Journal of Official Statistics
Vol. 4. No. 3. 1988, pp. 203–221

Using a Consumer Price Index Database to Measure Intercity Differences in Living Costs

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Abstract: This paper demonstrates the use of the U.S. consumer price database for estimating interarea price indexes for four categories of food items. Construction of these indexes demonstrates methods for overcoming various difficulties encountered when using price quotes resulting from a sampling design that was created for intertemporal price comparisons rather than interspatial comparisons. Measures of the variances of the indexes are also provided.

The methodology represents an alternative to the Country Product Dummy method (Summers (1973)) and other hedonic techniques when the objective is to measure intercity differences in prices within a country. Our results indicate that interarea differences in food costs are similar to those implied by the Bureau of Labor Statistics average prices program.

Key words: Price indexes; interarea price comparisons; cost of living.

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Acknowledgement: The authors worked with two consulting groups directed by John Koop (Research Triangle Institute) and Ben Tepping (Westat, Inc.), as well as Curtis Jacobs of the Bureau of Labor Statistics (BLS) on the development of an interarea price index methodology. We also thank the editor and three anonymous referees for their helpful comments. The empirical results were estimated by the authors, who assume responsibility for any errors. The views are those of the authors and do not represent an official position of the BLS or the views of other BLS staff members.

1. Introduction

Interarea comparisons of living costs are of interest to governments to assess equity in needs-based transfer payments, to employees contemplating relocation, and to management when selecting a location for a business activity or when transferring employees. While countries devote considerable resources to the maintenance of consumer price indexes that measure changes in living costs over time, typically less is allocated to measure differences in living costs among cities at a point in time. The United States represents such a case. The last direct pricing that was done by the Bureau of Labor Statistics (BLS) specifically to measure differences in living costs among domestic cities was more than fifteen years ago. These price data, collected in 1970, were updated annually until 1982 when the government's only program that measured differences in living costs among domestic cities (the Family Budgets program) was discontinued due to lack of resources.

The price quotes underpinning the U.S. consumer price index (CPI) might represent a potential data source for constructing indexes that measure differences in living costs among cities at a point in time. Using CPI price quotes to also measure intercity differences in living costs would represent a substantial economy.

This paper demonstrates the use of United States CPI data for estimating interarea price indexes for food by constructing individual indexes for four categories of items: white bread, cereal, fresh fruits, and cola drinks. Construction of these indexes demonstrates methods for overcoming various difficulties encountered when using price quotes resulting from a sampling design that was created for intertemporal price comparisons rather than interspatial comparisons. Measures of variability in the estimated indexes also are provided.

These interarea indexes measure price differences among cities within a country at a point in time. We emphasize that the method is not proposed here as a way of measuring international differences in living costs, where determining item comparability is even more difficult. However, it does represent an alternative to such regression techniques as Summers's (1973) Country-Product-Dummy (CPD) or hedonic methods (e.g., Rosen (1974) and Triplett (1986)), when the objective is to measure intercity differences in prices within a country. The methodologies are compared in Section 3. Brand-name products are mentioned in a number of examples.

2. Consumer Price Index Sampling Design and Price Quote Data

Because this methodology takes into account the sampling design of the U.S. CPI, we begin with a brief discussion of the CPI sample design and the price data collected. This description of the CPI program pertains to 1979 since our price data are from that year. For a detailed description of the sampling design of the Consumer Price Index, see Jacobs (1978) and U.S. Department of Labor (1984).

2.1. *Sample areas*

Prices are collected in 87 areas referred to here as primary sampling units (PSUs) in 85 geographical areas. These PSUs include standard consolidated areas, standard metropolitan statistical areas, cities, or the urbanized portions of one county or two or more adjacent counties with similar demographic and economic characteristics. The sample of PSUs was selected as follows. The U.S. was divided into 1 166 PSUs. Similar PSUs were combined into 85 geographic area strata based on characteristics including, among other things, region of the country (Northeast, North Central, South, and West) and population size (sizes A, B, C, and D). Twenty-seven of the 85 strata contained one PSU (self-representing A-size PSUs).[3] From each of the remaining 58 non-self-representing strata, one sample PSU was selected.

Each of the 27 self-representing strata is also referred to as a market basket (MB) area. The non-self-representing strata form another 12 market basket areas with 4, 6, or 8 strata in each. Interarea Price Indexes (IAPIs) are computed for each of these 39 market basket areas.

[3] An exception is the New York area stratum which has three PSUs, each of which is self-representing.

2.2. *Item classification structure*

The CPI item structure contains seven major groups: food and beverages, housing, apparel and upkeep, transportation, medical care, entertainment, and other goods and services. Each major group is subdivided into expenditure classes (ECs), which in turn consist of 265 item strata. Within each item stratum, one or more substrata are defined. These substrata are called entry level items (ELIs). For example, Table 1 illustrates the relationship between item strata and ELIs for the expenditure class Cereal and Cereal Products. This EC consists of three item strata and a total of five ELIs.

Table 1. Cereal and cereal products expenditure class: item strata and entry level items (1979)

Description	Item stratum	ELI
Flour	1	1
Prepared flour mixes		2
Cereal	2	3
Rice	3	4
Pasta and cornmeal		5

2.3. *ELI selection*

Expenditure data from the Consumer Expenditure (CE) Survey of households are tabulated for each of the four regions (Northeast, North Central, South, and West). For each region, samples of ELIs are selected for each item stratum, with the probability of selection proportional to the relative expenditures for each ELI within the item stratum in each region. In each region, eight sets of ELIs are selected independently for the all urban household CPI population and eight parallel sets using expenditures for the urban wage and clerical worker household CPI population. At least one ELI in each item stratum is priced in each market basket area. The selected sets of ELIs assigned to a PSU are called half samples for reasons that relate to the calculation of index variances.

2.4. *Outlet selection*

A household Point of Purchase Survey (POPS) is used to identify outlets where specific items are purchased by households meeting the qualifications of the CPI index populations in each PSU. The amount of expenditures and name and location of the place of purchase are collected for over 100 categories of expenditures. Each ELI is associated with a particular POPS item category. One such item category is POPS category 110 which consists of five ELIs from the Cereal and Cereal Products EC and 12 ELIs from the Miscellaneous Prepared Food EC, as shown in Table 2.

For each POPS item category, outlets are selected for pricing in each PSU using probabilities proportional to the relative expenditures at the outlet for the POPS item category reported by the households in the PSU.

Table 2. Point of purchase survey (POPS) expenditure category 110 (1979)

Description	Category
Cereal and cereal products (5 ELIs)	110
Flour	
Prepared flour mixes	
Cereal	
Rice	
Pasta and cornmeal	
Miscellaneous prepared food (12 ELIs)	
Canned and packaged soup	
Frozen prepared meals	
Other frozen prepared food	
Potato chips and snacks	
Nuts	
Seasonings and spices	
Olives, pickles, relishes	
Other condiments	
Sauces and gravies	
Canned or packaged salads, desserts, misc.	
Baby food	
Other prepared food	

2.5. *Item selection*

During the first visit to a particular outlet, the field agent has a set of entry level items (ELIs) to be priced. For each of the entry level items, the field agent has a written specification checklist that indicates alternative physical attributes for each of the most important price determining characteristics of items within the ELI as determined by a CPI commodity analyst. Applying sampling techniques with measures of size proportional to percentages of dollar sales (usually provided by the outlet), the agent identifies a specific store item or service falling within the entry level item description. Upon selecting a specific item within an outlet, the checklist is completed by indicating the detailed attributes of the item selected. For example, the cereal checklist includes entries for ready-to-eat or cooked cereal, grain type, presence of sugar, type of packaging, brand, etc.

This sampling process within the outlet generally results in different items being priced in different outlets (and areas) which considerably complicates the task of constructing an interarea price index (IAPI). For example, when pricing the entry level item, cereal, a 20 ounce box of Kellogg's Cornflakes may be selected for pricing in one outlet and a 12 ounce box of Post Alphabits in another.

2.6. *Price quotes*

The data used in this research are the price quote records collected under the CPI program in March 1979. These data consist of the prices and detailed characteristics of the items priced. Records for four of the 88 food item strata are examined in this research: cereal, white bread, other fresh fruits, and cola drinks.

3. Methodology[4]

Conceptually, the IAPI is a spatial cost of living index which compares the cost of living in two geographic areas. It may be approximated by a fixed weight price index in which the cost of a fixed basket of goods and services in a particular area (e.g., a market basket area) is compared to the cost of the same basket in a reference area (e.g., the urban U.S.) at a point in time. The IAPI should measure only price level differences from place to place and not differences in expenditure patterns. The IAPI could be used to assess differences in households' living costs among geographic areas.

The traditional approach to index construction begins with a list of items to be priced and a detailed description of the physical characteristics of each item. Data collectors are then sent to a sample of cities to price the items containing these specified characteristics. It is the expense of this collection process that makes us look to the existing consumer price index database as an alternative source of price quotes. But in using CPI price quotes, the traditional process is reversed. In contrast to specifying items to price a priori, we use the physical item characteristics associated with the CPI price quotes to specify items a posteriori. Specifically, we begin by grouping together identical and comparable items into item classes. Item class price relatives are computed and used in constructing the IAPIs.

3.1. *Item classes*

We describe an item class definition by such terms as "broad" or "tight" to convey a sense of the relative degree of specificity characterizing the definition. For example, the "tight-

[4] This methodology was developed by Westat, Inc. (1980) under BLS contract.

est" item class definition within cereal products would be one that would include cereal of a particular manufacturer, with a particular name, in a particular box (e.g., a 12 ounce box of General Mills's Total). There would be only one specific item that meets this definition. One way of determining if two items priced in different geographic regions are identical is to compare their Universal Product Codes (UPC codes) as, for example, in Love (1986). The UPC is a system that permits identification of merchandise. Each manufacturer is assigned a code and each manufacturer, in turn, assigns a unique number to each product it makes. The combination of manufacturer and product identification numbers appears on most non-produce, non-meat items as machine readable bar codes. (Unfortunately, the UPC codes are not recorded on the U.S. CPI database.)

A "broader" item class definition might be one specifying cereals made from wheat that are not sugar coated and are packaged in 12 ounce boxes. This definition would place the 12 ounce box of Total in the same item class as a 12 ounce box of Wheaties. The formation of item classes implies a willingness to use prices of two different specific items within an item class but from different areas as a measure of price level differences between areas.

Item class definitions should be "tightened" only as long as the additional detail in definition captures real quality differences in items. For example, six packs and single bottles of some brand of cola should be in separate item classes because investigation suggests that size affects unit price. However, there certainly would be no benefit in dividing the items in a particular bread item class into two "tighter" classes, say, red and blue packaging, if the color of packaging does not represent a real difference in quality. Thus, the problem is to determine definitions that minimize the heterogeneity of items within item classes and yet still include enough quotes for calculating an IAPI.

Three sets of item class definitions were formed on the basis of the degree of specificity. In defining each set of item classes for each ELI, we proceeded as follows. The checklist (see Section 2.5), which indicates the price determining characteristics of items in the ELI, was used as an aid in forming a preliminary set of item class definitions. We then tested the difference between item class average prices using *t*-tests. Based on these results, we formed the final item class definitions. The results shown here are based on the "tightest" item class definitions that we examined.

There were 620 potentially usable cereal price quotes. Four hundred and eighty-nine of these quotes fell into 53 item classes that were formed by separating ready-to-eat and cooked cereals, and then considering type of grain, presence of sugar, and size of package. The remaining records were discarded either because of missing information or because they did not fall into any of the item classes.

For bread, 27 item classes were formed based on type (regular, vienna, etc.), packaging, weight, and whether the brand was national or local. This classification covered 1 090 of the 1 146 price quotes available.

Twenty-seven item classes were formed for colas based on packaging (returnable bottles, throwaway bottles, and cans), number of ounces in each container, packaging unit (per each, per six pack, etc.) and whether national or local brand. Of the 1 229 cola quotes 1 212 were included in these item class definitions.

The category "other fresh fruits" included all fruits except apples, bananas, and oranges. Twenty-four item classes were defined based on kind of fruit (watermelons, cherries, lemons, etc.) and type of packaging (loose, multi-pack, etc.). Of the 4 790 quotes, 4 347 fell into the item classes formed.

We note that, in some respects, the formation of item classes may be perceived as being easier for the food items examined here than for non-food commodities and services. The treatment of a non-food ELI, men's footwear, using this approach is described elsewhere (Westat, 1980, Appendix E, pp. E-37-E-62).

3.2. *Item class price relatives*

To construct the MB area-to-U.S. price relative for an item class, we proceeded in the following manner. The average price of each item class in an ELI substratum in a PSU was computed. These PSU average prices were then aggregated across PSUs in a market basket area. Finally, the MB area-to-U.S. price relative was constructed. As an aid to the reader, a glossary of symbols and a glossary of terms are contained in Appendices C and D, respectively.

Denote the price (per ounce) of an item in the ith item class in the jth outlet in PSU h as p_{hij} and the corresponding quantity (in ounces) as q_{hij}. The average price of a particular item class in PSU h is

$$\bar{p}_{hi} = \frac{\sum_{j=1}^{M_{hc}} p_{hij} q_{hij}}{\sum_{j=1}^{M_{hc}} q_{hij}} .$$

Multiplying and dividing the denominator by p_{hij}, we have

$$\bar{p}_{hi} = \frac{\sum_{j=1}^{M_{hc}} p_{hij} q_{hij}}{\sum_{j=1}^{M_{hc}} \frac{p_{hij} q_{hij}}{p_{hij}}}$$

$$= \frac{\sum_{j=1}^{M_{hc}} \hat{E}'_{hij}}{\sum_{j=1}^{M_{hc}} \hat{E}'_{hij}/p_{hij}} , \qquad (1)$$

where

$\bar{p}_{hi}$ is the average price of the ith item class in PSU h;

$\hat{E}'_{hij}$ is the estimated expenditure on the ith item class in the jth outlet in PSU h, and the $'$ denotes that the expenditure is derived from the POPS; and

M_{hc} is the number of price quotes for the cth POPS item category (containing the ith item class) in PSU h.

The application of (1) requires an estimate of the expenditure E_{hij}, which is not collected either by the POPS or by the CPI field agent. Given the sampling design of the CPI, Westat (1980, p. III-4-5) shows that the expected value

$$\mathbf{E}\left[\sum_{j=1}^{m_{he}} \alpha_{hej} \beta_{hij}\right] = m_{he} \mathbf{E}\left[\alpha_{hej} \mathbf{E}(\beta_{hij} \mid j)\right]$$

$$\doteq m_{he} \left[\sum_{j=1}^{M_{hc}} (E_{hij}/E'_{hc})\right] ,$$

where

α_{hej} is the proportion the eth ELI (containing the ith item class) is of the cth POPS item category expenditure in outlet j in PSU h;

β_{hij} is an indicator variable which equals 1 if the item priced in outlet j in PSU h is in the ith item class and equals 0 otherwise;

m_{he} is the number of price quotes for the eth ELI (containing the ith item class) in the cth POPS item category in PSU h; and

E'_{hc} is the expenditure on the cth POPS item category containing the eth ELI (and the ith item class) in PSU h.

Thus, the expenditure $\sum_j \hat{E}'_{hij}$ is estimated as

$$\sum_{j=1}^{M_{hc}} \hat{E}'_{hij} = \left[\frac{E'_{hc}}{m_{he}} \right] \sum_{j=1}^{m_{he}} \alpha_{hej} \beta_{hij} \quad . \tag{2}$$

Similarly, Westat (1980, p. III-5) shows that

$$\mathbf{E} \left[\sum_{j=1}^{m_{he}} \alpha_{hej} \beta_{hij} / p_{hij} \right]$$

$$\doteq m_{he} \sum_{j=1}^{M_{hc}} [(E_{hij}/E'_{hc})/p_{hij}] \, ,$$

and, finally, that

$$\mathbf{E} \left[\frac{\sum_{j=1}^{m_{he}} \alpha_{hej} \beta_{hij}}{\sum_{j=1}^{m_{he}} \alpha_{hej} \beta_{hij}/p_{hij}} \right] \doteq \frac{\sum_{j=1}^{M_{hc}} E_{hij}}{\sum_{j=1}^{M_{hc}} E_{hij}/p_{hij}} \, .$$

Therefore, the estimator for the PSU average price of item class i is

$$\bar{p}_{hi} = \frac{\sum_{j=1}^{m_{he}} \alpha_{hej} \beta_{hij}}{\sum_{j=1}^{m_{he}} \alpha_{hej} \beta_{hij} \left(\frac{1}{p_{hij}} \right)} \quad . \tag{3}$$

From (1) or (3), the PSU average price of item class i is computed as a weighted harmonic mean of the prices (per ounce) of items in the item class collected in PSU h.

Using these PSU average prices of an item class, the average price for the mth market basket area is computed as

$$\bar{p}_{mi} = \frac{\sum_{h \varepsilon m} \left(\frac{1}{P_h} \right) \hat{E}_{hi}}{\sum_{h \varepsilon m} \left(\frac{1}{P_h} \right) \hat{E}_{hi} \left(\frac{1}{\bar{p}_{hi}} \right)} \, , \tag{4}$$

where

$\hat{E}_{hi}$ is an estimate of the expenditure on item class i in PSU h (see below), and

P_h is the ratio of the population in PSU h to its area stratum population.

For self-representing PSUs, $P_h=1$, and for non-self-representing PSUs, $0 < P_h < 1$. It may be noted that $\hat{E}_{hi}/P_h$ gives an estimate of the expenditure on item class i in the area stratum, rather than the expenditure in PSU h only.

The expenditure on item class i in PSU h, $\hat{E}_{hi}$, is estimated in two steps. First, expenditure data for the item strata (E_z) from the 1972–1973 CE Survey for the urban U.S. are updated to March 1979 by multiplying by the appropriate item stratum price relative ($p_{z79}/p_{z72\text{–}73}$) for the urban U.S. derived from the CPI. Second, the expenditures $\sum_j \hat{E}'_{hij}$ estimated from the POPS are adjusted to the updated expenditure levels from the CE Survey at the U.S. level. This is accomplished by multiplying by the ratio of updated urban U.S. expenditures on the zth item stratum from the CE Survey to those from the POPS. That is,

$$\hat{E}_{hi} = \left[\frac{E_{z72\text{–}73} \, (p_{z79} / p_{z72\text{–}73})}{\sum_{i \varepsilon z} \sum_h \left(\frac{1}{P_h} \right) \sum_j \hat{E}'_{hij}} \right] \sum_{j=1}^{M_{hc}} \hat{E}'_{hij} \, . \tag{5}$$

Since the item strata examined here consist of only one ELI each, the subscript z refers to both the ELI and item stratum.

We note that, for market basket areas consisting of a single self-representing PSU, $\bar{p}_{mi}$ computed in (4) is equivalent to $\bar{p}_{hi}$ in (3), since $P_h=1$ and the term in brackets in (5) which appears in both the numerator and denominator of (4) drops out.

It follows that

$$\hat{E}_{mi} = \sum_{h \varepsilon m} \frac{1}{P_h} \hat{E}_{hi} \tag{6}$$

is an estimate of the expenditure on item class i in MB area m, and that

$$\hat{E}_i = \sum_m \hat{E}_{mi} \tag{7}$$

is an estimate of the U.S. expenditure on the ith item class.

Finally, the U.S. average price, $\bar{p}_i$, is computed as a weighted harmonic mean of market basket area average prices, so that the MB area to U.S. price relative is

$$\left(\frac{\bar{p}_{mi}}{\bar{p}_i}\right) = \frac{\bar{p}_{mi}}{\left(\dfrac{\sum\limits_m \hat{E}_{mi}}{\left(\sum\limits_m \hat{E}_{mi}\left(\dfrac{1}{\bar{p}_{mi}}\right)\right)}\right)} \quad . \tag{8}$$

These price relatives are used to construct the IAPIs.

3.3. Interarea price indexes

The interarea price indexes at the item strata and aggregate levels for each market basket area are computed as Laspeyres indexes. The weights used reflect the fixed market basket concept, where the market basket consists of the implicit average quantities of each item class consumed in the U.S. The implicit quantities are the ratio of the U.S. expenditure on item class i to its U.S. average price. This index yields transitive price comparisons. Other index number formulas have been suggested for multilateral compraisons by, for example, Caves, Christensen, and Diewert (1982), Kravis, Kennessey, Heston, and Summers (1975), and Ruggles (1967). However, the choice between index number formulas is beyond the scope of this research.

The zth item stratum index for the mth market basket area is estimated as a weighted average of market basket area-to-U.S. average price relatives for the items in the item stratum; that is,

$$\mathrm{I}_{mz} = \frac{\sum\limits_{i \varepsilon z} \hat{E}_i \dfrac{\bar{p}_{mi}}{\bar{p}_i}}{\sum\limits_{i \varepsilon z} \hat{E}_i} \quad . \tag{9}$$

Similarly, the aggregate index for the mth market basket area is estimated as

$$\mathrm{I}_m = \frac{\sum\limits_z \hat{E}_z \mathrm{I}_{mz}}{\sum\limits_z \hat{E}_z} \quad , \tag{10}$$

where $\hat{E}_z$ are the estimated expenditures on item stratum z in the U.S.

3.4. Variance estimation

The estimation of the variances is based on the method of pseudo-replication (McCarthy (1973)). Each of the 27 self-representing PSUs is a market basket area. Two half samples of ELIs, identified as μ and ν, are selected for each of these market basket areas. The non-self-representing PSUs form another 12 market basket areas. Each of the non-self-representing PSUs within a market basket area is assigned a sample of ELIs. The PSUs in these market basket areas are paired into half samples, and the indexes are computed for each half sample and the combined sample. Since the indexes computed for each half sample have the same expected value and equal variances (they were drawn from the same population), the variance of the aggregate index for market basket area m for the combined sample (a within MB area variance) is computed as

$$S^2_{\mathrm{I}m} = \frac{1}{4}\left[\mathrm{I}_{m\mu} - \mathrm{I}_{m\nu}\right]^2 , \tag{11}$$

where

$\mathrm{I}_{m\mu}$ is the aggregate index for half sample μ for MB m, and

$\mathrm{I}_{m\nu}$ is the aggregate index for half sample ν for MB m.

The market basket area variance is estimated with one degree of freedom. The average market basket variance is estimated as

$$S_{\mathrm{I}}^2 = \frac{1}{4 \cdot 39} \sum_{m=1}^{39} [\mathrm{I}_{m\mu} - \mathrm{I}_{m\nu}]^2 \quad . \tag{12}$$

3.5. The "missing" data problem

The index formulas conventionally applied to interarea price measurement require price data for the same bundle of items in each area. In practice, data are not available that allow comparison of the prices of the same specific items across all areas. For example, an examination of a portion of our data showed that among 463 cereal price quote records there were 129 different specific items; among 1 180 cola quotes there were 195 different items; and among 1 088 bread quotes there were 665 different items. The specific items were not priced in all areas.

"Missing" or incomplete price data is a common problem in making place to place comparisons. The problem is perhaps most familiar in the context of multi-country comparisons, as, for example, in the United Nations International Comparison Project (Kravis, et al. (1975), (1978)). A first step in overcoming the "missing" data problem is to group similar items into classes, with each item class (hopefully) having at least one price quote from each area. The usual index formulas could then be used with item classes assuming the role of specific items. However, if the specific items within an item class are of different qualities, then the estimated index would measure price level differences along with differences in expenditure patterns between areas.

If there are still "missing" prices for any item class, then a second step requires the selection of a method to overcome the problem. One method is to compute area average prices for those areas where prices are available and to use a modified formula (described below) for the reference area (urban U.S.) average price of an item class. Another method involves the estimation of a particular area-to-reference area (urban U.S.) relative price of an item class by the Country-Product-Dummy (CPD) method (Summers (1973), Kravis, et al. (1975)) using linear regression techniques.

This research focuses on the first of the two methods for resolving "missing" price data problems. Suppose that the price of an item class is available in only a small number of MB areas. When the U.S. average price in the denominator of the price relatives is calculated in (8) as a weighted harmonic mean of the MB area average prices (and the summation extends only over those MBs where prices are reported), then the market basket area in the numerator of the price relatives may have a relatively large influence on the estimated U.S. average price in the denominator so that the price relatives are biased towards one (Westat (1980, p. III-11)). This bias is insignificant when item class prices in only a few MB areas are "missing," but increases with the number of MB areas that have "missing" prices.

To mitigate this problem, the MB area-to-U.S. average price relatives are instead computed according to the modified formula (Westat (1980, p. III-12))

$$\frac{\bar{p}_{mi}}{\bar{p}_i} = \bar{p}_{mi} \div \left[\frac{\hat{E}_i}{\dfrac{\hat{E}_{mi}}{\bar{p}_{mi}} + \dfrac{\hat{E}_i - \hat{E}_{mi}}{\bar{p}_{\bar{m}i}}} \right] , \tag{13}$$

where

$\bar{p}_{\bar{m}i}$ is the average price of item class i estimated as a weighted harmonic mean over all MBs reporting prices in the U.S. (except MB m), and

$\hat{E}_i$ is the U.S. expenditure on item class i.

Westat (1980, pp. III-13-20) shows that when prices are "missing" the MB area-to-U.S. average price relatives are closer to a value of one when the U.S. average price is estimated as a weighted harmonic mean of MB average prices for all MBs reporting a price as in (8) than when estimated according to (13). Thus, in this research the MB area-to-U.S. average price relatives of item class *i* are estimated using (13). It should be noted, however, that when there are no missing prices, (13) and (8) are equivalent.

To examine the effects on our results of using this alternative method of computing the U.S. average price, indexes were constructed in which the MB area-to-U.S. average price relatives were computed according to (13) and according to (8). For these data, we found that generally the same rankings of MB areas were obtained using (8) as those shown in Table 3. Where the rankings did vary, the difference was due to small differences in the magnitude of the index numbers (≤ 0.7 index points).

3.6. *Comparison with alternative methodologies*

This method allows for the construction of interarea price indexes without prices for identical items in all areas. For example, price quotes for a 12 ounce can of Coca-Cola are not required in all areas. In contrast to CPD and hedonic approaches, the method does not incorporate regression techniques to impute "missing" prices or to adjust prices for item quality differences or for market basket composition. In practice this greatly simplifies computational tasks. At the extreme, this method requires that each item be priced in at least two areas; although in practice, having prices in more than two areas is desirable. In contrast, the CPD and hedonic methods require re-estimation of the regression equations periodically and enough price quotes to obtain precise parameter estimates.[5]

On the other hand, the CPD method has an advantage over this method if prices are missing for *all* item classes in an item stratum in a particular market basket area. The CPD method generates imputed values for the missing prices which could be used in index calculation, while this method does not. However, this situation did not arise in the data we examined.

4. Results

Table 4 shows the indexes estimated for each of the item strata examined here: cereal (column 2), other fresh fruits (column 3), white bread (column 4), and cola drinks (column 5).[6] We did not formulate any a priori hypotheses about how these indexes should compare with one another. Nevertheless, the pair-

[5] Some research in constructing interarea price relatives for food items using the CPD method has been undertaken (Blanciforti (1986)). Further research is underway to compare the results using the CPD method with those considered here for non-food commodities and services.

[6] The estimated market basket and PSU average prices are subject to a ratio-estimate bias, which becomes important when samples sizes are small. It is assumed that the bias is approximately inversely proportional to the number of price quotes available for estimating the MB (or PSU) average price. The market basket item strata indexes were adjusted for the bias by (Westat (1980, p. III-68))

$$I_{mzadj} = 2 \cdot [\, I_{mz}] - I_{mz(.)}$$

where

I_{mz} is the *m*th market basket area index for item stratum *z* based on the combined sample; and

$I_{mz(.)}$ is the mean of $I_{mz\mu}$ and $I_{mz\nu}$, the *m*th market basket area indexes for item stratum *z* for half samples μ and ν, respectively.

For each MB area, the adjusted item stratum indexes are aggregated using the weights noted in the text. Appendix A shows the bias-adjusted indexes. These are not presented as our main results because we presently are evaluating the validity of the bias assumption noted above.

Table 3. Pearson correlation coefficients
(Probability > R under H_0: Rho=0)

	Cereal	Fruit	Bread	Cola
Cereal	1.00000 (0.0000)	0.41545 (0.0085)	0.24392 (0.1345)	0.25305 (0.1201)
Fruit		1.00000 (0.0000)	0.61604 (0.0001)	0.11574 (0.4829)
Bread			(1.00000) (0.0000)	0.29324 (0.0700)
Cola				1.00000 (0.0000)

wise correlation between the indexes is provided in Table 3. All six of the pairwise correlations are positive and two are significant at the 1% level; bread and other fruit have a correlation of 0.62, while cereal and other fruit have a correlation of 0.45.

The CPI average price program last published city average prices for flaked corn cereal, white bread, and cola drinks in June 1978. For comparison purposes, ratios of the individual city price to the U.S. average price were formed using those data (Appendix B). The ratios then were correlated with the results shown in Table 4. Before discussing these results, we note that the CPI average price program item definitions covered only a subset of the item classes contained in the indexes constructed here. For example, a 12 ounce box of flaked corn cereal was a CPI average price program item definition, while the index shown here is for all cereal. In addition, although the items in the CPI average price program were specified in detail, identical items were not always priced in all areas. When prices were not available in an area, they were imputed by, e.g., substituting another brand or package size. Thus, the average prices reflect variations in brand, quality, and package size, as well as true price differences among areas.

Given these differences in definitions and the year difference in reference dates, the pairs of measures still are correlated strongly. The correlation between the two bread measures is 0.42; between the two cola measures, 0.34; and between the two cereal measures, 0.43. All correlations are significantly different from zero.

Although variances are not estimated for the item stratum indexes, Table 4 (columns 7–10) shows the number of market basket area price quotes for these indexes. Other fresh fruits had the most price quotes, a total of 4 347. As with the other item strata samples, these quotes were distributed unevenly across the market basket areas. Within other fresh fruits, the market basket areas for the non-self-representing area strata had the largest number of quotes ranging from 289 for Southern B-size cities to 115 for West D-size cities. There were 252 fruit quotes for New York and 42 for Anchorage. Cereal had the fewest quotes available. There were 26 for New York and only 4 for Philadelphia.

Columns 6, 11, and 12 of Table 4 show, respectively, the aggregate index for the four item strata, the total number of price quotes for each market basket area, and the variance of the aggregate index. The weights used to aggregate the item strata indexes in

Table 4. Index estimates for food item strata using March 1979 CPI quotes

Area	Indexes				
	Cereal	Fruit	Bread	Cola	Combined
(1)	(2)	(3)	(4)	(5)	(6)
San Diego A West	109.1	88.5	98.6	82.7	91.7
Milwaukee A NorthCen	98.0	124.1	87.1	85.6	94.1
NorthCentral C PSUs	90.0	96.8	99.2	92.7	94.8
New York A Northeast	95.2	104.5	86.5	98.1	95.6
South Region B PSUs	99.4	98.2	97.5	92.4	95.8
Dallas A South	99.9	98.1	91.5	96.4	95.8
Houston A South	84.6	114.0	106.0	87.9	96.8
South Region D PSUs	104.4	104.2	94.6	93.9	97.3
South Region C PSUs	103.9	100.9	86.7	100.6	97.3
Buffalo A Northeast	95.1	88.2	108.1	96.3	98.0
Northeast D PSUs	96.4	97.2	92.1	103.0	98.1
West Region C PSUs	103.6	94.8	98.0	98.8	98.5
Northeast B PSUs	101.6	105.9	100.1	94.3	98.8
NorthCentral D PSUs	99.7	100.1	95.6	100.4	98.9
West Region B PSUs	108.2	95.0	98.2	98.1	99.0
Boston A Northeast	107.3	102.2	104.2	93.7	99.9
NorthCentral B PSUs	90.8	97.4	98.3	105.8	100.3
Atlanta A South	110.3	90.6	101.7	102.4	101.3
Northeast C PSUs	97.1	100.0	102.2	103.0	101.5
Washington DC A South	114.1	86.1	93.6	112.5	103.1
Minneapolis A NorthCen	105.6	111.8	93.7	105.4	103.3
Seattle A West	100.2	103.0	105.5	103.9	103.7
Baltimore A South	105.0	108.1	83.3	115.3	103.9
West Region D PSUs	128.2	97.7	92.9	105.9	104.0
Miami A South	94.8	105.4	106.9	106.1	104.6
Portland, Ore. A West	112.0	105.0	100.0	105.9	105.0
San Francisco A West	107.6	108.0	111.1	100.3	105.5
Philadelphia A Northeast	96.0	120.8	119.9	93.6	105.7
Los Angeles A West	93.1	97.6	111.6	110.8	106.4
Cincinnati A NorthCen	105.5	114.4	91.3	113.6	106.5
Chicago A NorthCen	98.2	118.2	102.9	108.2	107.0
St. Louis A NorthCen	100.6	100.8	109.8	110.2	107.2
Kansas City A NorthCen	109.2	98.3	111.5	112.2	109.3
Pittsburgh A Northeast	103.5	104.7	116.3	109.2	109.6
NE Penn. A Northeast	94.8	97.5	138.0	108.9	113.1
Detroit A NorthCen	96.0	95.8	124.2	120.7	114.2
Cleveland A NorthCen	114.0	124.9	119.1	114.9	117.6
Anchorage A	118.3	161.8	138.0	114.8	129.5
Honolulu A West	128.0	189.9	159.3	102.9	136.4

each MB area, as in (10), represent the relative expenditures on these item strata for the urban U.S. in 1979. The weights are: cereal, 0.1364; other fresh fruits, 0.1665; white bread, 0.2762; and cola drinks, 0.4209.

Although there is little other empirical evidence to compare with these results, it is not surprising that Anchorage and Honolulu are the two highest cost market basket areas for these items.

It is interesting to note that for these food items, southern market basket areas appear

Table 4 (cont.). Index estimates for food item strata using March 1979 CPI quotes

Area	Sample sizes					Variance of combined Index
	Cereal	Fruit	Bread	Cola	Total	
(1)	(7)	(8)	(9)	(10)	(11)	(12)
San Diego A West	8	83	25	28	144	1.95
Milwaukee A NorthCen	12	91	20	12	135	1.97
NorthCentral C PSUs	20	174	39	56	289	1.65
New York A Northeast	26	252	53	59	390	19.89
South Region B PSUs	35	289	60	69	453	.06
Dallas A South	9	101	19	24	153	3.88
Houston A South	8	86	24	24	142	4.44
South Region D PSUs	13	115	30	36	194	12.46
South Region C PSUs	32	228	67	87	414	.12
Buffalo A Northeast	12	69	26	24	131	15.93
Northeast D PSUs	14	130	39	38	221	3.24
West Region C PSUs	18	150	32	36	236	3.50
Northeast B PSUs	13	159	34	40	246	1.20
NorthCentral D PSUs	10	123	30	34	197	4.38
West Region B PSUs	14	118	41	52	225	2.97
Boston A Northeast	8	101	16	28	153	.04
NorthCentral B PSUs	18	132	32	30	212	19.18
Atlanta A South	9	89	26	19	143	3.68
Northeast C PSUs	16	170	30	34	250	2.22
Washington DC A South	13	42	28	22	105	.13
Minneapolis A NorthCen	9	76	22	20	127	5.88
Seattle A West	13	88	29	22	152	3.95
Baltimore A South	9	92	16	16	133	7.63
West Region D PSUs	7	127	31	37	202	15.56
Miami A South	8	104	14	28	154	11.28
Portland, Ore. A West	12	94	27	25	158	4.70
San Francisco A West	8	89	10	26	133	5.43
Philadelphia A Northeast	4	63	23	12	102	17.84
Los Angeles A West	12	114	26	38	190	.10
Cincinnati A NorthCen	6	66	31	26	129	.38
Chicago A NorthCen	14	92	27	33	166	6.36
St. Louis A NorthCen	9	46	20	26	101	16.45
Kansas City A NorthCen	12	97	29	25	163	7.96
Pittsburgh A Northeast	11	88	22	26	147	2.60
NE Penn. A Northeast	8	116	22	17	163	.03
Detroit A NorthCen	9	70	19	24	122	67.60
Cleveland A NorthCen	10	84	14	24	132	1.00
Anchorage A	7	42	16	8	73	67.46
Honolulu A West	13	97	21	27	158	13.65

to be the least expensive. The low cost for the South found here is similar to that shown in the BLS Family Budgets "all food at home" component. (For a description of the Family Budgets, see Sherwood (1977).) It has long been felt that the South's position in the budgets was due to the mix of items priced in the South (i.e., differences in food preferences) as opposed to price level differences, since the quantities and qualities of some items in the Family Budgets market baskets were allowed to vary across regions to reflect regional preferences and climatic patterns. However, the IAPIs reflect only price level differences. Of course, the results here are only suggestive since the four item strata examined cannot be considered representative of "all food at home."

Little confidence can be placed in the variances estimated for any particular market basket area index since each variance was estimated with only one degree of freedom. General conclusions about the magnitude of the typical variance of the market basket area indexes can be made, however, by examining the market basket area estimates as a whole. For example, 25 of the estimated market basket area variances are less than six index points. The average market basket area variance is 9.2. This is particularly encouraging since we have used only a small part of the total CPI database – one month of data and only four of the 88 ELIs composing the "food at home" component of the CPI.

As noted in Section 3.1, we also experimented with two alternative sets of item class definitions based on "broad" and "intermediate" levels of item class specification. The number of item classes in each of the four food item strata decreased, and the number of usable price quotes increased, when "loosening" the level of item class specification. For example, under the "tight" specifications, cereal had 53 item classes covering 489 price quotes, while the "intermediate" and "broad" specifications had 37 and 13 item classes covering 612 and 620 price quotes, respectively. Similarly, at the "intermediate" level of specification, other fresh fruits had 20 item classes consisting of 4 722 price quotes, white bread had 15 item classes containing 1 090 quotes, and cola drinks had 10 item classes for 1 216 quotes. At the "broad" level, other fresh fruits had eleven, white bread six, and cola drinks five item classes containing 4 773, 1 146, and 1 229 price quotes, respectively.

The IAPIs were also constructed using these alternative "broad" and "intermediate" item classes. As expected, the average within MB area variance was highest, 11.0, under the "broad" item class specifications, but this variance under the "intermediate" item class specifications was about the same as that under "tight" specifications, i.e., 9.1 and 9.2, respectively.

Comparing the aggregate indexes for the "tight," "intermediate," and "broad" item classes for each MB area, we found that for 36% of the MB areas the indexes were within 3 index points (one average MB area standard deviation) of one another, and 74% were within 6 index points. The aggregate indexes for the remaining ten MB areas were very different for the three sets of item class definitions. For example, the aggregate index for Philadelphia was 105.7 for "tight" item classes, 108.2 for "intermediate" item classes, and 121.0 for "broad" classes. For New York, the aggregate indexes were 95.6, 102.0, and 110.0 for the "tight," "intermediate," and "broad" item classes, respectively; while for Detroit they were 114.2, 111.6, and 103.5 for the "tight," "intermediate," and "broad" item classes.

5. Conclusions

This paper demonstrates the suitability of the Consumer Price Index database for constructing an interarea price index for "food at home" by presenting index estimates for four food item strata: cereal, other fresh fruits, white bread, and cola beverages.

The indexes presented indicate interarea differences in food costs that are similar to those implied by the last city food price averages published by BLS before the 1979 Consumer Price Index revision. The estimated variances are well within an acceptable range, particularly since publication of results would be at a more aggregated level than shown here.

Appendix A

Ratio-Bias Adjusted Indexes

Market basket area	Cereal	Fruit	Bread	Cola	Combined
SanDiego A West	109.76	91.76	97.74	84.90	92.90
Milwaukee A North Central	101.20	121.52	89.70	87.64	95.70
North Central C PSUs	91.26	97.54	98.17	97.42	96.81
New York A Northeast	93.39	102.84	69.62	98.56	90.57
South Region B PSUs	100.25	98.11	95.24	88.82	93.70
Dallas A South	97.13	97.05	88.95	96.43	94.56
Houston A South	83.04	111.75	112.49	90.54	99.11
South Region D PSUs	105.73	102.57	93.74	88.76	94.75
South Region C PSUs	103.46	98.42	80.72	99.53	94.68
Buffalo A Northeast	96.96	87.44	106.30	95.46	97.32
Northeast D PSUs	97.15	98.04	93.38	105.97	99.97
West Region C PSUs	105.65	93.96	96.72	96.43	97.35
Northeast B PSUs	104.51	102.27	99.99	94.11	98.51
North Central D PSUs	100.11	95.87	93.88	101.61	98.32
West Region B PSUs	103.67	92.78	98.11	97.89	97.89
Boston A Northeast	112.21	100.85	106.92	90.65	99.78
North Central B PSUs	87.75	94.91	90.32	105.03	96.92
Atlanta A South	106.31	90.49	103.75	107.01	103.26
Northeast C PSUs	96.82	101.49	98.57	104.53	101.33
Washington DC A South	117.10	87.26	92.98	115.27	104.70
Minneapolis A North Central	101.65	109.47	92.84	108.29	103.31
Seattle A West	101.49	96.91	102.90	103.20	101.84
Baltimore A South	96.06	107.02	85.25	122.72	106.12
West Region D PSUs	132.75	95.67	89.28	104.12	102.52
Miami A South	85.75	104.75	98.20	104.56	100.27
Portland, Ore. A West	113.34	102.14	102.91	106.04	105.52
San Francisco A West	110.16	102.85	99.44	100.03	101.72
Philadelphia A Northeast	95.03	122.70	118.75	82.77	101.03
Los Angeles A West	92.76	93.97	111.74	108.57	104.86
Cincinnati A North Central	102.70	114.84	90.52	112.07	105.30
Chicago A North Central	99.24	113.38	103.87	108.92	106.95
St. Louis A North Central	98.99	101.41	115.49	109.51	108.38
Kansas City A North Central	110.56	93.91	107.07	110.50	106.80
Pittsburgh A Northeast	106.67	105.40	115.69	110.04	110.37
NE Penn A Northeast	91.83	95.89	142.99	105.16	112.25
Detroit A North Central	94.83	92.11	127.34	120.18	114.03
Cleveland A North Central	118.10	122.26	118.11	116.68	118.20
Anchorage A	124.66	161.36	141.82	110.97	129.75
Honolulu A West	131.08	178.30	171.00	97.32	135.76

Appendix B

Ratio of City to U.S. Prices (June 1978)

Area	Flaked Corn	White Bread	Cola
San Diego A West	0.96	0.86	0.78
Milwaukee A NorthCen	0.99	0.92	1.06
NorthCentral C PSUs	.	.	.
New York A Northeast	0.96	1.12	1.71
South Region B PSUs	.	.	.
Dallas A South	1.03	0.98	0.91
Houston A South	1.02	0.96	1.00
South Region D PSUs	.	.	.
South Region C PSUs	.	.	.
Buffalo A Northeast	0.93	0.96	1.33
Northeast D PSUs	.	.	.
West Region C PSUs	.	.	.
Northeast B PSUs	.	.	.
NorthCentral D PSUs	.	.	.
West Region B PSUs	.	.	.
Boston A Northeast	1.05	1.19	1.36
NorthCentral B PSUs	.	.	.
Atlanta A South	1.01	1.05	1.04
Northeast C PSUs	.	.	.
Washington DC A South	1.07	0.87	1.50
Minneapolis A NorthCen	0.99	0.86	1.24
Seattle A West	0.99	0.85	1.57
Baltimore A South	1.00	0.79	1.44
West Region D PSUs	.	.	.
Miami A South	.	.	.
Portland, Ore. A West	.	.	.
San Francisco A West	1.04	1.26	1.01
Philadelphia A Northeast	1.01	1.12	1.38
Los Angeles A West	0.96	0.97	1.14
Cincinnati A NorthCen	1.08	1.02	1.30
Chicago A NorthCen	1.01	1.04	1.06
St. Louis A NorthCen	1.03	0.98	1.09
Kansas City A NorthCen	1.13	0.96	1.51
Pittsburgh A Northeast	0.97	1.12	1.36
NE Penn. A Northeast	.	.	.
Detroit A NorthCen	1.06	1.09	1.52
Cleveland A NorthCen	1.04	1.06	1.12
Anchorage A	1.27	1.88	1.59
Honolulu A West	1.48	1.32	1.47

Derived from the issue of "Estimated Retail Food Prices by City," (BLS, 1978).

Appendix C

Glossary of Symbols

p_{hij}	the price of the *i*th item in the *j*th outlet in PSU *h*
q_{hij}	the corresponding quantity
M_{hc}	the number of price quotes for items in the *c*th POPS item category in PSU *h*
m_{he}	the number of price quotes for items in the *e*th ELI in the *c*th POPS item category in PSU *h*
$\hat{E}'_{hij}$	the estimated expenditure on the *i*th item in the *j*th outlet in PSU *h* (the ′ indicates the expenditure is derived from the POPS)
α_{hej}	the proportion the *e*th ELI (containing item *i*) is of the *c*th POPS item category in outlet *j* in PSU *h*
β_{hij}	an indicator variable which equals 1 if item *i* is priced in outlet *j* in PSU *h* and equals 0 otherwise
E'_{hc}	the expenditure on the *c*th POPS item category containing the *e*th ELI (and item *i*) in PSU *h*
P_h	the ratio of the PSU *h* population to the population of the geographic area stratum containing PSU *h;* equals 1 for self-representing PSUs and $0<P_h<1$ for non-self-representing PSUs
$\bar{p}_{hi}$	the average price of item *i* in PSU *h*
$\hat{E}_{hi}$	the estimated expenditure on item *i* in PSU *h* derived from the CE Survey expenditures and POPS expenditures
$\bar{p}_{mi}$	the average price of item *i* in market basket area *m*
$\hat{E}_{mi}$	the estimated expenditure on item *i* in market basket area *m*
$\bar{p}_i$	the average price of item *i* in the U.S.
$\hat{E}_i$	the estimated expenditure on item *i* in the U.S.
I_{mz}	the interarea price index for the *z*th item stratum in the *m*th market basket area
I_m	the aggregate interarea price index for market basket area *m*
S^2_{Im}	the variance of the aggregate interarea price index for market basket area *m*
S^2_I	the average market basket area variance

Appendix D

Glossary of Terms

Acronym	Term	Definition
CE Survey	consumer expenditure survey	a survey of household expenditures which serves as the basis for selecting ELIs to be priced and for weighting price relatives
EC	expenditure class	a grouping of consumer expenditures
ELI	entry level item	a substratum of an item stratum (for example, see Table 1)
	item class	a collection of individual items which are identical or comparable
	item stratum	a subgrouping of an expenditure class consisting of one or more ELIs
MB area	market basket area	a geographic area stratum consisting of a self-representing PSU or a sample of 4, 6, or 8 non-self-representing PSUs; there are 39 MB areas in total
POPS	point of purchase survey	a survey of households used to identify outlets where purchases are made for over 100 categories of expenditures
	POPS item category	an expenditure category of items in the POPS (for example, see Table 2)
PSU	primary sampling unit	a geographic area stratum consisting of a standard consolidated area, standard metropolitan statistical area, city, or urbanized portion of two or more adjacent counties with similar demographic and economic characteristics; there are 87 PSUs in total
	self-representing PSU	a PSU with a population $\geqslant$ 1.25 million

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Received November 1986
Revised November 1988