P}{P_L} - 1 = r_{pqw^0}\frac{\sigma_{pw^0}}{P_L}\frac{\sigma_{qw^0}}{Q_L}$$

$$\frac{P_P - P_L}{P_L} = r_{pqw^0}\frac{\sigma_{pw^0}}{P_L}\frac{\sigma_{qw^0}}{Q_L}$$

Therefore, the divergence between the Paasche price index and the Laspeyres price index is determined by three factors:

(1) the coefficient of correlation, r_{pqw^0}, between the price and quantity relatives,
(2) the standard deviation of the price relative as a ratio of the mean price, σ_{pw^0}/P_L (i.e. the coefficient of variation), and
(3) the standard deviation of the quantity relative as a ratio of the mean quantity, σ_{qw^0}/Q_L (i.e. the coefficient of variation)

The two coefficients of variations, however, are always positive and thus the direction of divergence between the Paasche and Laspeyres price indexes is only determined by the correlation coefficient. As previously stated in equation (10), the direction of divergence between the Laspeyres and Paasche quantity index numbers is identical to that of the price index numbers. The gap between the Paasche and Laspeyres indexes can be summarized in three scenarios:

Case 1: $P_L > P_P$ and $Q_L > Q_P$. The Laspeyres price index (and equally its quantity index) is greater than the Paasche price (quantity) index. This is simply the typical demand situation and occurs when demand factors dominate. In this case the price and quantity relatives are negatively correlated ($r_{pqw^0}<0$) so that the Laspeyres price and quantity indexes are systematically greater than the Paasche price and quantity indexes, respectively. This is the normal situation of a demand-oriented market whereby buyers dominate and sellers face a negatively sloped demand curve. The market for consumer goods is an obvious example for this situation.[23]

Case 2: $P_L < P_P$ and $Q_L < Q_P$. The Laspeyres price index (and equally its quantity index) is less than the Paasche price (quantity) index. This situation arises when supply factors dominate. In this case the price and quantity relatives are positively correlated ($r_{pqw^0}>0$) so that the Paasche price and quantity indexes are systematically greater than the Laspeyres price and quantity indexes, respectively. This situation is likely to occur in markets dominated by suppliers where consumers are unable to react to rising prices, either by reducing consumption or through substitution. This is found to be most common in

[23] See Allen (1975).

commodities sold by exporters on a large international market[24] and in lodging and energy commodities.[25]

Case 3: $P_L = P_P$ and $Q_L = Q_P$. The Laspeyres price index (and equally its quantity index) is equal to the Paasche price (quantity) index. In this case, neither demand nor supply factors dominate and there is no correlation ($r_{pqw^0}=0$) between price and quantity relatives.

4. A Bortkiewicz Analysis of the 2005 Basket Update

4.1 Aggregate Analysis: The "All-items" Classification and the Major Components

One reason for conducting a Bortkiewicz analysis is to detected any potential errors that may have occurred in updating the weights applied to the new basket of goods and services as determined by the 2005 SHS.

Statistics Canada only conducts a basket update every four to five years and it is, therefore, not possible to compute the Paasche price index for every year in history because information on current quantities for all years remains unknown. It is, however, possible to compute the Paasche index in the years in which the basket of goods and services is updated. Using the new updated 2005 basket, the Paasche index for the year 2005 can be computed and compared to the Laspeyres index that was calculated in 2005 using the old (2001) basket of goods and services. Likewise, the same process can be followed for the updates to the basket that occurred in 1992, 1996 and 2001; however, the focus of this paper will be on the most recent update.

In theory it is expected, for the most part, that the Laspeyres index will be greater than the Paasche index. Using the estimates of expenditures given by the 2001 and 2005 SHS and prices surveyed over the interim, the Paasche price and quantity indexes are 1.68% lower than the corresponding Laspeyres index for the "All-items" classification (Table1). Hence, there was the usual negative correlation between price and quantity changes. This result provides evidence for a downward sloping demand curve and a consumer market dominated by buyers.

[24] See Allen (1975).
[25] See von der Lippe (2007).

Table 1. Laspeyres and Paasche Price and Quantity Indexes for the "All-items" Classification[26]

$V^{01} = \sum p_{01}q_{01}$ ($000)	$V^{05} = \sum p_{05}q_{05}$ ($000)	$\sum p_{05}q_{01}$ ($000)	$\sum p_{01}q_{05}$ ($000)	$P_L = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$P_P = \sum p_{05}q_{05} / \sum p_{01}q_{05}$	$(P_p - P_L) / P_L$	$Q_L = \sum p_{01}q_{05} / \sum p_{01}q_{01}$	$Q_P = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$(Q_p - Q_L) / Q_L$	$w^{01} = p_{01}q_{01} / \sum p_{01}q_{01}$
466,962,192	571,532,643	509,309,406	532,948,097	1.0907	1.0724	(0.0168)	1.1413	1.1222	(0.0168)	100.0%

The Paasche to Laspeyres differential is dominated by the weighted correlation coefficient between price and quantity relatives. The weighted correlation coefficient was -0.6391, which is quite large when compared to the coefficient of variation for price and quantity relatives of 0.1317 and 0.1995, respectively (Table 2).

Table 2. Bortkiewicz Decomposition Statistics for the "All-items" Classification

Weighted price variance $= \sigma_{pw}^{02} = \sum[(p_{05}/p_{01} - P_L)^2 * (w^{01})]$	$\sigma_{pw}^{0} = [\sigma_p^2]^{0.5}$	Weighted quantity variance $= \sigma_{qw}^{02} = \sum[(q_{05}/q_{01} - Q_L)^2 * (w^{01})]$	$\sigma_{qw}^{0} = [\sigma_q^2]^{0.5}$	Weighted covariance $= r_{pqw}^{0} = V^{05}/V^{01} - P_L*Q_L$	Weighted correlation coefficient $= R_{pqw}^{0} = r_{pqw}^{0} / (\sigma_{pw}^{0})(\sigma_{qw}^{02})$	Coefficient of price variation $= \sigma_{pw}^{0} / P_L$	Coefficient of quantity variation $= \sigma_{qw}^{0} / Q_L$	$(P_P - P_L) / P_L = r_{pqw}^{0} / (P_L)(Q_L)$
0.0206	0.1436	0.0517	0.2275	(0.0209)	(0.6386)	0.1317	0.1993	(0.0168)

At the major component level, the highest level of aggregation below the "All-items" classification, seven of the eight components had a negative impact on the divergence between the Laspeyres and Paasche indexes (Table 3). Recreation, reading and education, and alcohol and tobacco components were by far the largest contributors to the divergence between the two indexes, followed by shelter and household operations and furnishing. Food, on the other hand, had no contribution to the divergence between indexes. This, however, is due to an artifact of the data and will be discussed in detail in the following section. Table 3 also shows that the Laspeyres price and quantity indexes are greater than the corresponding Paasche indexes for all eight major components except health and personal care. This result is contrary to the expectation that under "normal" economic conditions consumers are expected to respond to rising prices by substituting away from relatively more expensive commodities and towards relatively cheaper ones.

[26] In all tables 01 represents the year 2001 and 05 the year 2005.

Table 3. The Laspeyres and Paasche Indexes and their Contribution to the Divergence between Indexes for the Eight Major Components

Code	Description	$V^{01} = \sum p_{01}q_{01}$ ($000)	$V^{05} = \sum p_{05}q_{05}$ ($000)	$\sum p_{05}q_{01}$ ($000)	$\sum p_{01}q_{05}$ ($000)	$P_L = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$P_P = \sum p_{05}q_{05} / \sum p_{01}q_{05}$	$Q_L = \sum p_{01}q_{05} / \sum p_{01}q_{01}$	$Q_P = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$(P_p - P_L) / P_L$ or $(Q_p - Q_L) / Q_L$	$w^{01} = p_{01}q_{01} / \sum p_{01}q_{01}$	Element contribution to index divergence
0	All-Items	466,962,192	571,532,643	509,309,406	532,948,097	1.0907	1.0724	1.1413	1.1222	(0.0168)	100.0%	(0.0168)
1	Food	79,021,317	96,306,676	86,421,166	88,074,166	1.0936	1.0935	1.1146	1.1144	(0.0002)	16.9%	(0.0000)
2	Shelter	123,291,663	146,921,432	138,773,840	130,775,776	1.1256	1.1235	1.0607	1.0587	(0.0019)	26.4%	(0.0011)
3	Household Operations & Furnishings	51,909,735	65,214,091	53,519,764	63,626,791	1.0310	1.0249	1.2257	1.2185	(0.0059)	11.1%	(0.0011)
4	Clothing	28,069,118	31,897,376	27,167,301	33,106,472	0.9679	0.9635	1.1795	1.1741	(0.0045)	6.0%	(0.0005)
5	Transportation	88,934,108	112,007,474	99,625,687	100,409,508	1.1202	1.1155	1.1290	1.1243	(0.0042)	19.0%	(0.0009)
6	Health & Personal Care	21,776,345	27,632,855	23,031,037	26,118,568	1.0576	1.0580	1.1994	1.1998	0.0003	4.7%	(0.0001)
7	Recreation, Reading & Education	58,581,109	74,003,426	59,558,072	77,299,101	1.0167	0.9574	1.3195	1.2425	(0.0583)	12.5%	(0.0092)
8	Alcohol & Tobacco	15,378,797	17,549,313	21,212,540	13,537,715	1.3793	1.2963	0.8803	0.8273	(0.0602)	3.3%	(0.0039)

4.2 Analysis of the Basic Class Elements

In this analysis we are restricted to comparing Laspeyres and Paasche indexes at an aggregate level such as "All-items" or food. The basic class is the lowest level that a consistent set of survey expenditures is used to estimate basket weights. At the basic class level, Laspeyres and Paasche price indexes are identical; so too are the corresponding quantity indexes (see Appendix A). This occurs because over time the weights at the basic class level are price updated and thus do not take into consideration substitution effects.

Given this restriction, however, it is still possible to perform an analysis of the impact of each basic class on the overall divergence between the Laspeyres and Paasche price indexes.[27] A more generalized formula is required in order to perform this analysis. The generalized Bortkiewicz decomposition that follows is due to Schultz (1997), who contributed greatly to Statistics Canada's understanding of the procedure.

In section three, the divergence between the Laspeyres and Paasche price indexes was expressed as follows:

$$(26)\ \frac{P_P - P_L}{P_L} = r_{pqw^0}\ \frac{\sigma_{pw^0}}{P_L}\ \frac{\sigma_{qw^0}}{Q_L}$$

where r_{pqw^0} is the weighted correlation, and σ_{pw^0} and σ_{qw^0} are the weighted standard deviations of price and quantity, respectively. Using the following definition for the weighted correlation coefficient:

[27] In order to perform the analysis the 170 basic classes from the 2001 SHS and the 173 basic classes from the 2005 SHS had to be mapped via 164 basic and pseudo-basic classes. A detailed discussion on the concordance issues between baskets is provided in Appendix B.

$$(27)\; r_{pqw^0} = \frac{\sum_{i=1}^{n} w_i^0 \left((p_i^1/p_i^0) - P_L\right)\left((q_i^1/q_i^0) - Q_L\right)}{\sigma_p \sigma_q}$$

we can re-write the divergence between the Paasche and Laspeyres price indexes as follows:

$$(28)\; \frac{P_P - P_L}{P_L} = \sum_{i=1}^{n} w_i^0 \left(\frac{(p_i^1/p_i^0) - P_L}{P_L}\right)\left(\frac{(q_i^1/q_i^0) - Q_L}{Q_L}\right)$$

For the purpose of this study it is necessary to decompose the relative divergence across all *i* elements in the basket of goods and services.[28] As noted by Schultz (1997), a more generalized decomposition of Bortkiewicz's theorem (equation (28)) can be expressed as follows:[29]

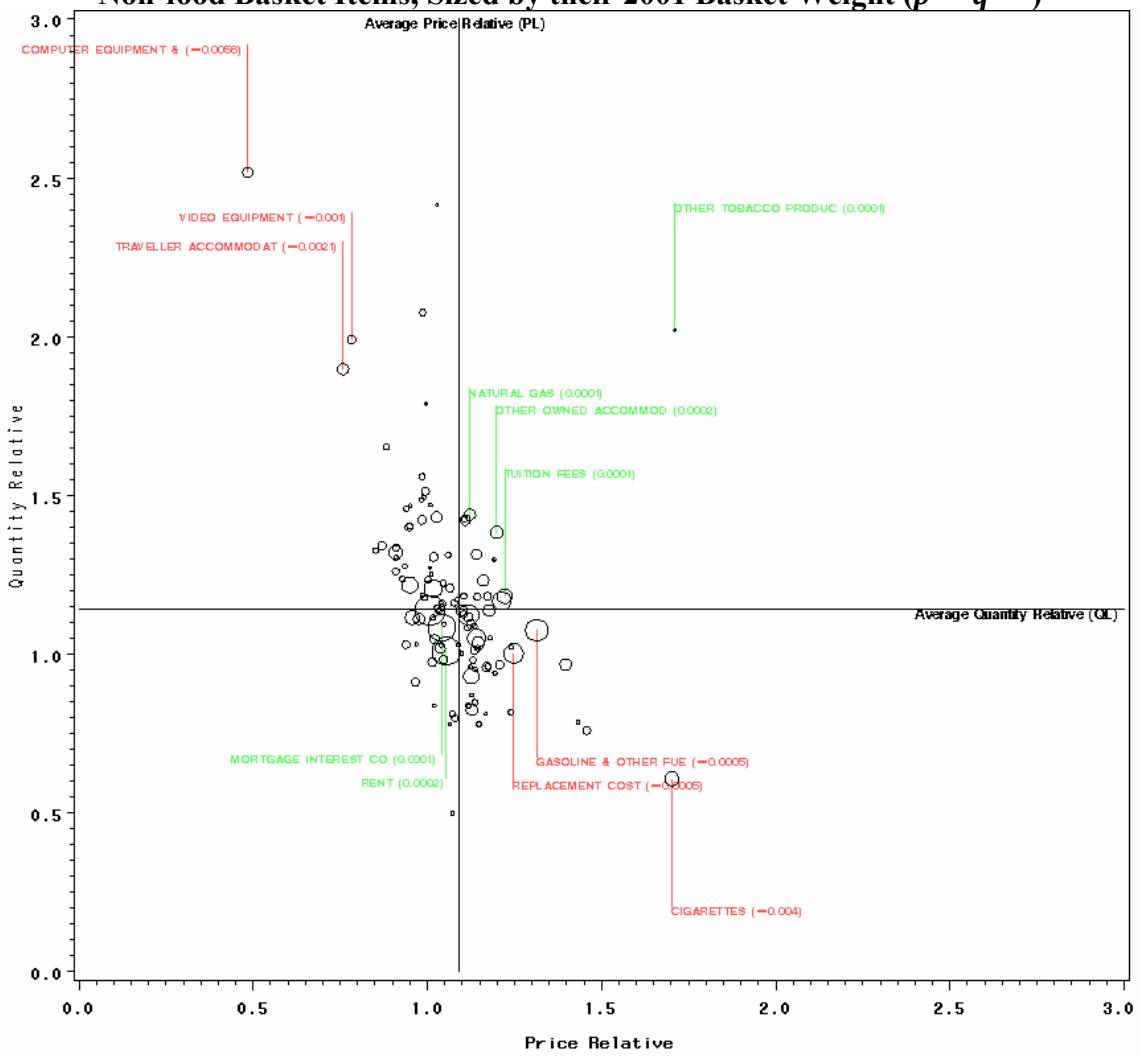
$$(29)\; \frac{P_P - P_L}{P_L} = \sum_i \left[\left(\frac{(p_i^1/p_i^0) - P_L}{P_L}\right) * \left(\frac{(q_i^1/q_i^0) - Q_L}{Q_L}\right) * \left(\frac{p_i^0 q_i^0}{\sum_i p_i^0 q_i^0}\right)\right]$$

That is, the contribution that each element, *i,* had on the divergence between the Laspeyres and Paasche indexes is the product of (1) the relative difference in price movements from the average price movement, (2) the relative difference in quantity shifts from the average quantity shift, and (3) the element's proportional weight in the previous basket.

Using equation (29) it is possible to compute the contribution that each element in the basket of goods and services had on explaining the overall difference between the Laspeyres and Paasche price indexes at the "All-items" level. Appendix A presents the results of the calculations. Graphically, Chart 1 illustrates the three factors that explain the divergence between the two indexes for all elements except food. In the figure, each element is plotted against its price and quantity relatives and the size of each point represents the element's proportional weight in the basket of goods and services ($p^{2001}q^{2001}$). It is thus the product of the deviations of the price and quantity relatives from their means (as indicated by the horizontal and vertical lines in the chart, respectively) and the element's weight in the basket which determines the contribution that each element had on explaining the overall divergence between the Laspeyres and Paasche indexes. As expected, most basic classes had a negative relationship between price changes and quantity shifts from 2001 to 2005, supporting the view that consumers tend to increase their purchases of items with below-average price increases. This is evident by the fact that most of the data points fall into quadrants II and IV of the chart.

[28] Here *i* denotes all individual commodities and their groups.
[29] Appendix C provides a proof of this formula.

Chart 1. Scatter Plot of Price and Quantity Changes between 2001 and 2005 for Non-food Basket Items, Sized by their 2001 Basket Weight ($p^{2001}q^{2001}$)



Below we provide a brief discussion of the elements which contributed significantly to the divergence between the two indexes.

4.2.1 Negative Contributors

Due to a 51% reduction in prices from 2001 to 2005 and an increase in quantities consumed of more than 150%, computer equipment and supplies contributed more than any other basic class to the negative divergence between the Laspeyres and Paasche index. In previous CPI basket updates computers consistently placed among the leading negative contributors. Between 2001 and 2005, current dollar expenditures on computers increased by over 22% as a digital lifestyle continued to penetrate Canadian households.

Similarly, video equipment continued to gain basket share due in part to steady price decreases and a 90% increase in quantities consumed. This recreational commodity was the fourth largest negative contributor to the divergence between indexes.

As in years past, the basic class cigarettes was also a leading negative contributor to the divergence between indexes. From 2001 to 2005, a series of tax increases led to a 70% rise in cigarette prices and contributed to a 39% decrease in quantities consumed. The tobacco price increase, in combination with other public health measures such as smoking bans in public places, contributed to a cut in smoking rates among Canadians aged 12 and older from 26% in 2000/2001 to 22% in 2005.[30]

Due to a methodological error in the calculation of traveller accommodation prices, which was only corrected in 2006, this basic class became a leading negative contributor to the divergence between indexes. In the official published series, prices for traveller accommodation decreased by 24% from 2001 to 2005 and quantities consumed increased by 90%. Using a revised methodology, however, prices for this basic class would have increased slightly by 8.5% and quantities consumed would have only increased by 33%, resulting in a negligible downward contribution to the divergence between indexes.[31]

Results from a preliminary Bortkiewicz analysis helped to correct for an error in the calculated weights for replacement cost. In the early stages of the Bortkiewicz analysis, replacement cost was pinpointed as a very large positive contributor. Initially, the replacement cost weight, based on the SHS question "Value of home owned", showed a 24% increase in quantities between 2001 and 2005. In the same period, the index for replacement cost rose 25%, as prices were pegged to the New Housing Price Index. A correction to the 2005 basket weight for replacement cost was made by using price-updated ($p^{2005}q^{2001}$) expenditures, and as a result, the 2005 expenditure weight for this large budget item was reduced from $21,481,464,000 to $17,373,132,000. With this adjustment, quantities were virtually unchanged and replacement cost became a large negative contributor.

From 2001 to 2005, as gasoline prices increased by 31% consumption edged upwards. The derived quantity change for this period was 7.5%; the Monthly Refined Petroleum Products survey showed a similar increase of 5.2%.[32] This resilience to energy price shocks actually represents a decrease relative to the average (Laspeyres) quantity increase of 14% and thus gasoline served as a negative contributor to the divergence between indexes.

4.2.2 Positive Contributors

Pushing the divergence between indexes in the other direction were two of the largest basket items, rent and mortgage interest cost. Both of these items saw slight but below-

[30] The Daily (June 13, 2006).
[31] Using the revised price change for traveler accommodation would have had only a small impact on other basic class contributions and would have reduced the magnitude of the overall index divergence to -0.0147.
[32] CANSIM Table 134-0004 Supply and disposition of refined petroleum products, monthly (cubic metres).

average price increases, in addition to sub-par quantity increases. As a result, these items became leading positive contributors to the divergence between indexes.

Other owned accommodation expenses was the second largest positive contributor to the divergence between indexes, owing to a 20% increase in prices and a 38% increase in quantities. The increase in expenditures on this basic class was not surprising since it was largely tied to the revived real estate market and included expenses on real estate commissions, legal fees, appraisals, surveying and mortgage penalties, transfer taxes and land registration fees.

The positive contribution of other tobacco products and smokers' supplies proved to be a surprise and occurred due to a change in the scope of the SHS question. In 2001, expenditures on cigars were included with cigarettes; in 2005, however, they were moved to other tobacco products, explaining in part the 245% increase in expenditures for this relatively small basic class.

From 2001 to 2005, Canadians continued a decades-long shift from oil to natural gas as a source of heat, even though natural gas prices rose at an above-average rate. This resulted in natural gas having a positive contribution on the divergence between indexes.

Tuition fees were a leading positive contributor as above average price increases were coupled with an 18% increase in real expenditures. This figure mirrors the 19% increase in full- and part-time university enrolment from the 2000/2001 academic year to the 2004/2005 year[33] as Ontario's double cohort and rising numbers of foreign students and young adults pushed up the demand for higher education.[34]

Air transportation also saw above average increases in prices and quantities and contributed positively to the divergence between indexes. After slumping earlier in the decade, the Canadian airline industry rebounded in 2004 and by 2005 passenger-miles flown by major Canadian air carriers were 25% higher than in 2001.[35] This closely tracks the 31% change in quantities observed in the Bortkiewicz analysis.

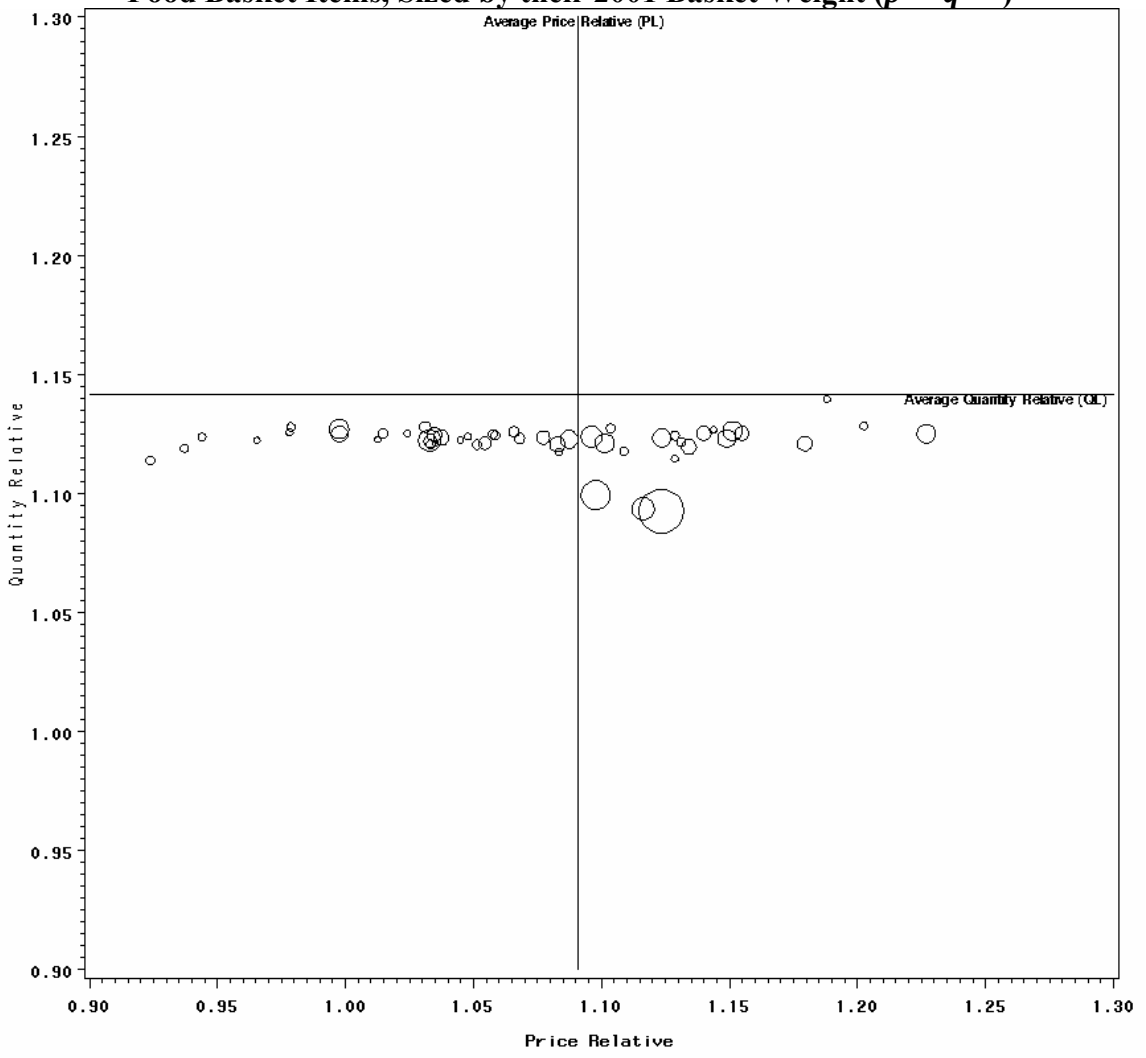
4.2.3 Special Case: Food

Aside from the large negative and positive contributors to the divergence between the Laspeyres and Paasche indexes, one group which contributed very little to the divergence should be noted. As discussed earlier, all the basic classes under food had their 2005 basket weights calculated by using the aggregated store-bought or restaurant food expenditures from the 2005 SHS and redistributing their weights using price-updated 2001 expenditures ($p^{2005}q^{2001}$). Chart 2, which has a layout identical to Chart 1, indicates that each store-bought food element had a quantity change near 12% while the restaurant-

[33] CANSIM Table 477-0013 University enrolments, by registration status, program level, Classification of Instructional Programs, Primary Grouping (CIP_PG) and sex, annual (number).
[34] The Daily (November 7, 2006).
[35] CANSIM Table 401-00011 Operating and financial statistics of major Canadian airlines, monthly (data in thousands).

bought food elements had a quantity change near 9%. These quantity changes are only slightly below the aggregate Laspeyres quantity index (average quantity index). As a result, the relative difference in quantity shifts from the average quantity shift is very small and the product of the three factors determining an element's contribution to the divergence between the two indexes is minimal, indicating that the food elements had a negligible impact on the divergence between indexes. This conclusion is further apparent by the fact that all data points lie in quadrants III and IV of the chart.

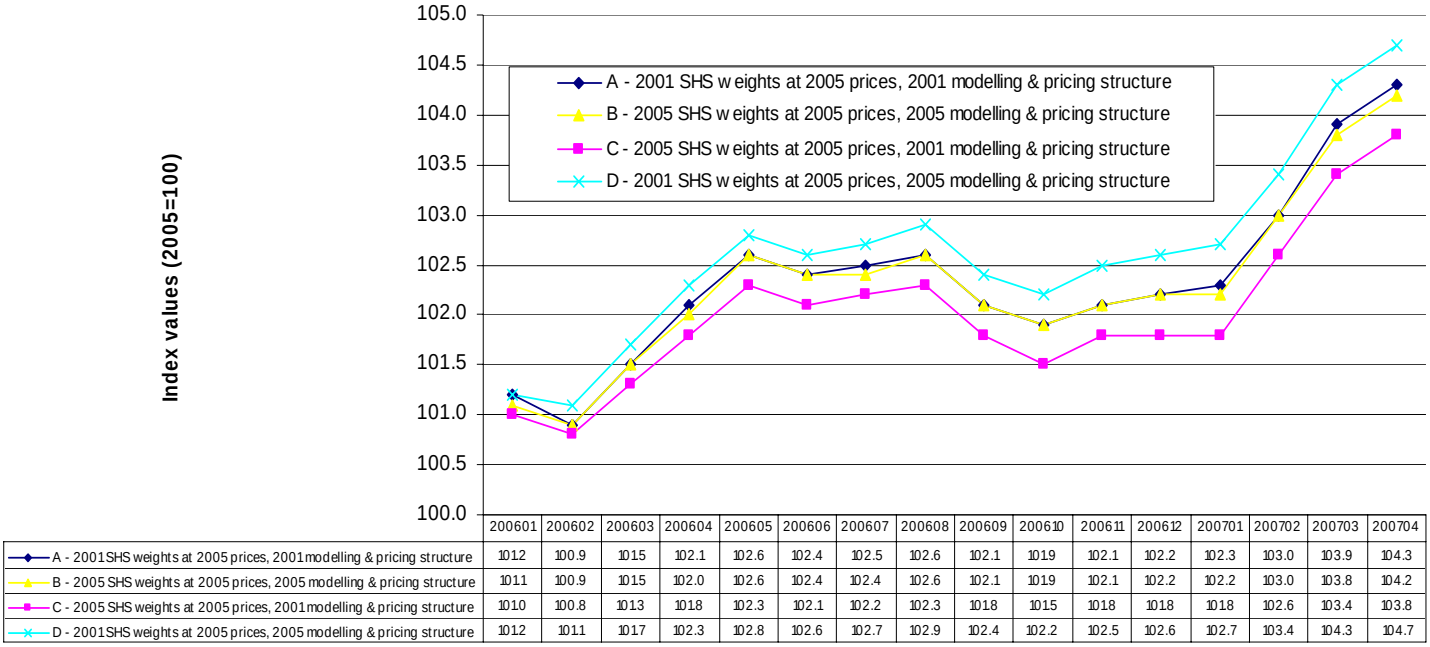
Chart 2. Scatter Plot of Price and Quantity Changes between 2001 and 2005 for Food Basket Items, Sized by their 2001 Basket Weight ($p^{2001}q^{2001}$)



5. Comparison of Consumer Price Indexes Associated with the 2001 and 2005 Baskets

In May 2007, Statistics Canada updated the CPI to reflect changes in the spending patterns of Canadian households. The weights of various items in the basket of goods and services used to calculate the index was updated from 2001 to 2005. In addition, the CPI base year (the period for which the value of 100 is assigned to the index) also changed from 1992 to 2002. Given that the use of different baskets generally leads to different index numbers, it is of interest to know how much the CPI would have differed if the 2005 basket had been employed from January 2006 through to April 2007 instead of the 2001 basket. A comparison of consumer price index series associated with the 2001 and 2005 baskets is presented below in Chart 3. For comparison purposes both baskets have been valued in 2005 prices. That is, the series pertaining to the 2001 basket is the rebased "old" (series A) official CPI series (2005=100) while the series pertaining to the 2005 basket is the "new" (series B) CPI series, set on a 2005 time base.[36]

Chart 2.Consumer Price Indexes Based on Alternative Weights and Prices



	200601	200602	200603	200604	200605	200606	200607	200608	200609	200610	200611	200612	200701	200702	200703	200704
A - 2001SHS weights at 2005 prices, 2001modelling & pricing structure	101.2	100.9	101.5	102.1	102.6	102.4	102.5	102.6	102.1	101.9	102.1	102.2	102.3	103.0	103.9	104.3
B - 2005 SHS weights at 2005 prices, 2005 modelling & pricing structure	101.1	100.9	101.5	102.0	102.6	102.4	102.4	102.6	102.1	101.9	102.1	102.2	102.2	103.0	103.8	104.2
C - 2005 SHS weights at 2005 prices, 2001modelling & pricing structure	101.0	100.8	101.3	101.8	102.3	102.1	102.2	102.3	101.8	101.5	101.8	101.8	101.8	102.6	103.4	103.8
D - 2001SHS weights at 2005 prices, 2005 modelling & pricing structure	101.2	101.1	101.7	102.3	102.8	102.6	102.7	102.9	102.4	102.2	102.5	102.6	102.7	103.4	104.3	104.7

In April 2007, the "new" All-items series was lower than the old series by a marginal 0.1 index points. After indexes are rounded to the first decimal, in 6 out of the 16 months the "new" index would have yielded lower results, while in the other 10 months the indexes would have yielded identical results.

[36] The "old" series corresponds to $\sum P_t Q_{2001} / \sum P_{2005} Q_{2001}$ and the "new" series corresponds to $\sum P_t Q_{2005} / \sum P_{2005} Q_{2005}$.

A major implication of comparing the two series is that there have been significant structural changes to the modeling of several elements in the basket of goods and services. In particular, changes to the modeling structure of mortgage interest cost and traveler accommodation have been implemented and are incorporated into the "new" index but have not been built into to the "old" index. As a result, it is not sufficient to compare between these two index series since they differ in their methodological structure. To correct for this there are two options. The first option is to compute an "updated new" series (series C), which uses the weights from the 2005 SHS but the modeling structure (pricing rules) from 2001 and compare this series to the "old" series.[37] The other option is to compute an "updated old" series (series D), which uses the 2001 SHS structure but the 2005 modeling structure (pricing rules) and compare this to the "new" series.[38]

As illustrated in Chart 3, the "updated new" series (series C) is 0.5 index points lower than the "old" series (series A) in April 2007. The "updated new" series is consistently lower than the "old" series and from January 2006 to April 2007 the average monthly difference between the two series is -0.3 index points. Likewise, the "new" series (series B) is consistently lower than the "updated old" series (series D) and in April 2007 is also 0.5 index points lower. From January 2006 to April 2007, the average monthly difference between the "new" series and the "updated old" series is -0.3 index points. The consistency of these results is expected and provides a check on the methodology used for this analysis.

6. Conclusions and Areas of Future Research

This paper has attempted to use the Bortkiewicz framework to compare the Laspeyres and Paasche price indexes for the most recent basket update of the CPI. The paper has provided an overview of the statistical relationships between the two indexes and has provided justifications based on economic theory and on prior research for our expectation that the base-weighted Laspeyres price index would exceed the current-weighted Paasche index. In comparing the two indexes based on 2001 or 2005 expenditure weights, this paper showed that, on the whole, Canadian households shifted consumption away from relatively high-priced goods and services and towards relatively lower-priced ones.

This analysis has also shed light on anomalies such as replacement cost and food, both of which had an unusual basis for their 2005 weights, and traveler accommodation, which had a known error in its pricing. In addition, it drew attention to another basic class, other tobacco products, which was an extreme outlier due to a definitional change. Overall, the analysis served as a useful tool in identifying possible discrepancies in the updated weights applied to the elements in the basket of goods and services as determined by the 2005 SHS.

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[37] Series C is calculated using the following formula: $[\sum(P_tQ_{2001}/P_{2005}Q_{2001})* P_{2005}Q_{2005}] / \sum P_{2005}Q_{2005}$.

[38] Series D is calculated using the following formula: $[\sum(P_tQ_{2005}/P_{2005}Q_{2005})* P_{2005}Q_{2001}] / \sum P_{2005}Q_{2001}$.

In light of the Bortkiewicz analysis, further work is recommended in the following areas. First, it would be useful to consider a comparison between the computed Laspeyres and Paasche indexes to a "superlative" index such as the Fisher or Törnqvist index. This would represent an attempt to better estimate cost of living changes and would provide information about the amount of substitution bias. Second, it is proposed that further research be conducted into the method used to estimate food weights. Finally, since the Bortkiewicz analysis undertaken here offers strong evidence for a downward-sloping demand curve, a regression model could possibly provide better estimates for quantity changes and expenditure totals for the individual food elements.

Appendix A: Basic Class Detail

Code	Description	$V^{01} = \sum p_{01}q_{01}$ ($000)	$V^{05} = \sum p_{05}q_{05}$ ($000)	$\sum p_{05}q_{01}$ ($000)	$\sum p_{01}q_{05}$ ($000)	$P_L = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$P_P = \sum p_{05}q_{05} / \sum p_{01}q_{05}$	$Q_L = \sum p_{01}q_{05} / \sum p_{01}q_{01}$	$Q_P = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$W_j^c = P_{01}Q_{01} / \sum P_{01}Q_{01}$	$PR_j = [(P_{05}/P_{01}) - P_L] / P_L$	$QR_j = [(Q_{05}/Q_{01}) - Q_L] / Q_L$	Element Contribution $= W_j^c * PR_j * QR_j$
0	**All-Items**	**466962192**	**571532643**	**509309406**	**532948097**	**1.0907**	**1.0724**	**1.1413**	**1.1222**	**1.0000**	**n.a**	**n.a**	**(0.0168)**
11010101	Fresh Or Frozen Beef	3336151	4109328	3656758	3749042	1.0961	1.0961	1.1238	1.1238	0.0071	0.0050	(0.0154)	(0.0000)
11010102	Fresh Or Frozen Pork	1300007	1506934	1343183	1458495	1.0332	1.0332	1.1219	1.1219	0.0028	(0.0527)	(0.0170)	0.0000
11010103	Other Fresh Or Frozen Meat (Excl. Poultry)	324697	439545	385741	369987	1.1880	1.1880	1.1395	1.1395	0.0007	0.0892	(0.0016)	(0.0000)
11010201	Fresh Or Frozen Chicken	2336931	3014669	2684788	2624071	1.1489	1.1489	1.1229	1.1229	0.0050	0.0533	(0.0162)	(0.0000)
11010202	Other Fresh Or Frozen Poultry Meat	352578	443457	397905	392942	1.1286	1.1286	1.1145	1.1145	0.0008	0.0347	(0.0235)	(0.0000)
11010301	Ham & Bacon	1134751	1341228	1196440	1272073	1.0544	1.0544	1.1210	1.1210	0.0024	(0.0333)	(0.0178)	0.0000
11010302	Other Processed Meat	2294694	2801046	2495117	2576049	1.0873	1.0873	1.1226	1.1226	0.0049	(0.0031)	(0.0164)	0.0000
11020101	Fresh Or Frozen Fish (Incl. Portions & Fish Sticks)	887958	1032618	915606	1001437	1.0311	1.0311	1.1278	1.1278	0.0019	(0.0546)	(0.0118)	0.0000
11020102	Canned & Other Preserved Fish	416659	441945	393322	468166	0.9440	0.9440	1.1236	1.1236	0.0009	(0.1345)	(0.0155)	0.0000
110202	Other Seafood & Marine Products	490731	541705	480286	553485	0.9787	0.9787	1.1279	1.1279	0.0011	(0.1027)	(0.0118)	0.0000
11030101	Fresh Milk	2432579	3069755	2733092	2732224	1.1235	1.1235	1.1232	1.1232	0.0052	0.0301	(0.0159)	(0.0000)
11030102	Butter	470891	638911	566219	531346	1.2024	1.2024	1.1284	1.1284	0.0010	0.1025	(0.0113)	(0.0000)
11030103	Cheese	2680980	3475718	3086540	3019021	1.1513	1.1513	1.1261	1.1261	0.0057	0.0555	(0.0133)	(0.0000)
11030104	Ice Cream & Related Products	565571	717523	639721	634355	1.1311	1.1311	1.1216	1.1216	0.0012	0.0371	(0.0173)	(0.0000)
11030105	Other Dairy Products	1351853	1756758	1561323	1521068	1.1550	1.1550	1.1252	1.1252	0.0029	0.0589	(0.0141)	(0.0000)
110302	Eggs	603349	765529	680964	678276	1.1286	1.1286	1.1242	1.1242	0.0013	0.0348	(0.0150)	(0.0000)
11040101	Bread & Unsweetened Rolls & Buns	2378615	3282791	2918138	2675848	1.2268	1.2268	1.1250	1.1250	0.0051	0.1248	(0.0143)	(0.0000)
11040102	Biscuits	1261263	1526392	1358718	1416911	1.0773	1.0773	1.1234	1.1234	0.0027	(0.0123)	(0.0157)	0.0000
11040103	Other Bakery Products	1525721	1956678	1739213	1716491	1.1399	1.1399	1.1250	1.1250	0.0033	0.0451	(0.0143)	(0.0000)
11040201	Rice (Incl. Mixes)	318059	366489	325730	357858	1.0241	1.0241	1.1251	1.1251	0.0007	(0.0610)	(0.0142)	0.0000
11040202	Breakfast Cereal & Other Grains (Excl. Infant)	1568655	1903341	1698722	1757607	1.0829	1.0829	1.1205	1.1205	0.0034	(0.0071)	(0.0183)	0.0000
11040203	Pasta Products	651281	767169	684723	729700	1.0513	1.0513	1.1204	1.1204	0.0014	(0.0361)	(0.0183)	0.0000
11040204	Flour & Flour Based Mixes	301432	353503	314948	338333	1.0448	1.0448	1.1224	1.1224	0.0006	(0.0420)	(0.0166)	0.0000
11050101	Apples	603107	717369	637775	678374	1.0575	1.0575	1.1248	1.1248	0.0013	(0.0304)	(0.0145)	0.0000
11050102	Oranges	571576	680291	605008	642699	1.0585	1.0585	1.1244	1.1244	0.0012	(0.0295)	(0.0148)	0.0000
11050103	Bananas & Plantains	489772	513519	458940	548017	0.9370	0.9370	1.1189	1.1189	0.0010	(0.1409)	(0.0196)	0.0000
11050104	Other Fresh Fruit	1994448	2238205	1989780	2243456	0.9977	0.9977	1.1249	1.1249	0.0043	(0.0853)	(0.0144)	0.0000
11050201	Fruit Juices	1622147	1887563	1678479	1824214	1.0347	1.0347	1.1246	1.1246	0.0035	(0.0513)	(0.0147)	0.0000
11050202	Other Preserved Fruit & Fruit Preparations	625507	724108	646249	700868	1.0332	1.0332	1.1205	1.1205	0.0013	(0.0527)	(0.0183)	0.0000
110503	Nuts	344378	405528	360845	387022	1.0478	1.0478	1.1238	1.1238	0.0007	(0.0393)	(0.0153)	0.0000
11060101	Potatoes	542906	558572	501528	604656	0.9238	0.9238	1.1137	1.1137	0.0012	(0.1530)	(0.0242)	0.0000
11060102	Tomatoes	595378	740735	657072	671186	1.1036	1.1036	1.1273	1.1273	0.0013	0.0119	(0.0123)	(0.0000)
11060103	Lettuce	379023	417303	370737	426630	0.9781	0.9781	1.1256	1.1256	0.0008	(0.1032)	(0.0138)	0.0000
11060104	Other Fresh Vegetables	2730825	3069775	2723952	3077520	0.9975	0.9975	1.1270	1.1270	0.0058	(0.0855)	(0.0126)	0.0000
11060201	Frozen & Dried Vegetables (Excl. Canned)	505924	626883	560945	565394	1.1088	1.1088	1.1175	1.1175	0.0011	0.0166	(0.0208)	(0.0000)
11060202	Canned Vegetables & Other Vegetable Preparations	790199	948199	842179	889676	1.0658	1.0658	1.1259	1.1259	0.0017	(0.0228)	(0.0135)	0.0000
11070101	Sugar & Syrup	324597	351644	313354	364261	0.9654	0.9654	1.1222	1.1222	0.0007	(0.1149)	(0.0167)	0.0000
11070102	Confectionery	1605544	2038597	1821107	1797290	1.1343	1.1343	1.1194	1.1194	0.0034	0.0400	(0.0192)	(0.0000)
11070201	Margarine	364253	440861	394601	406955	1.0833	1.0833	1.1172	1.1172	0.0008	(0.0068)	(0.0211)	0.0000
11070202	Other Edible Fats & Oils, Nes	291466	375609	333379	328387	1.1438	1.1438	1.1267	1.1267	0.0006	0.0487	(0.0128)	(0.0000)
11070301	Coffee	676273	772065	686195	760902	1.0147	1.0147	1.1251	1.1251	0.0014	(0.0697)	(0.0142)	0.0000
11070302	Tea	226274	262526	234195	253647	1.0350	1.0350	1.1210	1.1210	0.0005	(0.0511)	(0.0178)	0.0000

Code	Description	$V^{01} = \sum p_{01}q_{01}$ ($000)	$V^{05} = \sum p_{05}q_{05}$ ($000)	$\sum p_{05}q_{01}$ ($000)	$\sum p_{01}q_{05}$ ($000)	$P_L = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$P_P = \sum p_{05}q_{05} / \sum p_{01}q_{05}$	$Q_L = \sum p_{01}q_{05} / \sum p_{01}q_{01}$	$Q_P = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$W_j^c = P_{01}Q_{01} / \sum P_{01}Q_{01}$	$PR_j = [(P_{05}/P_{01}) - P_L] / P_L$	$QR_j = [(Q_{05}/Q_{01}) - Q_L] / Q_L$	Element Contribution $= W_j^c * PR_j * QR_j$
110704	Condiments, Spices & Vinegars	1640179	1911622	1701668	1842547	1.0375	1.0375	1.1234	1.1234	0.0035	(0.0488)	(0.0157)	0.0000
11070501	Soup (Excl. Infant Soup)	769399	922834	821720	864075	1.0680	1.0680	1.1231	1.1231	0.0016	(0.0208)	(0.0160)	0.0000
11070502	Infant & Junior Foods	245794	279400	248892	275923	1.0126	1.0126	1.1226	1.1226	0.0005	(0.0716)	(0.0164)	0.0000
11070503	Pre-Cooked Frozen Food Preparations	1698979	2245906	2003839	1904218	1.1794	1.1794	1.1208	1.1208	0.0036	0.0814	(0.0180)	(0.0000)
11070504	All Other Food Preparations	2699501	3332463	2972731	3026169	1.1012	1.1012	1.1210	1.1210	0.0058	0.0097	(0.0178)	(0.0000)
110706	Non-Alcoholic Beverages	3683420	4269157	3804551	4133233	1.0329	1.0329	1.1221	1.1221	0.0079	(0.0530)	(0.0168)	0.0000
1201	Food & Non-Alcoholic Bvgs Purchased In Table Service Restaurant	14136092	17351306	15880624	15445216	1.1234	1.1234	1.0926	1.0926	0.0303	0.0300	(0.0427)	(0.0000)
1202	Food & Non-Alcoholic Bvgs Purchased In Fast Food &Take-Out Restaurants	6128269	7393944	6727092	6735761	1.0977	1.0977	1.0991	1.0991	0.0131	0.0064	(0.0370)	(0.0000)
1203	Food & Non-Alcoholic Bvgs Purchased In Cafeteria. & Other Restaurants	3750681	4577658	4186531	4101089	1.1162	1.1162	1.0934	1.0934	0.0080	0.0234	(0.0420)	(0.0000)
2101	Rent	28679099	30492226	30238729	28919522	1.0544	1.0544	1.0084	1.0084	0.0614	(0.0333)	(0.1165)	0.0002
2102	Tenants' Insurance Premiums	439637	474203	494166	421876	1.1240	1.1240	0.9596	0.9596	0.0009	0.0306	(0.1592)	(0.0000)
2103	Tenants' Maintenance, Repairs & Other Expenses	377991	313152	402060	294407	1.0637	1.0637	0.7789	0.7789	0.0008	(0.0248)	(0.3176)	0.0000
2201	Mortgage Interest Cost	26156848	29507942	27246735	28327605	1.0417	1.0417	1.0830	1.0830	0.0560	(0.0449)	(0.0511)	0.0001
2202	Replacement Cost	13919466	17373132	17370624	13921476	1.2479	1.2479	1.0001	1.0001	0.0298	0.1442	(0.1237)	(0.0005)
2203	Property Taxes (Incl. Special Charges)	14885087	18692913	16652280	16709161	1.1187	1.1187	1.1225	1.1225	0.0319	0.0257	(0.0164)	(0.0000)
2204	Homeowners' Insurance Premiums & Mortgage Insurance	4500229	6077007	6286681	4350137	1.3970	1.3970	0.9666	0.9666	0.0096	0.2808	(0.1530)	(0.0004)
2205	Homeowners' Maintenance & Repairs	8284960	8680623	9330568	7707850	1.1262	1.1262	0.9303	0.9303	0.0177	0.0326	(0.1848)	(0.0001)
2206	Other Owned Accommodation Expenses	5166514	8561553	6191535	7144170	1.1984	1.1984	1.3828	1.3828	0.0111	0.0988	0.2116	0.0002
2301	Electricity	11708543	14029944	13364919	12291148	1.1415	1.1415	1.0498	1.0498	0.0251	0.0466	(0.0802)	(0.0001)
2302	Water	2270706	2647803	2741769	2192884	1.2075	1.2075	0.9657	0.9657	0.0049	0.1071	(0.1538)	(0.0001)
2303	Natural Gas	4793797	7735523	5379144	6893760	1.1221	1.1221	1.4381	1.4381	0.0103	0.0288	0.2600	0.0001
2304	Fuel Oil And Other Fuel	2108787	2335411	3074630	1601781	1.4580	1.4580	0.7596	0.7596	0.0045	0.3368	(0.3345)	(0.0005)
310101	Telephone Services	10960909	13440828	11144650	13219230	1.0168	1.0168	1.2060	1.2060	0.0235	(0.0678)	0.0567	(0.0001)
310102	Postal Services & Other Communication Services	565952	717306	702004	578288	1.2404	1.2404	1.0218	1.0218	0.0012	0.1373	(0.1047)	(0.0000)
310103	Internet Provision	1485485	3042438	1465643	3083626	0.9866	0.9866	2.0758	2.0758	0.0032	(0.0954)	0.8188	(0.0002)
310201	Child Care	3432696	3622503	3560169	3492799	1.0371	1.0371	1.0175	1.0175	0.0074	(0.0491)	(0.1085)	0.0000
310202	Domestic Services	1444395	1885154	1594387	1707808	1.1038	1.1038	1.1824	1.1824	0.0031	0.0121	0.0360	0.0000
310301	Detergent & Soap (Other Than For Personal Care)	1234411	1896556	1216474	1924521	0.9855	0.9855	1.5591	1.5591	0.0026	(0.0965)	0.3660	(0.0001)
310302	Other Household Chemical Products	1279317	1111698	1370892	1037438	1.0716	1.0716	0.8109	0.8109	0.0027	(0.0175)	(0.2895)	0.0000
310401	Paper Supplies	2484682	2550032	2598385	2438444	1.0458	1.0458	0.9814	0.9814	0.0053	(0.0412)	(0.1401)	0.0000
310402	Plastic & Foil Supplies	805177	860159	837036	827421	1.0396	1.0396	1.0276	1.0276	0.0017	(0.0469)	(0.0996)	0.0000
310501	Pet Food & Supplies	2329383	2994312	2480090	2812358	1.0647	1.0647	1.2073	1.2073	0.0050	(0.0238)	0.0579	(0.0000)
310502	Seeds, Plants & Cut Flowers	1456513	1759278	1625114	1576758	1.1158	1.1158	1.0826	1.0826	0.0031	0.0230	(0.0515)	(0.0000)
310503	Other Horticultural Goods	404374	403775	391763	416773	0.9688	0.9688	1.0307	1.0307	0.0009	(0.1117)	(0.0969)	0.0000
310504	Other Household Supplies	719364	1050221	707028	1068547	0.9829	0.9829	1.4854	1.4854	0.0015	(0.0989)	0.3015	(0.0000)
310505	Other Household Services	1961631	2718845	2300788	2318062	1.1729	1.1729	1.1817	1.1817	0.0042	0.0754	0.0354	0.0000
310506	Financial Services	2408994	2769629	2735115	2439392	1.1354	1.1354	1.0126	1.0126	0.0052	0.0410	(0.1128)	(0.0000)
32010101	Upholstered Furniture	2495117	3492971	2456472	3547923	0.9845	0.9845	1.4219	1.4219	0.0053	(0.0973)	0.2459	(0.0001)
32010102	Wooden Furniture	2821218	3016036	2881067	2953384	1.0212	1.0212	1.0468	1.0468	0.0060	(0.0637)	(0.0828)	0.0000
32010103	Other Furniture	2187352	3290997	2175743	3308556	0.9947	0.9947	1.5126	1.5126	0.0047	(0.0880)	0.3253	(0.0001)
32010201	Window Coverings	623266	793130	676713	730489	1.0858	1.0858	1.1720	1.1720	0.0013	(0.0045)	0.0269	(0.0000)
32010202	Bedding & Other Household Textiles	1024210	1195954	1016505	1205018	0.9925	0.9925	1.1765	1.1765	0.0022	(0.0900)	0.0309	(0.0000)

Code	Description	$V^{01} = \sum p_{01}q_{01}$ ($000)	$V^{05} = \sum p_{05}q_{05}$ ($000)	$\sum p_{05}q_{01}$ ($000)	$\sum p_{01}q_{05}$ ($000)	$P_L = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$P_P = \sum p_{05}q_{05} / \sum p_{01}q_{05}$	$Q_L = \sum p_{01}q_{05} / \sum p_{01}q_{01}$	$Q_P = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$W_j^c = P_{01}Q_{01} / \sum P_{01}Q_{01}$	$PR_j = [(P_{05}/P_{01}) - P_L] / P_L$	$QR_j = [(Q_{05}/Q_{01}) - Q_L] / Q_L$	Element Contribution $= W_j^c * PR_j * QR_j$
32010203	Area Rugs & Mats	384028	593946	457692	498353	1.1918	1.1918	1.2977	1.2977	0.0008	0.0927	0.1370	0.0000
32020101	Cooking Appliances	876726	1046656	820111	1118911	0.9354	0.9354	1.2762	1.2762	0.0019	(0.1424)	0.1182	(0.0000)
32020102	Refrigeration & Air Conditioning Appliances	1063609	1458854	1000465	1550930	0.9406	0.9406	1.4582	1.4582	0.0023	(0.1376)	0.2776	(0.0001)
32020104	Other Household Appliances	1154166	1325009	1071866	1426746	0.9287	0.9287	1.2362	1.2362	0.0025	(0.1485)	0.0831	(0.0000)
320202	Kitchen Utensils, Tableware, Non-Electric Cookware and Flatware	747877	886871	680715	974374	0.9102	0.9102	1.3029	1.3029	0.0016	(0.1655)	0.1415	(0.0000)
32020301	Household Tools (Incl. Lawn, Garden & Snow Removal Equipment)	2237971	2969777	2119824	3135296	0.9472	0.9472	1.4010	1.4010	0.0048	(0.1315)	0.2275	(0.0001)
32020302	Other Household Equipment	1277152	1700550	1212493	1791234	0.9494	0.9494	1.4025	1.4025	0.0027	(0.1296)	0.2289	(0.0001)
3203	Services Related To Household Furnishings & Equipment	1280023	1490778	1464220	1303240	1.1439	1.1439	1.0181	1.0181	0.0027	0.0488	(0.1079)	(0.0000)
4101	Women's Clothing	9435525	10905525	8960189	11484060	0.9496	0.9496	1.2171	1.2171	0.0202	(0.1293)	0.0664	(0.0002)
4102	Men's Clothing	7051539	7513787	6745082	7855170	0.9565	0.9565	1.1140	1.1140	0.0151	(0.1230)	(0.0240)	0.0000
4103	Children's Clothing (Including Infants')	2380392	2777251	2071299	3191691	0.8702	0.8702	1.3408	1.3408	0.0051	(0.2022)	0.1748	(0.0002)
4201	Women's Footwear (Excl. Athletic)	1484181	1834630	1487460	1830585	1.0022	1.0022	1.2334	1.2334	0.0032	(0.0811)	0.0807	(0.0000)
4202	Men's Footwear (Exc. Athletic)	990683	1121488	1006534	1103827	1.0160	1.0160	1.1142	1.1142	0.0021	(0.0685)	(0.0237)	0.0000
4203	Children's Footwear (Excl. Athletic)	224287	287032	225722	285206	1.0064	1.0064	1.2716	1.2716	0.0005	(0.0773)	0.1142	(0.0000)
4204	Athletic Footwear	1695539	1943106	1541507	2137266	0.9092	0.9092	1.2605	1.2605	0.0036	(0.1664)	0.1045	(0.0001)
430101	Leather Accessories	404059	598934	407662	593640	1.0089	1.0089	1.4692	1.4692	0.0009	(0.0750)	0.2873	(0.0000)
430102	Other Accessories	472421	658517	449011	692850	0.9504	0.9504	1.4666	1.4666	0.0010	(0.1286)	0.2850	(0.0000)
4302	Watches	411257	520289	415838	514557	1.0111	1.0111	1.2512	1.2512	0.0009	(0.0729)	0.0963	(0.0000)
4303	Jewellery (Excl. Watches)	1426835	1782989	1536464	1655770	1.0768	1.0768	1.1604	1.1604	0.0031	(0.0127)	0.0168	(0.0000)
4401	Clothing Materials & Notions	403362	344387	411456	337612	1.0201	1.0201	0.8370	0.8370	0.0009	(0.0647)	(0.2666)	0.0000
4402	Laundry Services (Incl. Self-Service Dry Cleaning)	553090	543160	623983	481450	1.1282	1.1282	0.8705	0.8705	0.0012	0.0344	(0.2373)	(0.0000)
4403	Dry Cleaning Services (Excl. Self-Service)	828109	774759	925682	693095	1.1178	1.1178	0.8370	0.8370	0.0018	0.0249	(0.2667)	(0.0000)
4404	Other Clothing Services	307839	291524	359412	249693	1.1675	1.1675	0.8111	0.8111	0.0007	0.0705	(0.2893)	(0.0000)
51010101	Purchase Of Automotive Vehicles	32117105	36809083	32362821	36529609	1.0077	1.0077	1.1374	1.1374	0.0688	(0.0761)	(0.0034)	0.0000
51010102	Leasing Of Automotive Vehicles	6617872	7949694	6022750	8735222	0.9101	0.9101	1.3199	1.3199	0.0142	(0.1656)	0.1565	(0.0004)
510102	Rental Of Automotive Vehicles	557714	639001	584009	610230	1.0471	1.0471	1.0942	1.0942	0.0012	(0.0399)	(0.0413)	0.0000
510201	Gasoline & Other Fuels	18162937	25654048	23875646	19515822	1.3145	1.3145	1.0745	1.0745	0.0389	0.2052	(0.0585)	(0.0005)
51020201	Automotive Vehicle Parts, Accessories & Supplies	2846016	3503181	3201192	3114499	1.1248	1.1248	1.0943	1.0943	0.0061	0.0313	(0.0412)	(0.0000)
51020202	Automotive Vehicle Maintenance & Repair Services	5754283	6823082	6597171	5951330	1.1465	1.1465	1.0342	1.0342	0.0123	0.0512	(0.0938)	(0.0001)
51020301	Automotive Vehicle Insurance Premiums	11865637	16813428	14397424	13856787	1.2134	1.2134	1.1678	1.1678	0.0254	0.1125	0.0232	0.0001
51020302	Automotive Vehicle Registration Fees	1648961	1418556	1778986	1314875	1.0789	1.0789	0.7974	0.7974	0.0035	(0.0109)	(0.3013)	0.0000
51020303	Drivers' Licences	413868	465550	592985	324926	1.4328	1.4328	0.7851	0.7851	0.0009	0.3137	(0.3121)	(0.0001)
51020304	Public Parking Fees	680175	842857	802663	714236	1.1801	1.1801	1.0501	1.0501	0.0015	0.0820	(0.0799)	(0.0000)
51020305	All Other Automotive Vehicle Operating Expenses	634356	710478	690407	652796	1.0884	1.0884	1.0291	1.0291	0.0014	(0.0021)	(0.0983)	0.0000
520101	City Bus & Subway Transportation	1920521	2591003	2195361	2266632	1.1431	1.1431	1.1802	1.1802	0.0041	0.0481	0.0341	0.0000
520102	Taxi & Other Local And Commuter Transportation	957678	1181695	1087154	1040960	1.1352	1.1352	1.0870	1.0870	0.0021	0.0408	(0.0476)	(0.0000)
520201	Air Transportation	3883875	5825235	4434700	5101693	1.1418	1.1418	1.3136	1.3136	0.0083	0.0469	0.1509	0.0001
520202	Rail, Highway Bus & Other Inter-City Transportation	873110	780583	1002416	679892	1.1481	1.1481	0.7787	0.7787	0.0019	0.0526	(0.3177)	(0.0000)
61010101	Prescribed Medicines	2637026	3505768	2686218	3441569	1.0187	1.0187	1.3051	1.3051	0.0056	(0.0660)	0.1435	(0.0001)
61010102	Non-Prescribed Medicines	1673077	1969913	1722301	1913611	1.0294	1.0294	1.1438	1.1438	0.0036	(0.0562)	0.0022	(0.0000)
610102	Eye Care Goods	1605392	1940147	1674332	1860263	1.0429	1.0429	1.1588	1.1588	0.0034	(0.0438)	0.0153	(0.0000)
610103	Other Health Care Goods	299944	534881	299079	536429	0.9971	0.9971	1.7884	1.7884	0.0006	(0.0858)	0.5670	(0.0000)
6102p	Dental Care & Other Health Care Services (Including Eye Care Services)	4349778	6218175	5049769	5356221	1.1609	1.1609	1.2314	1.2314	0.0093	0.0644	0.0789	0.0000

Code	Description	$V^{01} = \sum p_{01}q_{01}$ ($000)	$V^{05} = \sum p_{05}q_{05}$ ($000)	$\sum p_{05}q_{01}$ ($000)	$\sum p_{01}q_{05}$ ($000)	$P_L = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$P_P = \sum p_{05}q_{05} / \sum p_{01}q_{05}$	$Q_L = \sum p_{01}q_{05} / \sum p_{01}q_{01}$	$Q_P = \sum p_{05}q_{01} / \sum p_{01}q_{01}$	$W_j^c = P_{01}Q_{01} / \sum P_{01}Q_{01}$	$PR_j = \lvert(P_{05}/P_{01}) - P_L\rvert / P_L$	$QR_j = \lvert(Q_{05}/Q_{01}) - Q_L\rvert / Q_L$	Element Contribution $= W_j^c * PR_j * QR_j$
620101	Personal Soap	272661	676830	280270	658454	1.0279	1.0279	2.4149	2.4149	0.0006	(0.0576)	1.1159	(0.0000)
620102	Toilet Preparations & Cosmetics	4381403	4744409	4275729	4861667	0.9759	0.9759	1.1096	1.1096	0.0094	(0.1053)	(0.0278)	0.0000
620103	Oral-Hygiene Products	736683	861010	726288	873334	0.9859	0.9859	1.1855	1.1855	0.0016	(0.0961)	0.0387	(0.0000)
6202	Personal Care Services	4642717	5799202	5100266	5278952	1.0986	1.0986	1.1370	1.1370	0.0099	0.0072	(0.0037)	(0.0000)
710101	Sporting & Athletic Equipment	2133374	2061738	2001939	2197099	0.9384	0.9384	1.0299	1.0299	0.0046	(0.1396)	(0.0976)	0.0001
710102	Toys, Non-Video Games & Hobby Supplies	2307503	2030454	2228340	2102587	0.9657	0.9657	0.9112	0.9112	0.0049	(0.1146)	(0.2016)	0.0001
710103	Computer Equipment & Supplies	3933069	4806410	1909477	9900060	0.4855	0.4855	2.5171	2.5171	0.0084	(0.5549)	1.2055	(0.0056)
710106	Other Recreational Equipment & Services	1124875	1640247	992610	1858810	0.8824	0.8824	1.6525	1.6525	0.0024	(0.1910)	0.4479	(0.0002)
7101p	Photographic Equipment, Supplies & Services	1843688	2240624	1677806	2462152	0.9100	0.9100	1.3354	1.3354	0.0039	(0.1656)	0.1701	(0.0001)
710201	Purchase Of Recreational Vehicles & Outboard Motor	3907487	5744274	4013602	5592401	1.0272	1.0272	1.4312	1.4312	0.0084	(0.0582)	0.2540	(0.0001)
71020201	Fuel, Parts & Supplies For Recreational Vehicles	1033191	1045506	1280832	843364	1.2397	1.2397	0.8163	0.8163	0.0022	0.1366	(0.2848)	(0.0001)
71020202	Insurance, Licence & Other Services For Recreation	1392880	1570274	1634958	1337774	1.1738	1.1738	0.9604	0.9604	0.0030	0.0762	(0.1585)	(0.0000)
710301	Audio Equipment	1071540	1210175	912756	1420698	0.8518	0.8518	1.3258	1.3258	0.0023	(0.2190)	0.1617	(0.0001)
710303	Video Equipment	2256752	3515764	1766618	4491184	0.7828	0.7828	1.9901	1.9901	0.0048	(0.2823)	0.7437	(0.0010)
710306	Other Home Entertainment Equipment, Parts & Services	401115	214080	430031	199685	1.0721	1.0721	0.4978	0.4978	0.0009	(0.0170)	(0.5638)	0.0000
7103p	Purchase Of Audio & Video Media, And Rental Of Video Media & Videogames	2974271	2940145	3016800	2898697	1.0143	1.0143	0.9746	0.9746	0.0064	(0.0700)	(0.1461)	0.0001
710401	Traveller Accommodation	4767775	6858383	3614731	9046103	0.7582	0.7582	1.8973	1.8973	0.0102	(0.3049)	0.6624	(0.0021)
710402	Travel Tours	3736439	5882877	4140882	5308291	1.1082	1.1082	1.4207	1.4207	0.0080	0.0161	0.2448	0.0000
710501	Spectator Entertainment (Excl. Cablevision)	2829127	3173587	3310305	2712282	1.1701	1.1701	0.9587	0.9587	0.0061	0.0728	(0.1600)	(0.0001)
710502	Cablevision (Incl. Pay Tv) & Satellite E Services	4634721	6197682	5456073	5264689	1.1772	1.1772	1.1359	1.1359	0.0099	0.0793	(0.0047)	(0.0000)
710503	Use Of Recreational Facilities And Services	4411263	4100463	4974343	3636303	1.1276	1.1276	0.8243	0.8243	0.0094	0.0339	(0.2777)	(0.0001)
720101	Tuition Fees	7639803	11039554	9338396	9031531	1.2223	1.2223	1.1822	1.1822	0.0164	0.1207	0.0358	0.0001
720102	School Textbooks & Supplies	1772124	2198230	1955242	1992355	1.1033	1.1033	1.1243	1.1243	0.0038	0.0116	(0.0149)	(0.0000)
720103	Other Lessons, Courses & Education Services	1290187	2035903	1427723	1839781	1.1066	1.1066	1.4260	1.4260	0.0028	0.0146	0.2494	0.0000
720201	Newspapers	1218079	1172061	1383807	1031692	1.1361	1.1361	0.8470	0.8470	0.0026	0.0416	(0.2579)	(0.0000)
720202	Magazines & Periodicals	684310	767769	817122	642978	1.1941	1.1941	0.9396	0.9396	0.0015	0.0948	(0.1767)	(0.0000)
720203	Books And Other Printed Matter (Excl.Textbooks)	1217536	1557225	1273677	1488586	1.0461	1.0461	1.2226	1.2226	0.0026	(0.0409)	0.0712	(0.0000)
810101	Served Beer	1453709	1611996	1644559	1424925	1.1313	1.1313	0.9802	0.9802	0.0031	0.0372	(0.1412)	(0.0000)
810102	Served Wine	662675	728997	727479	664057	1.0978	1.0978	1.0021	1.0021	0.0014	0.0065	(0.1220)	(0.0000)
810103	Served Liquor	773766	836874	879523	736245	1.1367	1.1367	0.9515	0.9515	0.0017	0.0422	(0.1663)	(0.0000)
810201	Beer Purchased In Stores	2723122	3397149	3043311	3039733	1.1176	1.1176	1.1163	1.1163	0.0058	0.0247	(0.0219)	(0.0000)
810202	Wine & Cider Purchased In Stores	1245405	1730379	1319299	1633461	1.0593	1.0593	1.3116	1.3116	0.0027	(0.0287)	0.1492	(0.0000)
810203	Liquor Purchased In Stores	1366808	1631662	1422547	1567729	1.0408	1.0408	1.1470	1.1470	0.0029	(0.0458)	0.0050	(0.0000)
8201	Cigarettes	7052044	7262500	12002676	4267004	1.7020	1.7020	0.6051	0.6051	0.0151	0.5605	(0.4698)	(0.0040)
8202	Other Tobacco Products & Smokers' Supplies	101267	349756	173146	204561	1.7098	1.7098	2.0200	2.0200	0.0002	0.5676	0.7699	0.0001

Appendix B: Concordance of the 2001 and 2005 Baskets

One of the challenges faced every time there is a basket update is how to map the classifications from one year to the next. Given that the SHS typically changes from year to year to reflect user needs and consumer realities, over the 4-year span from 2001 to 2005 some new classes emerged and old ones disappeared.

To account for the changing definitions between the 2001 and 2005 SHS, the 170 basic classes in the 2001 CPI basket and the 173 basic classes in the 2005 basket were mapped via 164 basic and pseudo-basic classes for the purposes of the Bortkiewicz analysis. The following adjustments were made:

- 5 "not elsewhere specified" (n.e.s.) classes which did not exist in 2001 were created in 2005, and thus had their 2005 weights redistributed to their immediate siblings:
    - Class 3299, "Household furnishings and equipment, n.e.s.", $p^{2005}q^{2005}$ = \$840,372,000;
    - 5299, "Public transportation, n.e.s.", $p^{2005}q^{2005}$ = \$627,068,000;
    - 710599, "Cultural and recreational services, n.e.s.", $p^{2005}q^{2005}$ = \$523,118,000;
    - 720299, "Reading material and printed material, n.e.s." $p^{2005}q^{2005}$ = \$118,445,000;
    - 810299, "Alcoholic beverages purchased in stores n.e.s.", $p^{2005}q^{2005}$ = \$273,133,000.
- The 2001 basic class 4199, "Clothing n.e.s." had its weight ($p^{2001}q^{2001}$ = \$3,025,920,000) redistributed to its siblings in the 2001 basket.
- Pseudo class 6102p, "Dental Care & Other Health Care Services (Including Eye Care Services)" was created, since "Eye Care services" did not exist in the 2001 basket.
- Pseudo class 7101p, "Photographic Equipment, Supplies & Services" was created, since the split between photographic goods and services changed between 2001 and 2005.
- Pseudo class, 7103p, "Purchase of Audio & Video Media, And Rental of Video Media & Videogames" due to changes in the household survey.
- Finally, in order to have an "unbiased" analysis the 2001 weight for "Purchase of automotive vehicles" was adjusted since in the 2005 basket private sales of automobiles were subtracted; these sales had not been subtracted in the 2001 official basket.

Appendix C: Proof of Element Contribution

$$\frac{P^{(k)}_{t/b} - P^{(c)}_{t/b}}{P^{(c)}_{t/b}} = \sum_j \left[\frac{p^j_{t/b} - \bar{p}_{t/b}}{\bar{p}_{t/b}} * \frac{q^j_{k/c} - \bar{q}_{k/c}}{\bar{q}_{k/c}} * \frac{p^j_b q^j_c}{\sum_j p^j_b q^j_c} \right]$$

$$= \sum \left[\left(\frac{\frac{p_t}{p_b} - \frac{\sum p_t q_b}{\sum p_b q_b}}{\frac{\sum p_t q_b}{\sum p_b q_b}} \right) * \left(\frac{\frac{q_t}{q_b} - \frac{\sum p_b q_t}{\sum p_b q_b}}{\frac{\sum p_b q_t}{\sum p_b q_b}} \right) * \left(\frac{p_b q_b}{\sum p_b q_b} \right) \right]$$

$$= \sum \left[\left(\frac{p_t \sum p_b q_b - p_b \sum p_t q_b}{p_b \sum p_b q_b} * \frac{\sum p_b q_b}{\sum p_t q_b} \right) * \left(\frac{q_t \sum p_b q_b - q_b \sum p_b q_t}{q_b \sum p_b q_b} * \frac{\sum p_b q_b}{\sum p_b q_t} \right) * \left(\frac{p_b q_b}{\sum p_b q_b} \right) \right]$$

$$= \sum \left[\frac{\left(p_t \sum p_b q_b - p_b \sum p_t q_b \right) * \left(q_t \sum p_b q_b - q_b \sum p_b q_t \right)}{\sum p_b q_b \sum p_t q_b \sum p_b q_t} \right]$$

$$= \sum \left[\frac{p_t q_t \left(\sum p_b q_b \right)^2 - p_b q_t \sum p_t q_b \sum p_b q_b - p_t q_b \sum p_b q_b \sum p_b q_t + p_b q_b \sum p_t q_b \sum p_b q_t}{\sum p_b q_b \sum p_t q_b \sum p_b q_t} \right]$$

$$= \frac{1}{\sum p_b q_b \sum p_t q_b \sum p_b q_t} * \left[\sum p_t q_t \left(\sum p_b q_b \right)^2 - \sum p_t q_b \sum p_b q_b \sum p_b q_t - \sum p_b q_b \sum p_b q_t \sum p_t q_b + \sum p_t q_b \sum p_b q_t \sum p_b q_b \right]$$

$$= \frac{\sum p_t q_t \left(\sum p_b q_b \right)^2 - \sum p_t q_b \sum p_b q_b \sum p_b q_t}{\sum p_b q_b \sum p_t q_b \sum p_b q_t}$$

$$= \frac{\sum p_t q_t \sum p_b q_b - \sum p_t q_b \sum p_b q_t}{\sum p_b q_t \sum p_b q_b} * \frac{\sum p_b q_b}{\sum p_t q_b}$$

$$= \left(\frac{\sum p_t q_t \sum p_b q_b}{\sum p_b q_t \sum p_b q_b} - \frac{\sum p_t q_b \sum p_b q_t}{\sum p_b q_t \sum p_b q_b} \right) * \frac{\sum p_b q_b}{\sum p_t q_b}$$

$$= \frac{\frac{\sum p_t q_t}{\sum p_b q_t} - \frac{\sum p_t q_b}{\sum p_b q_b}}{\frac{\sum p_t q_b}{\sum p_b q_b}}$$

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