Construction of Price Indexes and Exploration of Biases Using Scanner Data

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The findings reported and the opinions expressed in this paper are those of the author(s), not of the Australian Bureau of Statistics.

This paper reports work-in-progress. The author(s) would welcome comments, which can be sent to malti.jain@abs.gov.au

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1 Introduction

The Australian Bureau of Statistics (ABS) recently obtained supermarket scanner data from AC Nielsen. We have begun a program of analyses to explore the possibilities for:

- informing and enhancing the ABS's current index practices (in the short to medium term) and
- (in the longer term perhaps) for exploiting scanner data directly in some index construction.

In this paper, we use the scanner data to construct various price indexes using different formulae. Then we explore the biases arising from three different sources: item substitution, outlet substitution and elementary index biases.

The indexes constructed in this paper are not comparable with official ABS price indexes. Nor can the estimates of biases reported here be generalised to draw conclusions about biases in the official indexes. We have used scanner data relating to supermarket sales of just nineteen commodities (out of hundreds) in just one capital city (out of eight) during just one year. Moreover, price statisticians in official agencies have developed procedures for mitigating many sources of potential bias; but these procedures are not captured in the analyses reported here.

Rather, the analyses in this paper explore methods of estimating and analysing substitution biases and the biases arising from the absence of quantity weights at the lowest aggregation level. Our main focus is on the relative magnitudes of the different varieties of bias, and the circumstances in which biases may arise.

Section 2 of the paper gives an overview of analyses that may be undertaken with scanner data. Section 3 describes the scanner dataset obtained by the ABS; the commodities and stores used in our analyses are briefly described. Section 4 defines the indexes we have constructed and explains our measures of various biases. Section 5 summarises our indicative bias measures and explains the ways in which the theoretical index constructions used in this paper differ from actual CPI practice. Section 6 presents our results. Section 7 summarises our findings and canvasses some limitations of this study and of scanner data. The attachments show the index formulae used and provide more details of the results.

2 Applications of Scanner Data and the ABS Analysis Program

Potential Applications of Scanner Data

It is conceivable that scanner data might eventually be used directly in some index construction, because they provide both:

- Price data — so the size of price samples might, for example, be increased substantially at relatively low cost.
- Quantity data — so it might be possible to construct, say, unit prices or superlative indexes. (It must be kept in mind, however, that some of the sales covered by the scanner data may not be sales to our indexes' target populations, say households in the case of the CPI. There is some evidence, for example, that small stores buy items from large stores when the latter offer attractive "specials".)

Even in the shorter term, however, scanner data can be useful for informing and enhancing the current index construction practices of statistical agencies. Scanner data might, for example, be a source of:

- An up-to-date listing of commodities being sold through the outlets covered by the dataset.

- (Approximate) commodity and outlet weights.
- Price, quantity and expenditure information to assist analyses of consumer behaviour.
- Information to assist hedonic modelling and hedonic-based quality adjustments.
- An early indication of new items and items going off the market.

Analyses being undertaken by the ABS

This paper uses Australian scanner data to quantify biases of different indexes at low levels of aggregation. The analysis is based on only those items and outlets that were common to all time periods covered by the year-long dataset. The scanner data have, in effect, been treated as the total "population" of items and stores. This assumes away all sampling errors. We define a "true" or benchmark index; systematic over- or under-estimation of a given index relative to the benchmark index gives us an indicative measure of bias.

A number of other analyses based on scanner data are being conducted or are planned by the ABS. Some of these relate to current ABS practices and may have implications in the short term, for example, imputation for missing values, splicing, and sampling of items and stores. Other analyses may have a longer term application, for example, unit values, and the sampling of items and stores (if scanner data were used directly in index construction).

Other ABS analysis projects using scanner data include:

- Imputation The scanner data lend themselves to analysis of the effects of not including new items and outlets in indexes and the best method for imputing for discontinued items and outlets. Under current CPI practices, for example, new items and outlets are introduced into the sample fairly infrequently and only if an existing sampled item or outlet needs to be replaced.

- Missing prices Missing prices are a fairly common problem for index compilers. Items temporarily missing are imputed and items that go out of production may also be imputed for a period before being replaced. This project is analysing the effect of observations that are not included in the index and the best method for imputing for missing prices.

- Unit values The prices in the scanner dataset for each item are, in effect, weekly unit values. A monthly or quarterly index can be calculated as an average of either weekly indexes or monthly or quarterly unit values. Also, unit values can be calculated across similar items or stores, for example, across different biscuits that are considered to be substitutable for one another; or across all stores of a chain. This has the potential to reduce substitution biases; it also potentially has practical application to the sampling of items and stores.

- Sampling Currently only a few statistical agencies (such as the US Bureau of Labor Statistics and the UK Office of National Statistics) use probability sampling to select the item and outlet samples for their CPIs; the ABS, like most other agencies, uses purposive sampling. Although the ABS has no intention of moving to probability-based sampling for its CPI in the near future, scanner data provide a better basis for determining appropriate sample sizes and purposive sample allocation.

- Different designs Scanner data can be used to guide the drawing of boundaries around the elementary aggregates so that more representative samples could be drawn.

3 The Scanner Data

The scanner dataset used in this analysis relates to a 65-week period (from February 1997 to April 1998).

The dataset shows weekly sales (quantity and prices) of each item (and details of brand, size, packaging, etc.) in each commodity group.

The dataset includes sales by all stores of the four supermarket chains in one capital city. These four chains (with over 100 stores) account for over 80 per cent of the grocery sales in that city. •

The dataset includes sales of 19 commodities. All items within those commodities have a unique 13-digit Australian Product Number (APN).

3.1 Time Period

The dataset relates to a 65-week period. The first 13 weeks were chosen as the "base period" for all our index construction. The following 52 weeks were divided into 12 months. (Months were defined as consisting of 4 or 5 weeks depending upon the number of days of the week falling in the month.) These months are referred to as the "current period".

> The base period price (Po) was computed as the unit value over the thirteen weeks of the base period. The base period quantity (Qo) is the average weekly quantity of the item sold in the base period.
>
> The monthly (current period) prices (Pt) were calculated as the unit values over the month. The quantities (Qt) were average weekly quantities for the month.

3.2 Stores (or Outlets)

The scanner data relate to stores belonging to four supermarket chains in one city. They account for about 15 per cent of all food stores in that city, but over 80 per cent of employment and sales in food stores.

Stores were divided into three types according to their presence in different time periods. A store could be:

- continuing (same store in all weeks covered by the dataset),
- closed down (during the current period), or
- new store (opened during the current period).

In the base period, 101 operating stores belonged to the four chains. One store closed down and seven new stores opened during the current period. Thus 100 stores were common between the base period and all current periods; only these "continuing" stores have been used in our analyses.

3.3 Commodities (and Items)

The following 19 commodities were selected for the analysis:

- biscuits
- bread
- butter
- cereals
- coffee
- detergent
- frozen vegetables
- honey
- jams
- juices

- margarine
- oil
- pasta
- pet foods
- soft drinks
- spreads
- sugar
- toilet paper
- tomatoes (tinned)

Most of these commodities corresponded to an "expenditure class" (EC) in the 12th Series Australian CPI. But the structure of Australian CPI has changed considerably in the last two years -- with the introduction of 13th Series in September 1998 and the 14th Series in September 2000.

> For example, butter which was an EC in the subgroup Dairy Products (with a weight of 0.055) in the 12th Series was moved to the EC Fats and Oils in the subgroup Other Food in the 13th series.
> Soft drinks and cordials (with a weight of 1.212 in the 12th Series and a weight of 0.98 in 13th Series) has been reclassified into an EC Soft Drinks, Water and Juices (with a weight of 1.31) in the 14th series.
>
> Most of the commodities analysed cover only a part of the EC in the 14th series.

Tables 1 and 2 summarise the commodities in the scanner dataset.

Some of the commodities include a large number of items (APNs), which do not always represent distinct products. For example, toilet papers of different colours are given different APNs. Such fine classification of items increases the incidence of missing values in the scanner data because every APN may not be sold every week. However, in our analysis they have been treated as different items.
Items have been classified into those:

- sold in the base period and all current periods
- sold in the base period and some current periods
- sold in the base period only
- sold in the current period only.

Numbers of APNs — Table 1. A small number of APNs disappeared from the market as shown in column 3 of Table 1. A very much larger number of APNs came into the market (column 4). Column 5 in Table 1 gives the number of APNs that were not sold in every week of the current period. Only the items sold in the base period and each of the current weeks (column 6) could be included in the analysis. These items have been called "continuous items". Thus only about 50 per cent of the APNs that were available at some stage have been analysed.

Proportions of Sales — Table 2. Table 2 shows the average weekly sales of commodities being analysed. Only the stores in which the item was sold continuously are included in the continuous dataset for analysis. For most of the commodities the continuous items contributed 50-80 per cent of the total sales. In about half of the commodities, the total sales of the continuous items was marginally less than the sales in the base period. Presumably some of the current period sales is shifted to the new items appearing in the market. Thus the analysis of continuous data would be excluding some of the substitution between items.

Items with negligible sales in the base period did not affect the indexes and in fact comprised mostly the items that were not sold in every week. In practice, these items would not be included in the CPI calculation and were therefore excluded from further analysis. The cutoff was defined as follows:

> If a commodity consists of N items with a total sales in the base period Y, then assuming all items have equal sales, each item would be expected to have a sale of Y/N. Any item with a sale of less than 0.2xY/N was considered to be small.

Data Used in Our Analyses — the "Continuous" Subset. Column 7 in Table 1 shows the number of APNs included in the analysis. Items below the cutoff contributed 2-3 per cent of the total base period sales and as much as 10 cent of the current period sales (Table 3). However, compared to the sales of the continuous items, items after the cutoff contributed only marginally less.

Table 1. Commodity Summary — Number of APNs

COMMODITY	Number of APNs	Number of APNs sold only in base period	Number of APNs sold only in current period	Disconti- nuous APNs	Number of APNs sold in each week	Number of continuous APNs/ Number of APNs (%)	Conti- nuous APNs above cutoff
Biscuits	1322	118	329	422	453	34.3	405
Bread	427	8	102	101	216	50.6	143
Butter	78	3	14	8	53	67.9	42
Cereal	548	9	149	140	250	45.6	165
Coffee	149	4	35	22	88	59.1	70
Detergent	177	3	26	42	106	59.9	87
Frozen vegetables	227	3	28	51	145	63.9	124
Honey	113	8	11	34	60	53.1	58
Jams	389	15	61	185	128	32.9	118
Juices	1125	19	226	293	587	52.2	515
Margarine	98	0	17	13	68	69.4	60
Oils	314	6	64	128	116	36.9	110
Pasta	471	20	127	130	194	41.2	181
Pet food	1062	25	255	267	515	48.5	460
Soft drinks	964	47	152	319	446	46.3	345
Spreads	102	1	13	30	58	56.9	50
Sugar	114	3	13	33	65	57.0	56
Toilet paper	164	7	29	28	100	61.0	90
Tomatoes	128	4	30	37	57	44.5	54

Table 2. Commodity Summary –– Average Weekly Sales

COMMODITY	Base period	Continuous items : base period	% of base period sales	Current period	Continuous items- current period	% of current period sales
	$' 000	$' 000		$' 000	$' 000	
Biscuits	876.1	597.0	68.1	988.4	656.72	66.4
Bread	856.8	737.3	86.1	865.0	708.36	81.9
Butter	166.5	131.6	79.0	168.3	126.71	75.3
Cereal	929.3	761.3	81.9	868.8	680.36	78.3
Coffee	385.5	299.3	77.6	440.4	335.52	76.2
Detergent	166.4	114.3	68.7	167.1	113.64	68.0
Frozen vegetables	229.2	160.5	70.0	217.2	152.21	70.1
Honey	71.9	49.1	68.3	80.8	56.91	70.4
Jams	125.2	68.2	54.5	130.9	71.42	54.5
Juices	1097.4	750.0	68.3	1034.1	689.44	66.7
Margarine	250.3	189.5	75.7	244.0	184.37	75.6
Oil	223.4	122.6	54.9	212.9	115.87	54.4
Pasta	162.8	88.8	54.5	160.5	91.29	56.9
Pet food	945.5	585.3	61.9	934.6	572.50	61.3
Soft drinks	1520.1	958.6	63.1	1489.1	977.33	65.6
Spreads	115.7	76.9	66.5	121.1	79.87	66.0
Sugar	126.7	109.6	86.5	136.1	117.99	86.7
Toilet paper	582.9	404.6	69.4	585.6	400.29	68.4
Tomatoes	71.1	46.3	65.1	74.7	46.91	62.8

Table 3. Commodity Summary –– Average Weekly Sales of Items Above the Cutoff

COMMODITY	Base period	Continuous items - base period	% of total base period sales	Current period	Continuous items- current period	% of total current period sales
	$' 000	$' 000		$' 000	$' 000	
Biscuits	856.1	595.4	69.5	869.8	652.3	75.0
Bread	829.6	727.2	87.7	775.5	698.4	90.1
Butter	161.9	129.6	80.0	153.2	124.6	81.3
Cereal	901.7	753.8	83.6	792.7	673.0	84.9
Coffee	374.0	295.5	79.0	414.6	330.9	79.8
Detergent	163.0	113.0	69.3	156.1	112.0	71.7
Frozen vegetables	224.1	159.6	71.2	199.0	149.5	75.1
Honey	71.1	49.1	69.1	76.3	56.9	74.6
Jams	121.9	68.1	55.9	118.3	71.3	60.3
Juices	1069.1	746.4	69.8	933.5	685.3	73.4
Margarine	245.6	187.6	76.4	226.8	182.7	80.6
Oil	219.7	122.3	55.7	199.7	115.5	57.8
Pasta	160.8	88.6	55.1	148.5	91.0	61.3
Pet food	929.6	581.7	62.6	843.6	568.4	67.4
Soft drinks	1479.3	950.3	64.2	1429.3	967.2	67.7
Spreads	112.7	76.6	68.0	114.0	79.5	69.7
Sugar	123.6	109.2	88.3	132.0	117.5	89.0
Toilet paper	573.5	401.9	70.1	541.0	397.6	73.5
Tomatoes	70.2	46.3	66.0	67.1	46.8	69.7

4 Analytical Framework

The ABS uses a base-weighted (Laspeyres) index as its basic formula for calculating the CPI. The Laspeyres index measures the change in the total cost of a basket of goods (with quantity weights fixed at those observed in the base period) between the base period and the current period; it is thus a measure of pure price change.

Irrespective of which basic index formula is used for CPI compilation, there is a level of aggregation below which weighting data are not available; the "elementary aggregate" (EA) level. A price index at this level is calculated by applying an "elementary index formula" to price data only. For this purpose, price data can be combined by taking an average of price ratios or by taking a ratio of average prices. The average can be calculated using arithmetic, geometric or harmonic mean. The elementary index formula used by a statistical agency may be chosen independently of its choice of the weighted formula for the higher levels of aggregation.

In the current structure of the Australian CPI, weights are typically available only down to expenditure class (EC) level. The ABS estimates the EC weights from its periodic Household Expenditure Surveys. Below the EC level, purposive sampling of items and outlets is used and item weights are based on other information collected from different sources for example data from manufacturers or distributors. However, no weights are available at the outlet level; a microindex is used to aggregate prices across outlets.

4.1 Population index formulae

For our analyses, the scanner data are assumed to represent the whole population of items and outlets. Therefore the indexes defined below are postulated to be "population indexes" rather than sample-based estimates.

At the lowest level, index compilation involves two levels of aggregation, across items and across outlets. Different aggregation methods can be used for the two levels.

Throughout our scanner data analysis, we have named all our indexes with the same naming convention.

In the index name "XY":

the "Y" refers to the initial of the formula used to aggregate across outlets, ie producing summations at the item level and

the "X" refers to the initial of the formula used to aggregate across items, ie producing an index at the commodity level.

Thus, for example, an LF index uses a Fisher formula to aggregate across outlets and a Laspeyres index to aggregate across items.

Each commodity has been treated as independent and we have not tried to aggregate across commodities.

In this study, all indexes have been calculated as direct indexes.

4.1.1 Laspeyres and Paasche indexes

The scanner data show quantity information for items at the outlet level. Therefore it is possible to use quantity weights in compiling an item index. This can be either a Laspeyres (base period) or a Paasche (current period) weight.

In general the Laspeyres price index at both commodity and item levels (LL_t) exhibits higher values than the corresponding Paasche index (PP_t) -- a relationship that holds whenever price and quantity relatives are negatively correlated. This is a typical behaviour in a market economy where consumers react to changes in relative prices by moving consumption away from those products which have become relatively more expensive and towards those which have become relatively less expensive. As the Laspeyres index assumes quantities remain constant and equal to those in the base period, it is likely to be higher than the true index of price change, while the Paasche index is likely to be lower.

The primary advantages of the LL_t which explains its wide acceptance, are its minimal data requirements, and the ease of understanding what the index measures. Its interpretation as the change in the price of a fixed basket of products and services is relatively straightforward and understood easily as a pure price change. The Paasche index has greater data requirements because current weights are required and such data are usually not available (outside of scanner data).

4.1.2 Fisher index

A Fisher index is a geometric mean of Laspeyres and Paasche indexes. A Fisher index uses information on values in both the base period and the current period for weighting purposes. Equal importance is attached to the two periods being compared. It also satisfies various tests that are considered important, such as the "time reversal" and "factor reversal" tests. Diewert (1976) has shown that the Fisher index is also a superlative index since it equals or approximates the true theoretical index corresponding to a family of flexible functional forms.

In our analyses, we have used the Fisher index as a proxy for the cost of living index. It is our benchmark for measuring the overall bias of an index.

4.1.3 Microindex formulae

In the absence of quantity data, indexes must be calculated from price data only. This is generally the case at the lowest level of aggregation in an index compilation. Such indexes are normally referred to as microindexes. The three most commonly used microindexes are:

- an average of price relative (APR) or Carli index,
- a ratio of average prices (RAP) or Dutot index and
- a geometric mean of relative prices (GM) or Jevons index.

4.1.4 Unit values

A unit value at any level is in effect a weighted average of prices. A unit value can be defined for an item aggregated across all outlets. An index that is calculated as a unit values across outlets and then aggregated using fixed base period weights across items has been denoted as LU.

4.1.5 Indexes computed in this study

A number of indexes were computed, representing combinations of indexes with and without quantity weights at the outlet level. These various combinations are summarised below. The first letter denotes the index used to aggregate across items and the second letter to denote the aggregation across outlets. In all indexes except FL'_t the outlets were aggregated first.

Table 4. Summary of price indexes and formula used

Index	Aggregation across items	Aggregation across outlets
LL_t	Laspeyres	Laspeyres
LP_t	Laspeyres	Paasche
PL_t	Paasche	Laspeyres
PP_t	Paasche	Paasche
FF_t	Fisher	Fisher
FL_t, FL'_t	Fisher	Laspeyres
LF_t	Laspeyres	Fisher
LC_t	Laspeyres	Carli
LD_t	Laspeyres	Dutot
LJ_t	Laspeyres	Jevons
LU_t	Laspeyres	Unit value

In calculating the weighted indexes, the quantity weights down to the outlet level for each APN were used. In calculating the microindexes, each APN was treated as a separate elementary aggregate (EA).

4.2 Sources of Bias in Consumer Price Indexes

Diewert (1996) has identified several possible sources of bias in consumer price indexes at the low level of aggregation. These are biases in the sense that a concept of a 'true index' exists. Diewert's concept of a 'true' or 'unbiased' index is a social cost of living index. This index allows consumers to change their baskets of goods in response to changes in relative prices.

Diewert identifies five sources, namely:

- substitution bias
- outlet substitution bias
- elementary index bias
- quality adjustment bias; and
- new goods bias.

The ABS, like most statistical agencies, uses a Laspeyres index as its basic formula for calculating the CPI. The Laspeyres index measures the change in the total cost of a basket of goods between the base period and the current period (with quantity weights fixed at those observed in the base period). A Laspeyres index can be expressed as a weighted sum of indexes at a lower level. At the lowest level of aggregation (ie, at the outlet level, where quantity weights are not available), the index is calculated using price data only.

It is well-known that a fixed-weight Laspeyres index overestimates a cost of living (COL) index since it does not take into account the substitutions that consumers make. Although a Fisher or another superlative index would be ideal for calculating a COL, it is not possible to use a superlative index for compiling CPI due to data limitations and timing. Therefore ABS has no alternative but to use a Laspeyres formula. At higher levels of aggregation the substitution is small and a periodic review of weights deals adequately with changes in the spending pattern of householders. These weights are revised after each Household Expenditure Survey (HES) run approximately every 5 years. The weights below the expenditure class (EC) level come from other sources and can be revised more often if considered necessary. However, the index is still a fixed-weight index. There are more substitutions happening below the EC level both between items and between outlets, and this can introduce substitution bias into the index. At the lowest level of aggregation, i.e. aggregation across outlets, an elementary index is used. In the ABS, elementary indexes used to be calculated using an arithmetic mean formula; but this was recently changed to a geometric mean formula, in order to reduce outlet substitution bias. Item substitution bias is kept to a minimum by grouping of similar and substitutable items into elementary aggregates.

In this study, we consider the first three sources of biases identified above. These are item substitution biases, outlet substitution biases and elementary index biases. In each case we have defined a benchmark or a "true" index which we have assumed to be free of that bias and thus measured the bias with respect to the benchmark.

4.2.1 Indicative measures of substitution biases

In calculating indexes, there are two levels of aggregation — across outlets and then across items. The arithmetic difference between an index using fixed weights at both levels and the benchmark index can be thought of as the combined impact of item and outlet substitution. This arises in practice where, for example, the CPI is defined as a fixed base-period-weighted index (a Laspeyres index) with fixed weights at both the item and outlet levels. In actual ABS practice, due to data limitations, a Laspeyres index is used to aggregate the items and an unweighted index to aggregate price relatives across outlets. For our analyses of biases, our benchmark index is a Fisher index at both levels of aggregation.

One assumption in using a Fisher index as a measure of the cost of living is that the items bought in a particular period are consumed in the same period. In reality, consumers typically not only substitute between items and outlets but also substitute across time, thereby introducing a time substitution bias (which we do not estimate separately).

It is almost impossible to isolate perfectly cleanly all the substitution biases, since they interact with each other. Only an indication of the relative importance of item versus outlet substitution bias can be obtained. Moreover, both include time substitution.

Total substitution bias**:** We have defined the total substitution bias as the difference between an index computed as a Laspeyres (at both the item and the outlet levels) and an ideal or true index, which we consider to be the Fisher index (again, at both the item and the outlet levels). This bias measure is $\mathbf{LL_t - FF_t}$

Outlet substitution bias: We have computed two item indexes — one applying the Laspeyres formula and the other applying the Fisher formula across all outlets. The difference between the two gives us an *indicative measure* of outlet substitution bias. The item indexes can then be aggregated using fixed base period weights, to give an overall indicative measure of outlet substitution bias across all items. This bias measure is $\mathbf{LL_t - LF_t}$

Item substitution bias: Another way of calculating these indexes is by reversing the order of aggregation — the items can be aggregated first, and then the outlets. The new indexes are denoted as LL'_t, LF'_t, FL'_t and FF'_t. As expected, LL'_t and FF'_t are identical to LL_t and FF_t respectively — but FL'_t is not the same as FL_t and LF'_t is not same as LF_t. The outlet indexes can be calculated across all items using either Laspeyres or Fisher indexes. The differences between the two provide an *indicative measure* of item substitution bias within each outlet. These can be aggregated using fixed base-period outlet weights to give an overall indicative measure of item substitution. This bias measure is $\mathbf{LL'_t - FL'_t}$

The sum of item and outlet substitution biases is not equal to the total substitution bias. However, the relative magnitude of item and outlet substitutions can be used as an indication of which of the biases is most serious.

4.2.2 Elementary index bias

We define the elementary index formula biases of the three microindexes (Carli, Dutot and Jevons) as the difference between them and a pure Laspeyres index (i.e. Laspeyres weights used to aggregate both items and outlets). For microindexes, item indexes are calculated using unweighted price data at the outlet level, but the item indexes are aggregated using fixed base period weights. Thus,

Elementary index formula bias (Carli) = $LC_t - LL_t$

Elementary index formula bias (Dutot) = $LD_t - LL_t$

Elementary index formula bias (Jevons) = $LJ_t - LL_t$

The 'true' index is assumed to be the Fisher index. The total bias in the micro indexes is the sum of elementary index formula bias and the substitution bias in the Laspeyres index.

5 Indicative Measures of Bias

This study was designed mainly to look at the relationship between various index formulae when they applied to what we have postulated to be "population" data. It also explores methods for quantifying item and outlet substitution biases.

The following table summarises the indexes and biases computed in this paper.

Table 5. Indexes and biases, by formula at item and outlet levels

Index No.	Index name	Aggregation formula at item level	Aggregation formula at outlet level	Comments	Bias indicator	Bias calcula-tion
(1)	FF_t	Fisher	Fisher	Ideal index : used as our benchmark		
(2)	LL_t	Laspeyres	Laspeyres	Pure price change index	Total substitution bias	(2) - (1)
(3)	LF_t	Laspeyres	Fisher		Outlet substitution bias	(2) - (3)
(4)	FL'_t *	Fisher	Laspeyres		Item substitution bias	(2) - (4)
(5)	LC_t	Laspeyres	Carli	Previous ABS method for CPI	Traditional definition of elementary index bias	(5) - (2)
					Total bias of Carli index	(5) – (1)
(6)	LD_t	Laspeyres	Dutot		Elementary index bias of Dutot index	(6) - (2)
					Total bias of Dutot index	(6) - (1)
(7)	LJ_t	Laspeyres	Jevons	Current ABS method for CPI	Elementary index bias of current ABS index	(7) - (2)
					Total bias of current ABS index	(7) - (1)

** This index was calculated by reversing the order of aggregation.*

The main finding of the analysis is that, for the commodities we have examined, the bias due to item substitution is much larger than the bias due to substitution between outlets.

6 Results

The indexes constructed in this paper are not comparable with official ABS price indexes. Nor can the estimates of biases reported here be generalised to draw conclusions about biases in the official indexes.

First, the results in this analysis cannot be generalised to the whole CPI basket. We have looked at only nineteen commodities over a 12-month period for only one capital city. Results may not be thought to vary significantly between cities, but they could vary considerably between commodities and over time. Moreover, the biases estimated here are based on theoretical indexes that are not used in practice for calculating the CPI.

Moreover, it should be noted that we have estimated indicative biases for monthly indexes, whereas Australian CPI is a quarterly index. In practice, the Australian CPI is based only on a sample of commodities and of prices. It is compiled quarterly with price collection spread over the whole 13-week period. We would expect that index volatility and some biases to be appreciably lower in a quarterly index.

Finally, our calculation of biases is based on a mechanical or "hands-off" application of the various index formulae to the scanner data just as we find them. Of course, over decades of experience, price statisticians in official agencies have developed a wide range of practices to ameliorate the biases and other potential flaws in their indexes.

Graphical presentations of various indexes for each commodity are given in Attachments 2 and 3.

Attachment 2 presents weighted indexes — LL_t, PP_t, FF_t, LF_t and FL'_t along with LU_t

Attachment 3 presents microindexes — LC_t, LD_t, LJ_t along with LL_t and FF_t

Main Features of the Results

For all 19 commodities in our scanner dataset, the charts of the various indexes exhibit much the same gross features:

A. A marked divergence between the indexes as we move from Period 0 to Period 1. It will be recalled that Period 0 is our 13-week "base period" and Period 1 is the first month of our "current period".

B. More gradual divergences between the indexes (and, in particular, divergence from our benchmark Fisher index FF) as we move from Period 1 to Period 12 (the final month of our current period).

Examination of the detailed price and quantity data for individual items (APNs) reveals why these features appear:

The year covered by our scanner dataset (early 1997 through early 1998) was a period of low inflation in Australia. Most APNs in our dataset show only a small upward trend in prices during that year (generally one or two small upward steps in price); some APNs show no upward trend. The most common changes in prices across the whole scanner dataset are transient drops in price lasting a week or two -- these correspond to supermarket "specials", and they are generally accompanied by a transient increase in the quantity sold as illustrated by the Charts 1 and 2 below. The charts show the prices and quantities for the 65 weeks for which we have the data. The prices are the weekly unit values and quantities have been aggregated across all stores within a chain. One of the items shown here is discounted more regularly than the second. In each case the quantities reflect the reaction to the price decline.

The effects of these patterns in the detailed price and quantity data are as follows:

A. During the 13-week base period (Period 0), many commodities exhibit transient falls in price and corresponding transient rises in the quantity sold. Thus the base period prices and quantities are generally correlated. The transients are generally not repeated into Period 1, and the various indexes diverge -- for example, the base-weighted LL index diverges from the benchmark index FF. It is important to note, however, that this apparent "bias" will not affect the real-world price indexes computed by most official statistical agencies. Price statisticians have developed methods for avoiding the price-quantity correlation in the base period. In the case of the Australian CPI, for example, the quantities are for the most part derived from a Household Expenditure Survey (independent of and separated in time from the base period prices); moreover, the compilers are careful to avoid using items that are "specials" in the base period. If scanner data were used for CPI compilation (as opposed to research) similar methods would have to be developed for dealing with the base-period correlations.

B. During the current period (Periods 1 through 12), we observe some gradual upward trend in prices, gradual changes in relative prices and gradual changes in quantities sold. This leads to the gradual divergence between, say, the base-period weighted LL index and our benchmark index FF. It is these divergences that may be thought truly to capture substitution biases.

The indicative estimates of bias in the tables below ignore the movements between Period 0 and Period 1; they are computed from the movements from Period 1 through Period 12.

Chart 1 : Prices (weekly unit values) and Quantities Sold Across all Stores of a Chain

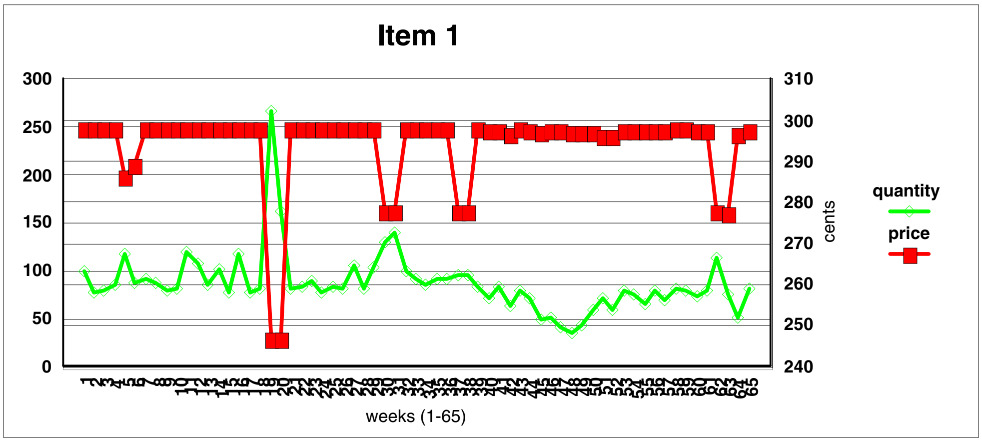
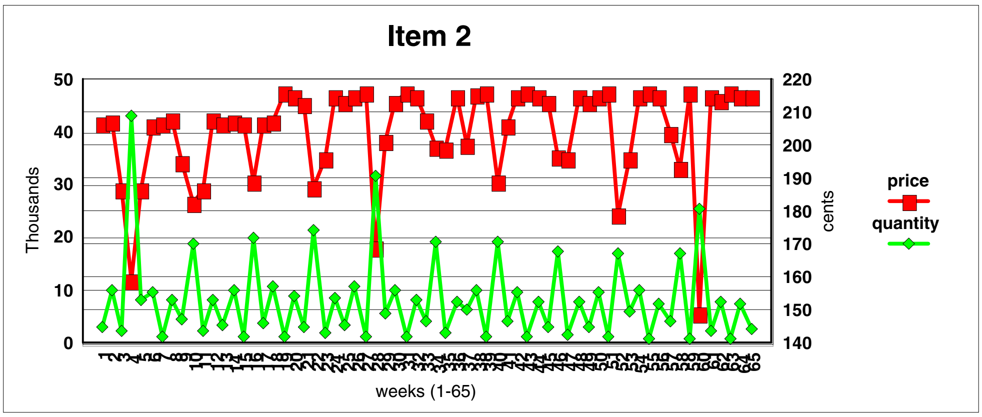


Chart 2 : Prices (weekly unit values) and Quantities Sold Across all Stores of a Chain



Weighted indexes

As expected LL_t and PP_t define the upper and lower bounds of the weighted indexes.

The Paasche index is very volatile and very sensitive to price and corresponding quantity changes; accordingly the Fisher index also shows considerable volatility.

The movements in LL_t and PP_t are mostly in the same direction. But in cases of large changes in quantity, the Laspeyres and Paasche indexes can move in opposite directions.

The Paasche index is generally 3-4 percentage points lower than the Laspeyres index. However, we came across a few interesting phenomena which highlight some of the limitations of the scanner data and the particularities that arise when dealing with a real-world dataset.

> The large difference in month 7 for Butter was caused by one item being sold at less than half the normal price in all stores of one chain and a consequent large increase in its sale.
>
> Coffee sales of one brand shot up in month 11 when a 250gm jar was sold at 150gm price in a number of stores. This resulted in a large decrease in the Paasche index and a small decrease in the Laspeyres index, leading to a 10 percentage point difference between the two. This was much more pronounced in weekly indexes. There was no corresponding decrease in sales in the following periods suggesting that the sale was not limited to household consumers. The increase in the sales was probably caused by small businesses buying from the large supermarkets. This suggests that the quantities from the scanner data should not be used blindly in CPI compilation, as the data does not distinguish between sales to householders (the target population) and sales to businesses.
>
> A similar case was observed for Toilet paper in month 7. Five APNs of the same brand and size but different colours were sold at considerably reduced price in a number of stores in one of the weeks. This resulted in a small decline in the Laspeyres index but a very large decline in the Paasche index. Again, no compensating decline in sales was observed in the following weeks. The size of the toilet rolls changed from 280 sheets per roll to 270 sheets gradually from month 5 onwards. The change was picked up by the Australian CPI price collectors and a quality change adjustment was made. However, there was no change in the APNs and thus it was not picked up in the scanner data. This highlights a serious implication if scanner data were eventually to be used for CPI compilation, since it is possible to miss such quality changes.

Indexes LF_t and FL'_t have been calculated to see the effect of substitution. First a Fisher index for each item (across all outlets) was calculated. These indexes were then aggregated using fixed item level weights.

LF_t being a Fisher index for each item allows for substitution between outlets. It generally lies roughly mid-way between LL and FF, suggesting that it still exhibits some substitution bias. On the other hand, FL' almost overlaps FF. FL' has been calculated as a Fisher index for each outlet (across all items). The outlet indexes are then aggregated using fixed outlet weights. Thus FL' allows for item substitution and appears to be almost free of substitution biases.

The divergence between LL and FF (our measure of the total substitution bias in the Laspeyres index) increases marginally over time.

Tables 6 summarise the different substitution biases of the Laspeyres index. These biases represent the average monthly bias. Note that the outlet substitution and item substitution biases do not add to the total substitution bias.

All the indexes reported here have been calculated from the "continuous" data subset. Thus any substitution to and from items and stores excluded from the analysis has been ignored. Other ABS studies are addressing this issue.

The indicative measures of item substitution biases are almost same as the corresponding total substitution biases, implying that most of the overall bias comes from item substitution. However, item substitution is overestimated to some extent because each APN has been treated as a different item. Some of the APNs are close substitutes for one another, for example, toilet rolls of the same size, packaging and brand but in different colours; pastas of the same size and brand but different shapes; fruit juices of same brand and packaging etc. The effect of treating the similar items that are normally sold at the same price will be analysed in the future.

Table 6. Indicative Substitution Biases in the Laspeyres Indexes

COMMODITY	Laspeyres index	Total substitution bias	Indicative outlet substitution bias	Indicative item substitution bias
	LL	LL - FF	LL - LF	LL - FL'
Biscuits	100.86	0.12	0.05	0.12
Bread	104.15	0.13	-0.002	0.12
Butter	100.80	0.07	0.05	0.06
Cereal	99.63	0.05	0.03	0.05
Coffee	107.29	0.22	0.14	0.23
Detergent	102.50	0.04	0.003	0.04
Frozen vegetables	101.54	0.04	0.005	0.04
Honey	102.53	0.06	0.02	0.05
Jams	100.49	0.12	0.06	0.11
Juices	101.54	0.16	0.05	0.15
Margarine	104.50	-0.11	-0.12	-0.09
Oils	96.60	0.18	0.05	0.18
Pasta	101.22	0.16	0.09	0.15
Pet food	101.29	0.09	0.05	0.09
Soft drinks	103.52	0.27	0.15	0.27
Spreads	101.71	0.02	0.03	0.02
Sugar	103.24	0.12	0.06	0.10
Toilet paper	100.10	0.04	0.09	0.03
Tomatoes	100.68	0.12	0.04	0.11

A prime (') indicates that the index is compiled by aggregating across items first and then across outlets.

The substitution biases for different commodities are not comparable since the bias would depend on the variation in prices of items across stores and over time. However, the outlet substitution bias can be compared with the item substitution bias for each commodity. The item substitution bias in most cases is about 2 times the outlet substitution bias.

<u>**Unweighted elementary indexes**</u>

The three elementary indexes LC, LD and LJ are all very close to one another although as expected the Carli index is always larger than the corresponding Jevons index. They are much more stable than the weighted indexes. They are generally smaller than the corresponding Laspeyres index LL, the exception being Frozen vegetables in month 5. For most of the commodities they are closer to Laspeyres index than the corresponding Fisher index, however, for Toilet Paper they are almost identical to the Fisher index except for month 7 which had an unusual sale as explained earlier. As mentioned earlier, Toilet paper has a very fine item classification. Different colours have different APNs. They are generally sold at the same price and are completely substitutable. This may be the reason for the large substitution bias. However micro indexes that average out the price movements over a large number of items are very stable and close to the Fisher index.

Looking at the graphs in the Attachment 3, microindexes perform much better than the pure Laspeyres index. They are closer to the corresponding Fisher index, however, a large part of substitution bias still remains. This bias is mainly due to the item substitution.

The elementary index biases, defined as the difference between the microindex and the Laspeyres, are presented in Table 7 below. They represent the average monthly bias in the indexes. Because the microindexes are smaller than the fixed-weighted Laspeyres, the formula biases are negative for all commodities. The total bias in microindexes is considerably lower than in a Laspeyres index. The total index biases for Jevons are generally smaller than Dutot indexes. The bias in the corresponding Carli index are always much higher. Thus justifying the use of Jevons index at the elementary aggregate level. Moreover, the data being used for this analysis includes only the continuously sold items. It is expected that when new items and outlets are introduced and the indexes are linked then the gains in using a Jevons index would be even more apparent.

Table 7. Indicative Elementary Index Bias and Total Bias in the Microindexes

		Carli		***Dutot***		***Jevons***	
COMMODITY	**LL**	**LC - LL**	**LC - FF**	**LD - LL**	**LD - FF**	**LJ - LL**	**LJ - FF**
Biscuits	100.86	-0.01	0.11	-0.01	0.1	-0.02	0.1
Bread	104.15	0.03	0.16	0.03	0.16	0.03	0.17
Butter	100.8	-0.03	0.04	-0.04	0.03	-0.04	0.03
Cereal	99.63	0.01	0.06	0.01	0.06	-0.01	0.05
Coffee	107.29	-0.07	0.15	-0.08	0.14	-0.09	0.14
Detergent	102.5	0.001	0.04	-0.01	0.03	-0.001	0.03
Frozen vegetables	101.54	-0.02	0.02	-0.03	0.01	-0.02	0.02
Honey	102.53	0.001	0.06	0.002	0.06	-0.01	0.06
Jams	100.49	0.001	0.12	-0.01	0.11	-0.01	0.11
Juices	101.54	-0.03	0.13	-0.04	0.12	-0.05	0.11
Margarine	104.5	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01
Oils	96.6	-0.03	0.15	-0.04	0.14	-0.04	0.14
Pasta	101.22	-0.001	0.002	-0.002	0.002	-0.002	0.001
Pet food	101.29	0.02	0.11	0.02	0.11	0.01	0.09
Soft drinks	103.52	-0.03	0.24	-0.04	0.23	-0.07	0.2
Spreads	101.71	-0.03	-0.005	-0.03	-0.004	-0.04	-0.01
Sugar	103.24	-0.02	0.1	-0.02	0.1	-0.03	0.09
Toilet paper	100.1	-0.002	0.04	-0.01	0.03	-0.02	0.02
Tomatoes	100.68	-0.05	0.07	-0.06	0.06	-0.07	0.05

The figures presented in Tables 6 and 7 are only indicative of the relative magnitudes of biases. As explained earlier, it is not possible to distinguish the various classes of bias perfectly cleanly.

7 Conclusions and Limitations

We have used Australian scanner data to construct indexes using different formulae; we have also made indicative estimates of the biases in these indexes, using the ideal Fisher index as the benchmark with respect to which bias is measured.

We have also attempted an indicative separation of the two types of substitution biases.

7.1 Relative magnitude of biases

Price statisticians have been well aware for a long time that the item substitution bias is much larger than the outlet substitution bias, and this is corroborated by our analyses. In most cases, item substitution bias is about twice as large as the outlet substitution bias.

The elementary index biases (with respect to a Laspeyres index) were found to be negative — but they were small compared to the bias of a Laspeyres index (with respect to the corresponding Fisher index). The Jevons index had the smallest total bias and showed considerable improvement over the Carli index.

7.2 Usability of scanner data

Of all the Australian scanner data available to us, only about half could be used for our analyses. This is because items that were not sold regularly were excluded. If this procedure were used in actual index compilation by statistical agencies, it could, of course, lead to under- or over-estimation of the price indexes. It also means that a large amount of potentially useful data is wasted. A separate ABS study is addressing issues of this kind.

Our analysis has also highlighted some other problems associated with scanner data. The use of weights derived from scanner data could be misleading. The data does not distinguish between final consumers (typically householders) and intermediate buyers (resellers). As was discovered in the analysis of coffee, other small retailers probably buy in bulk from big retailers when prices are low. This phenomenon can distort the results.

Also, if the producers do not change the APN when there is a change in quality, the prices would not reflect pure price change. This can introduce a quality change bias or new goods bias distorting the index.

We have gained some valuable insights from this analysis of scanner data, including the following:

- Continuing items and outlets account for less than half the data.
- Weekly quantities are very volatile.
- The number of APNs is very large.
- A large number of items have very small weekly sales.
- Buyers of items on special are not necessarily householders. The large quantities sold when an item comes on special needs to be looked carefully and may have to be treated as outliers.
- APN may not change when the quality of a product changes.

Abbreviations

ABS	Australian Bureau of Statistics
APN	Australian Product Number
APR	Average of Price Relatives
BLS	US Bureau of Labor Statistics
COL	Cost of Living Index
CPI	Consumer Price Index
EA	Elementary Aggregates
EC	Expenditure Class
RAP	Ratio of Average Prices
GM	Geometric Mean of Relative Prices
ONS	UK Office for National Statistics

Index notation

Throughout our scanner data analysis, we have named all our indexes with the same naming convention. In the index name XY, the Y refers to the initial of the formula used to aggregate across outlets, ie producing summations at the item level and the X refers to the initial of the formula used to aggregate across items, ie producing an index at the commodity level. The formula for each index is given in the attachment.

Summary of price indexes and formula used

Index	**Aggregation across items**	**Aggregation across outlets**
$\mathbf{LL_t}$	Laspeyres	Laspeyres
$\mathbf{LP_t}$	Laspeyres	Paasche
$\mathbf{PL_t}$	Paasche	Laspeyres
$\mathbf{PP_t}$	Paasche	Paasche
$\mathbf{FF_t}$	Fisher	Fisher
$\mathbf{FL_t}$, $\mathbf{FL'_t}$	Fisher	Laspeyres
$\mathbf{LF_t}$	Laspeyres	Fisher
$\mathbf{LC_t}$	Laspeyres	Carli
$\mathbf{LD_t}$	Laspeyres	Dutot
$\mathbf{LJ_t}$	Laspeyres	Jevons
$\mathbf{LU_t}$	Laspeyres	Unit value

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Attachment 1

Formulae for "Population Indexes"

For the analyses reported in this paper, the scanner data is taken to represent the whole population of items and outlets. Therefore the indexes defined below can be considered to be "population indexes" rather than a sample-based estimates.

Weighted Index Formulae

Laspeyres and Paasche indexes

We have denoted a fixed weighted index as LL_t to denote an index which is calculated using fixed base period weights to aggregate across both item and outlet levels and PP_t to denote a current weighted index at both levels. We have also calculated indexes that use fixed weights to aggregate across items but current weights to aggregate across outlets and vice versa. These indexes have been denoted as LP_t and PL_t respectively.

The commodity index computed as a Laspeyres to aggregate across item and outlet levels (LL_t) is given by

$$LL_t = \frac{\sum_i \sum_j P_{tij} Q_{0ij}}{\sum_i \sum_j P_{0ij} Q_{0ij}}$$

This can also be written as

$$LL_t = \sum_i W_{0i} \sum_j W_{0ij} R_{tij}$$

where R_{tij} is the price relative for item i and outlet j in period t, i.e. $R_{tij} = P_{tij} / P_{0ij}$,

$$W_{0ij} = \frac{P_{0ij} Q_{0ij}}{\sum_j P_{0ij} Q_{0ij}}$$

is the expenditure weight for item i and outlet j in the base period (t = 0) and

$$W_{0i} = \frac{\sum_j P_{0ij} Q_{0ij}}{\sum_i \sum_j P_{0ij} Q_{0ij}}$$

is the expenditure weight for item i in the base period (summed across outlets).

An index calculated as Paasche at both commodity and item level (PP_t) can also be expressed in terms of expenditure weights as

$$PP_t = \left(\sum_i W_{ti} \sum_j \frac{W_{tij}}{R_{tij}} \right)^{-1}$$

where

$$W_{tij} = \frac{P_{tij}Q_{tij}}{\sum_j P_{tij}Q_{tij}}$$

is the expenditure weight for item i and outlet j in period t ; and

$$W_{ti} = \frac{\sum_j P_{tij}Q_{tij}}{\sum_i \sum_j P_{tij}Q_{tij}}$$

is the expenditure weight for item i in period t (summed across outlets).

An index calculated as Laspeyres at commodity level and as Paasche at item level (LP_t) can be expressed as

$$LP_t = \sum_i W_{0i} I_{Pti}$$

$$= \sum_i W_{0i} \left(\sum_j \frac{W_{tij}}{R_{tij}} \right)^{-1} .$$

An index calculated as Paasche at commodity level and as Laspeyres at item level (PL_t) is given by

$$PL_t = \left(\sum_i \frac{W_{ti}}{I_{Lti}} \right)^{-1}$$

$$= \left(\sum_i \frac{W_{ti}}{\sum_j W_{0ij} R_{tij}} \right)^{-1} .$$

Fisher index

A Fisher index is a geometric mean of Laspeyres and Paasche indexes. Thus FF_t is the Fisher index at both item and outlet levels:

$$FF_t = (LL_t * PP_t)^{1/2}.$$

An index can also be computed which is Fisher index at one level but a Laspeyres or Paasche index at another. Thus an index computed as Fisher at the commodity level and Laspeyres at the item level (FL_t) is given by

$$FL_t = (LL_t * PL_t)^{1/2},$$

while an index computed as Laspeyres at the commodity level and Fisher at the item level (LF_t) is given by

$$LF_t = (LL_t * LP_t)^{1/2}.$$

Microindex formulae

Carli index

A Carli index for item i is

$$C_t(i) = \frac{1}{n}\sum_j \frac{P_{tij}}{P_{0ij}}$$

where n is the size of the sample.

This is same as an *average of price relatives*, ie,

$$C_t(i) = \frac{1}{n}\sum_j R_{tij}$$

A Laspeyres index reduces to a Carli index if base period expenditures are equal across all outlets.

Dutot index

A Dutot index is

$$D_t(i) = \frac{\frac{1}{n}\sum_j P_{tij}}{\frac{1}{n}\sum_j P_{0ij}}$$

This is same as the relative of the arithmetic means of prices or *ratio of average prices.* A Laspeyres index reduces to a Dutot index if it is assumed that the base period *quantities* are equal across all outlets.

Jevons index

The Jevons formula is

$$J_t(i) = \frac{\left(\prod_j P_{tij}\right)^{\frac{1}{n}}}{\left(\prod_j P_{0ij}\right)^{\frac{1}{n}}}$$

Expressed differently, the Jevons formula is same as the *geometric mean* of the price relatives R_{tij} (defined earlier).

$$J_t(i) = \prod_j \left(R_{tij}\right)^{\frac{1}{n}}$$

Commodity level indexes

Indexes that are compiled using microindexes at the item level (i.e. unweighted) and Laspeyres at the commodity level are therefore given by the following:

$$LC_t = \sum_i W_{0i} \frac{1}{n_i} \sum_j R_{tij}$$

$$LD_t = \sum_i W_{0i} \frac{\frac{1}{n_i} \sum_j P_{tij}}{\frac{1}{n_i} \sum_j P_{0ij}}$$

$$LJ_t = \sum_i W_{0i} \left(\prod_j R_{tij} \right)^{\frac{1}{n_i}}$$

Unit values

A unit value is simply a weighted average price defined as

$$\overline{P}_{tij} = \frac{\sum_k^{N_{tij}} P_{tijk} Q_{tijk}}{\sum_k^{N_{tij}} Q_{tijk}} \qquad t = 0,1,2....$$

Here $\overline{P}_{tij}$ defines the unit value for an item i in the outlet j at time t sold at N_{tij} different prices P_{tijk} and quantities Q_{tijk}. This would be the case where the item is sold at different prices during the time interval being considered. If the time period is very short then there will be only one price for each commodity ie $N_{tij} = 1$. In our scanner data the prices actually are average weekly prices since they are calculated from the total sales and total quantity sold in the week. Thus P_{tijk} and Q_{tijk} represent the prices and quantities for week k and $\overline{P}_{tij}$ is the monthly unit value.

A unit value can also be defined for an item aggregated across all outlets. Thus $\overline{P}_{ti}$ can be expressed as

$$\overline{P}_{ti} = \frac{\sum_j^{N_{ti}} \sum_k^{N_{tij}} P_{tijk} Q_{tijk}}{\sum_j^{N_{ti}} \sum_k^{N_{tij}} Q_{tijk}} \qquad t = 0,1,2....$$

An index that is calculated as a unit values across outlets and then aggregated using fixed base period weights across items is thus expressed as

$$LU_t = \sum_i W_{0i} \frac{\overline{P}_{ti}}{\overline{P}_{0i}}$$

Attachment 2

Price Indexes, By Commodity
Weighted Indexes

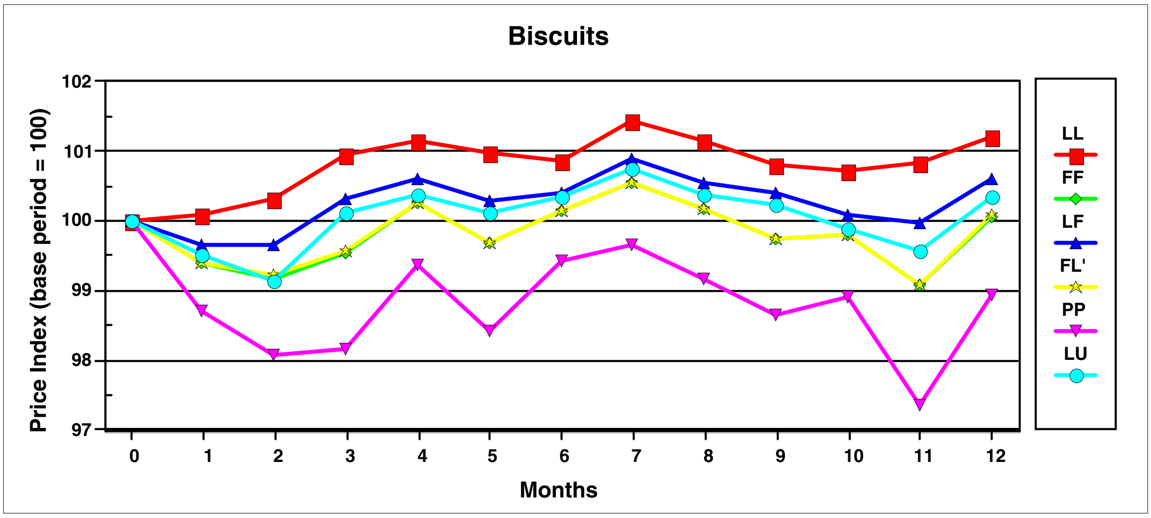
As expected, the Laspeyres and Paasche indexes define the lower and upper limits of the monthly weighted indexes for all commodities. Fisher index (FF) being the geometric mean of the Laspeyres (LL) and Paasche (PP) indexes, lies between the two.

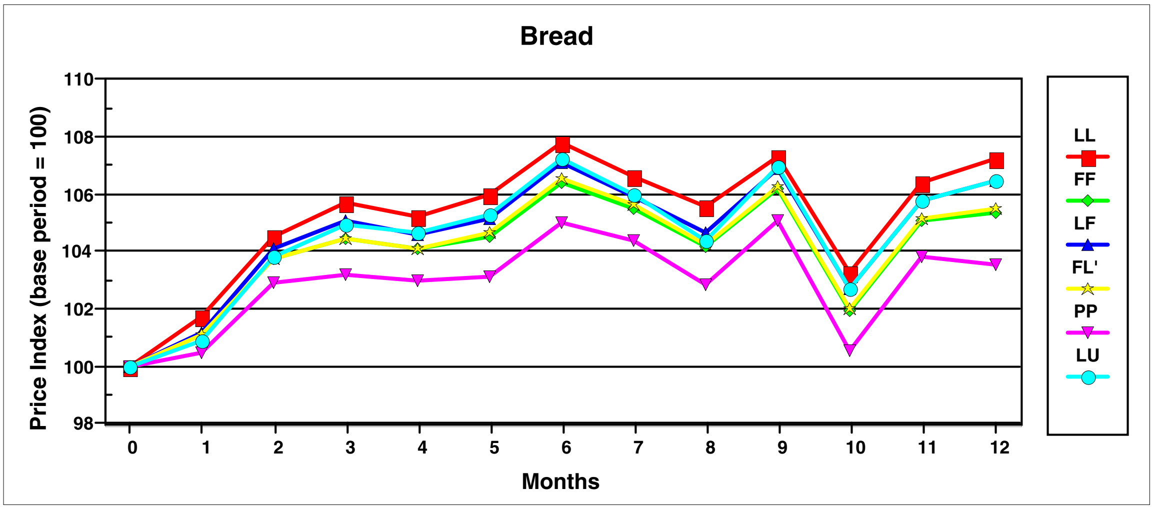
The direction of the movement of LL and PP for all commodities is same as expected except for butter where the two indexes moved in opposite direction in month 7. The increase in the quantity of butter sold during this period due to a large reduction in the price of a particular brand caused a significant fall in PP, while LL moved slightly in opposite direction.

The unusually large volume of sales for toilet paper in month 7 due to a reduction in price of 5 toilet paper brands by around 45% caused more than 10 percentage points difference between Laspeyres and Paasche indexes. Coffee showed a similar occurrence in month 11 due to a particular brand of coffee being sold at a special price.

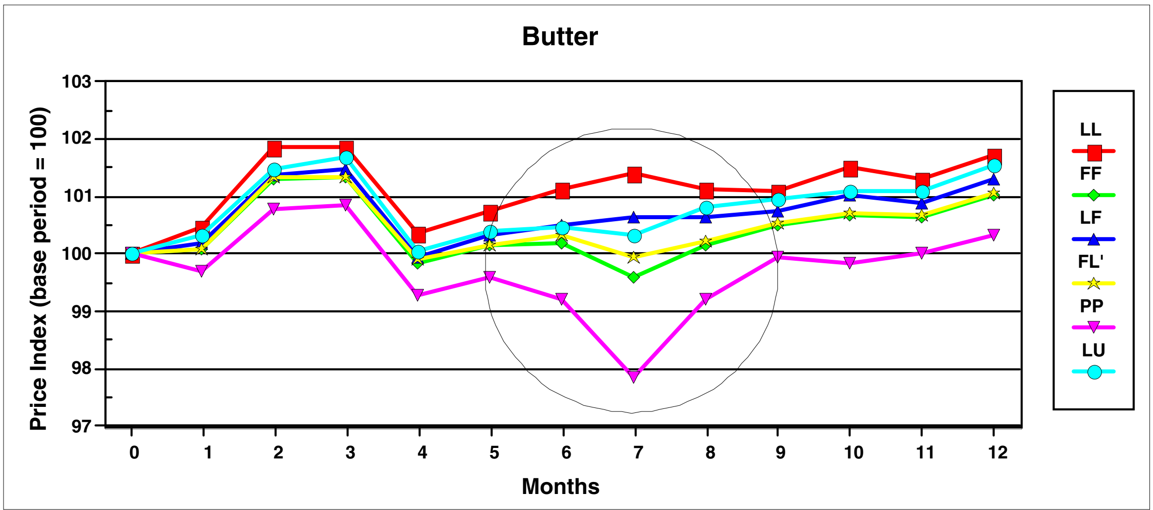
The indexes calculated as a Fisher or unit values at the item level (across outlets) and then aggregated using a Laspeyres index (across items), LF and LU respectively, are very close to each other while FL' calculated by aggregating across items first using a Fisher index and then aggregating across outlets using a Laspeyres index almost overlaps the corresponding Fisher index FF. All the four indexes lie close together between LL and PP.

The following charts show the monthly indexes LL, PP, FF, LF, FL' and LU. Month 0 corresponds to the base period; months 1 - 12 correspond to the current periods.

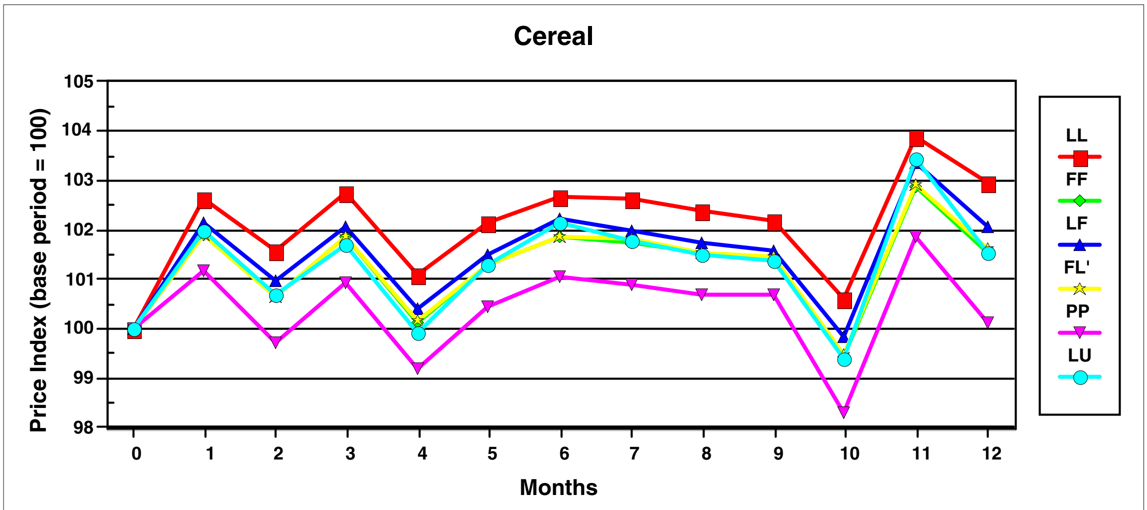




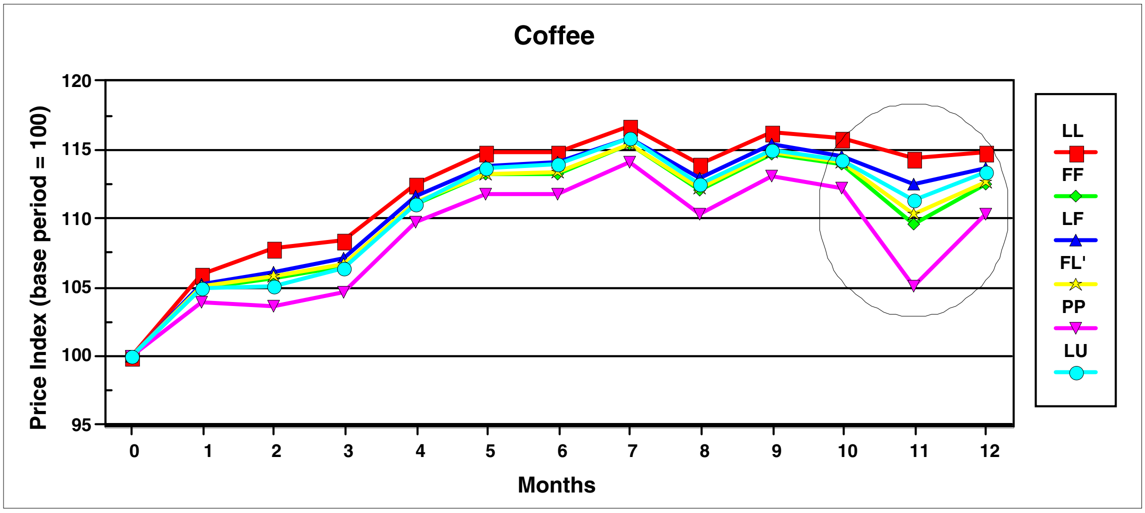
Bread
Price Index (base period = 100)
110
108
106
104
102
100
98
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

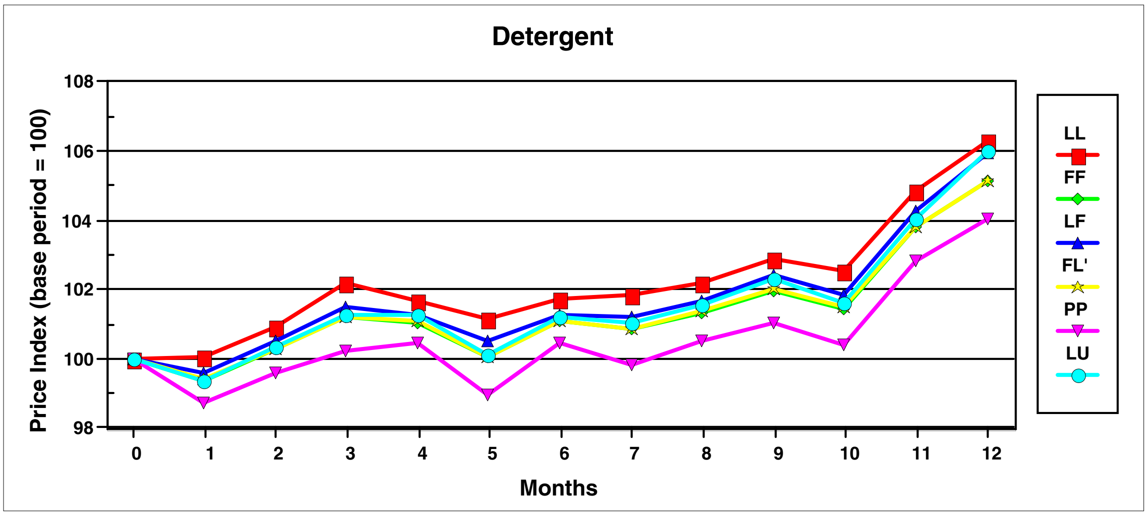


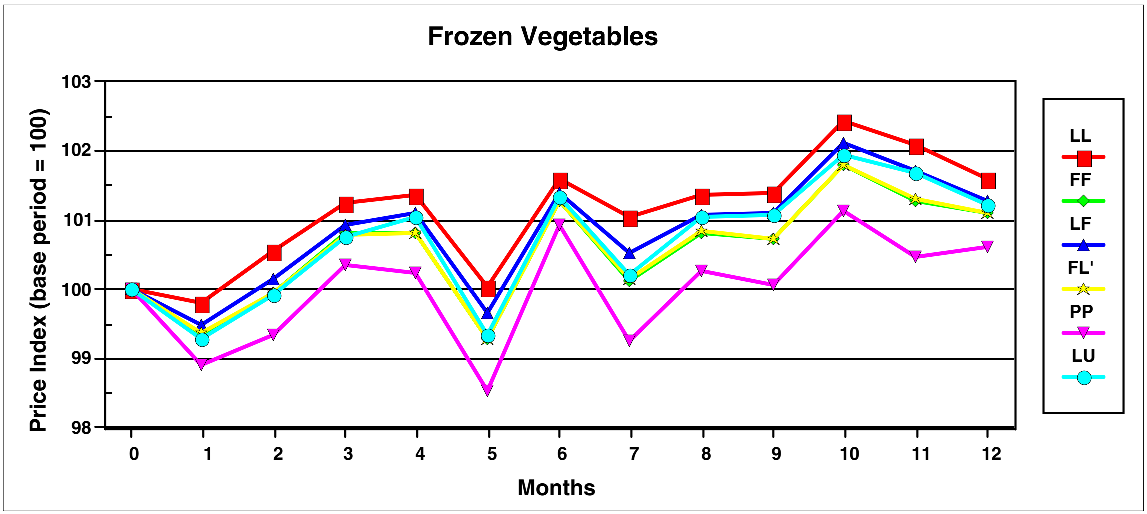
Butter
Price Index (base period = 100)
103
102
101
100
99
98
97
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

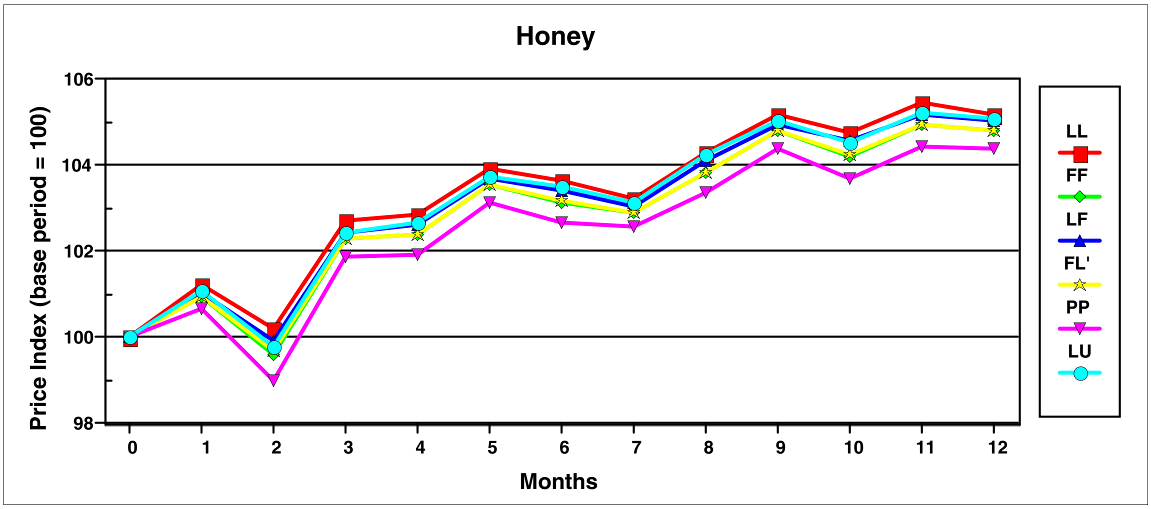


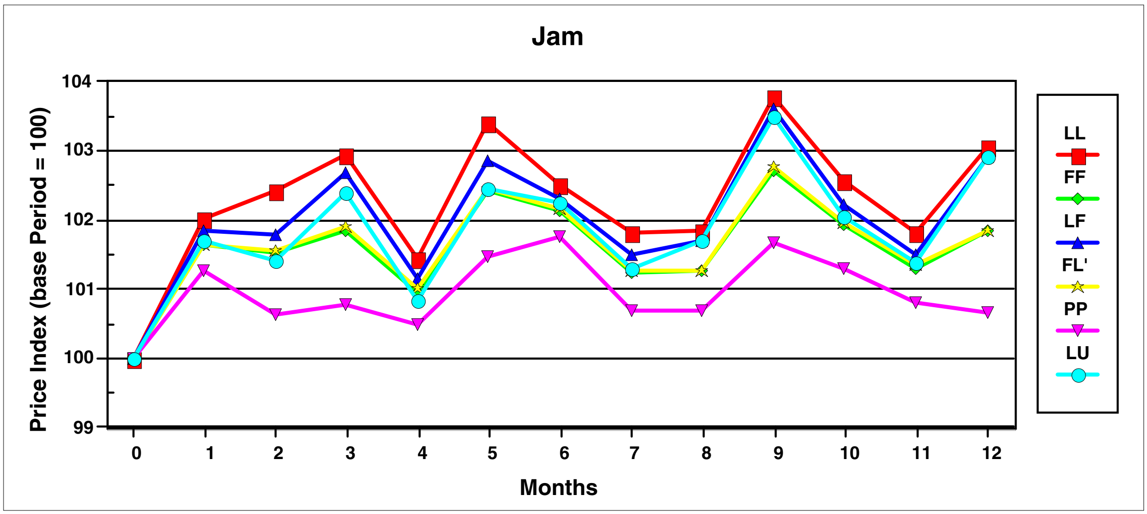
Cereal
Price Index (base period = 100)
105
104
103
102
101
100
99
98
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

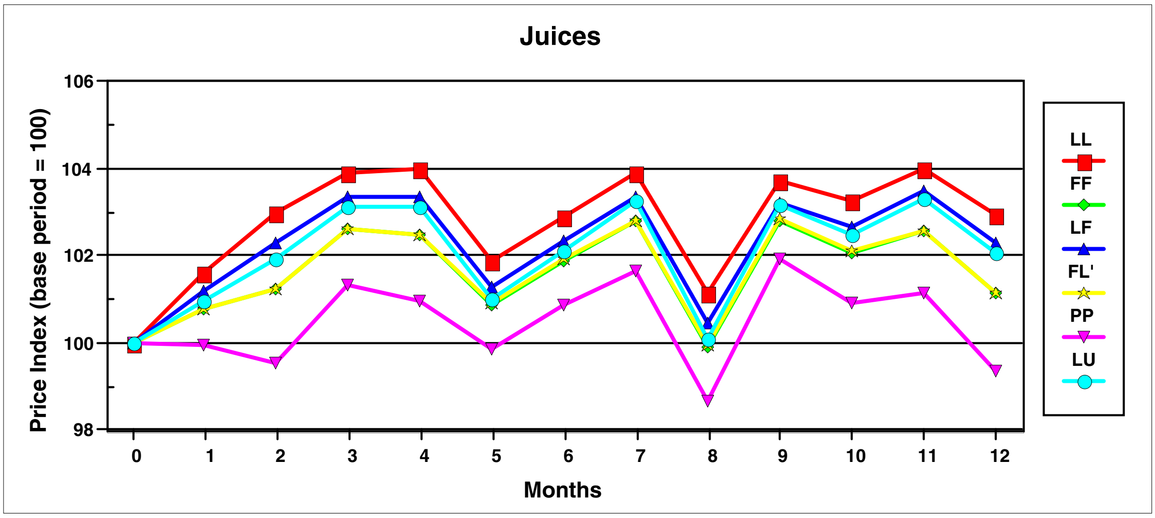

Coffee
Price Index (base period = 100)
120
115
110
105
100
95
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LF
FL'
PP
LU

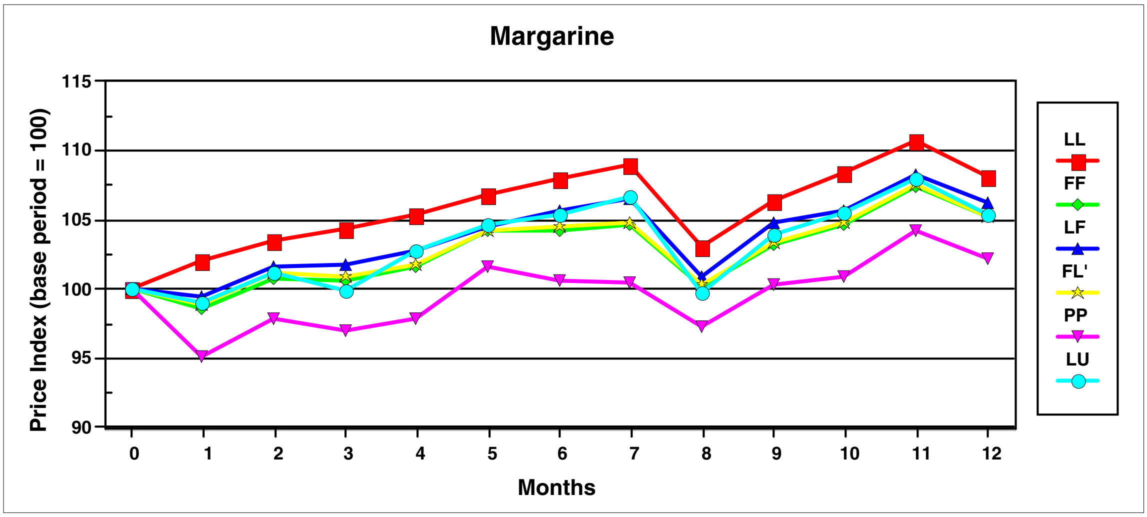

Detergent
Price Index (base period = 100)
108
106
104
102
100
98
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LF
FL'
PP
LU


Frozen Vegetables
Price Index (base period = 100)
103
102
101
100
99
98
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LF
FL'
PP
LU

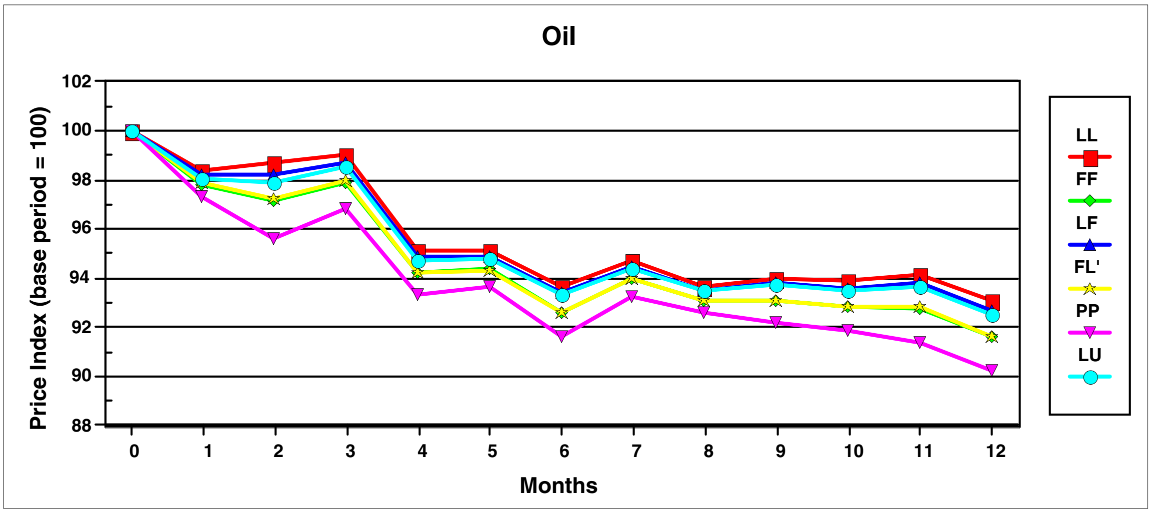

Honey
Price Index (base period = 100)
106
104
102
100
98
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU


Jam
Price Index (base Period = 100)
104
103
102
101
100
99
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

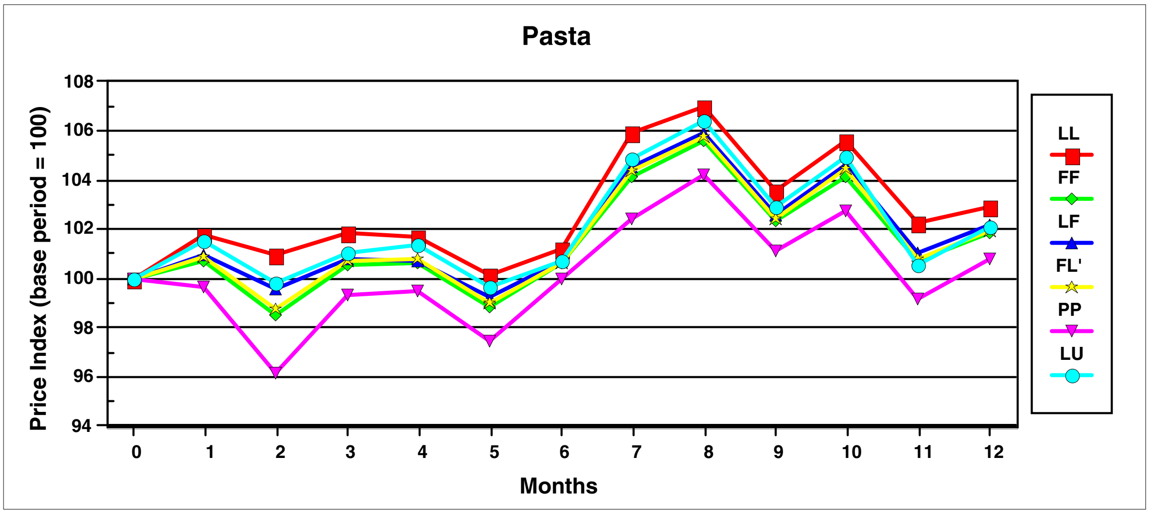

Juices
Price Index (base period = 100)
106
104
102
100
98
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU



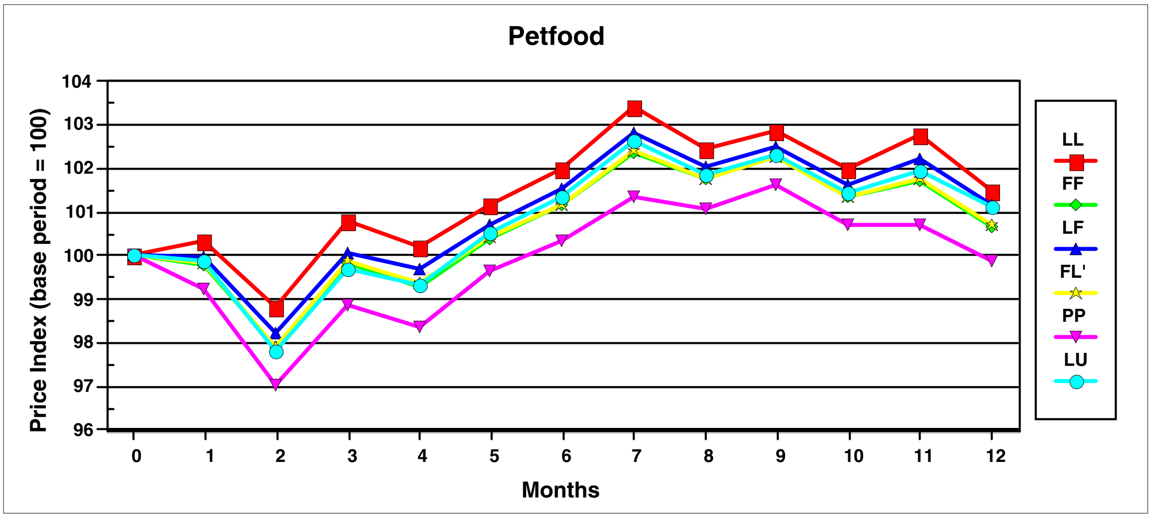
Margarine
Price Index (base period = 100)
115
110
105
100
95
90
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

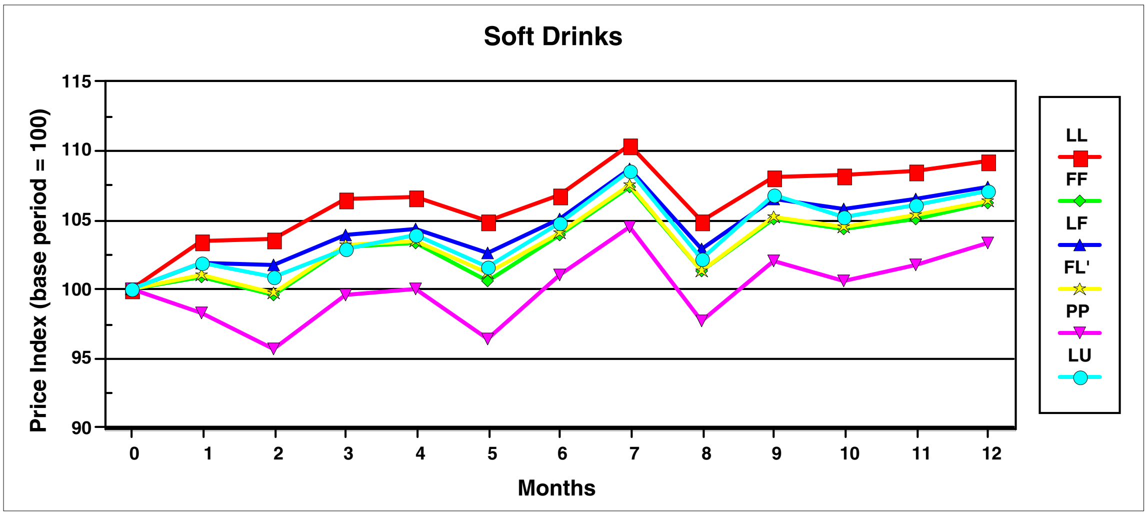


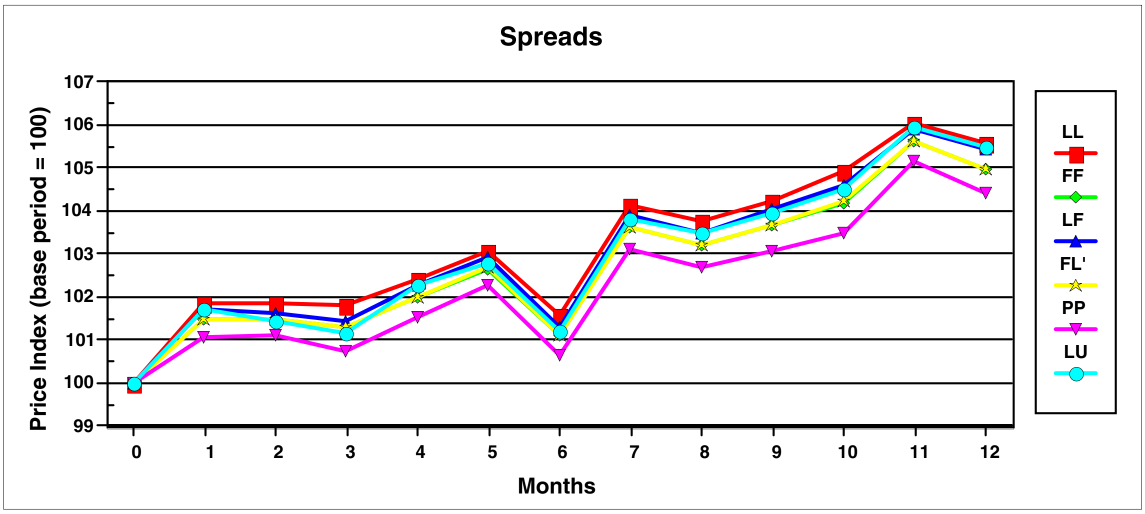
Oil
Price Index (base period = 100)
102
100
98
96
94
92
90
88
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

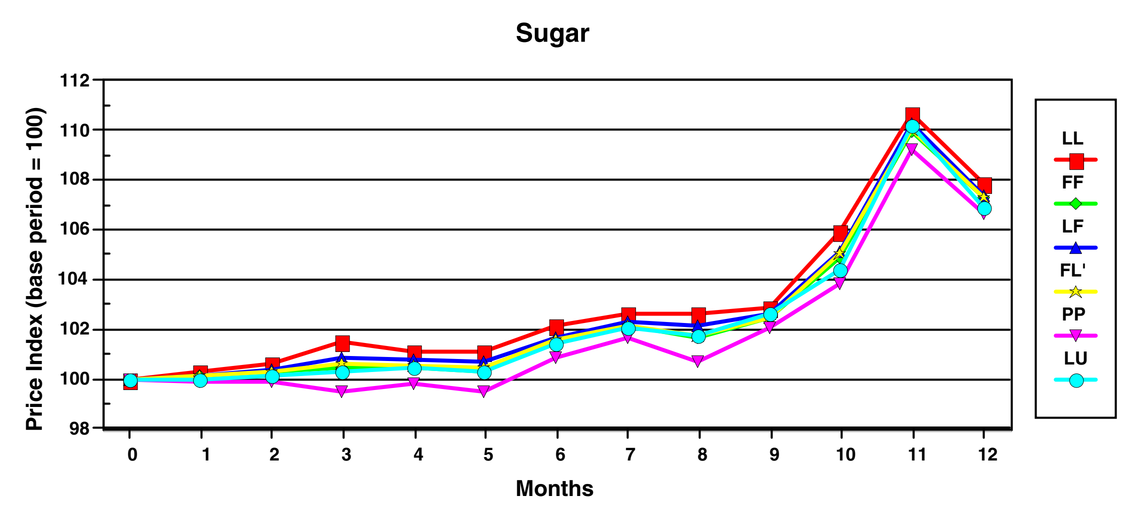


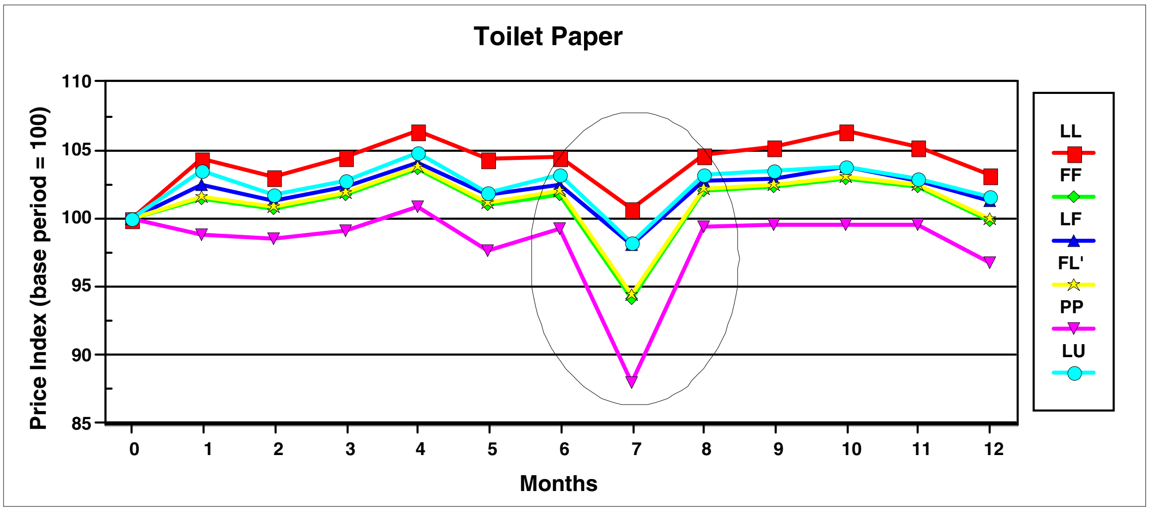
Pasta
Price Index (base period = 100)
108
106
104
102
100
98
96
94
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

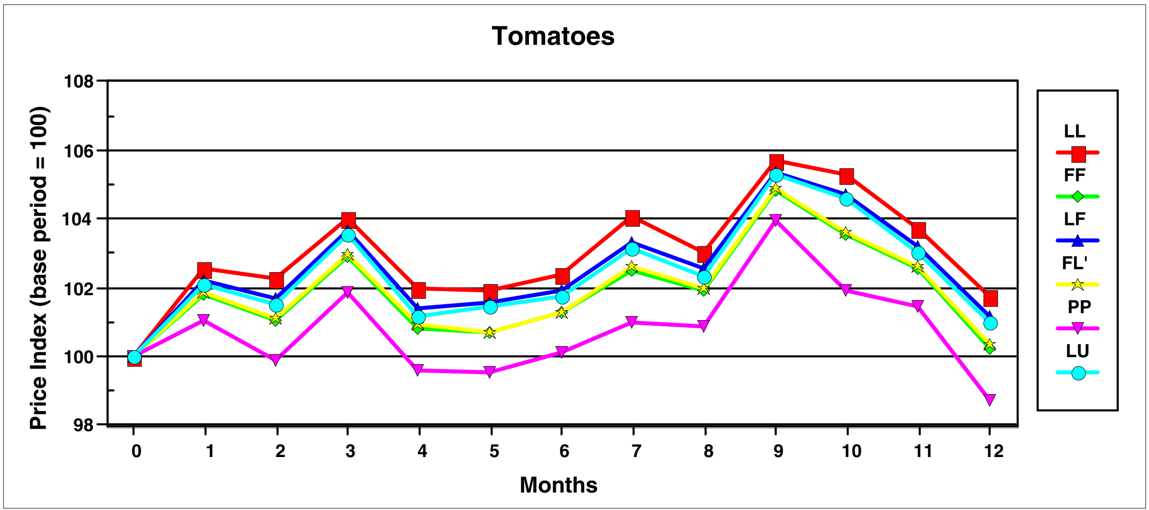

Petfood
Price Index (base period = 100)
104
103
102
101
100
99
98
97
96
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LF
FL'
PP
LU


Soft Drinks
Price Index (base period = 100)
115
110
105
100
95
90
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LF
FL'
PP
LU


Spreads
Price Index (base period = 100)
107
106
105
104
103
102
101
100
99
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LF
FL'
PP
LU


Sugar
Price Index (base period = 100)
112
110
108
106
104
102
100
98
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU


Toilet Paper
Price Index (base period = 100)
110
105
100
95
90
85
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

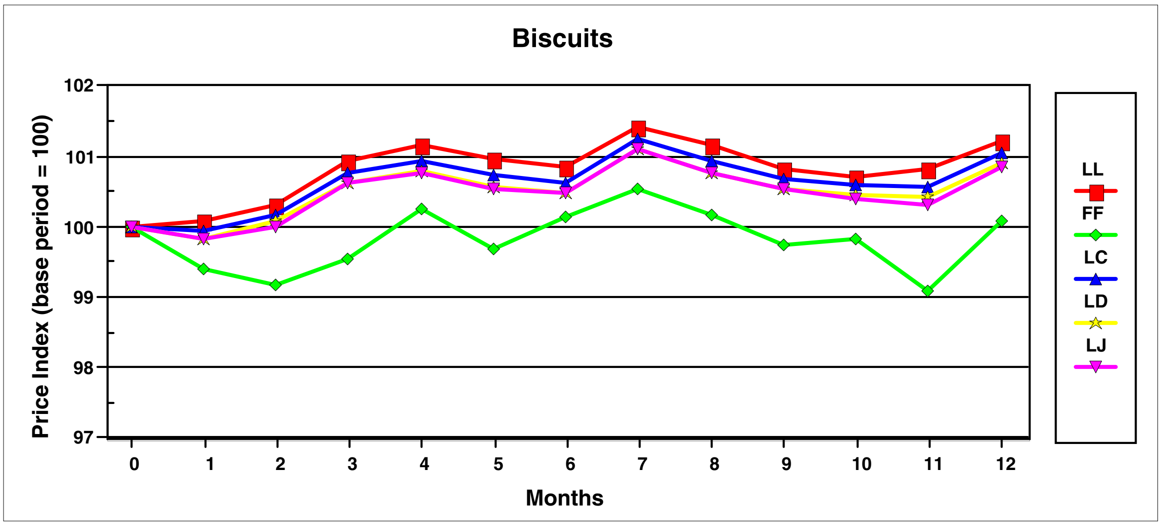

Tomatoes
Price Index (base period = 100)
108
106
104
102
100
98
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LF
FL'
PP
LU

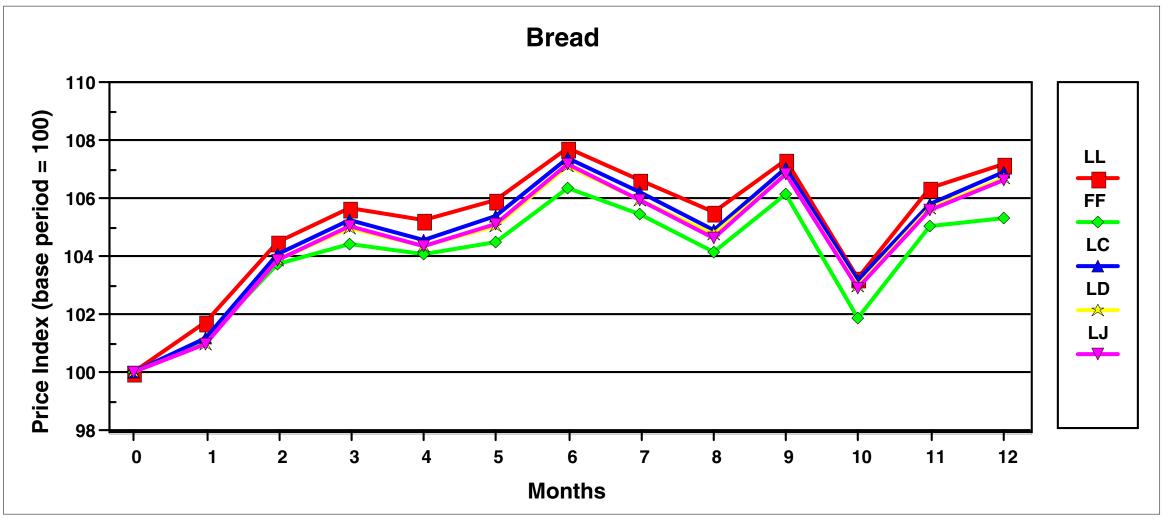
Attachment 3

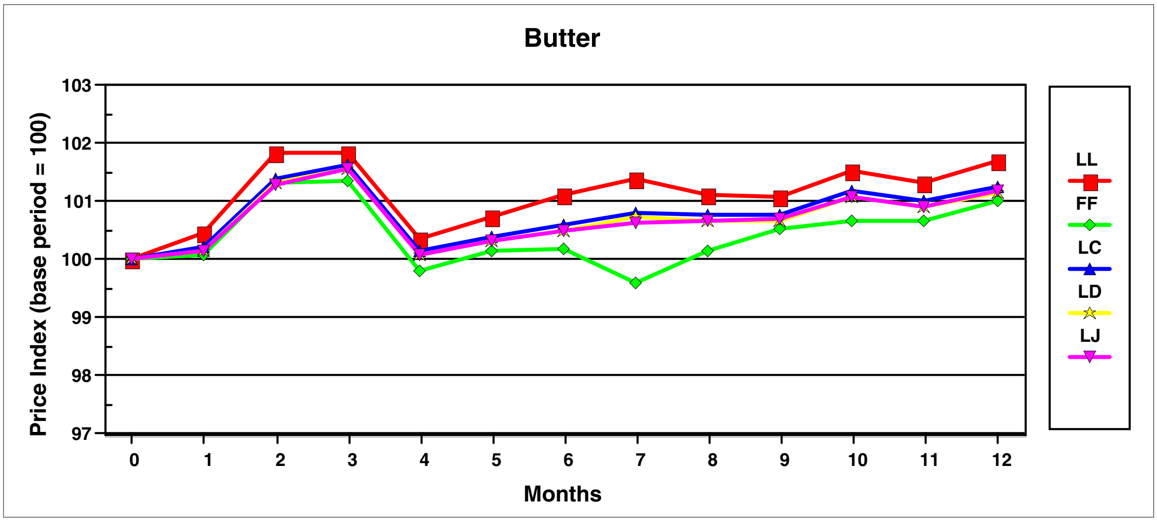
Price Indexes, By Commodity
Unweighted Elementary Indexes

The microindexes, i.e. indexes which are computed from aggregating price quotations at the very lowest level of aggregation (outlet level), turned out to be very close to each other. These are the Carli (LC), Dutot (LD) and Jevons (LJ). As seen from the graphs below, these three are very similar. But certain relationships hold true -- the Carli index is always above the Jevons and Dutot, but the Jevons and Dutot are very similar. All three generally lie much closer to the corresponding Laspeyres index, however, for pasta, toilet paper and tomatoes, they are much closer to the corresponding Fisher index.

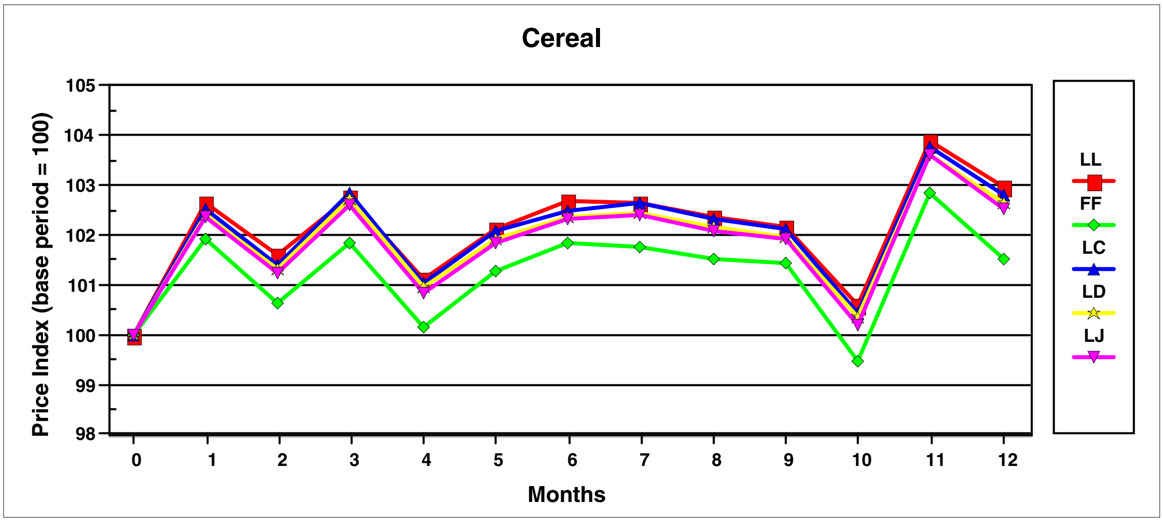
The following charts show the unweighted monthly indexes LC, LD and LJ along with LL and FF. Month 0 corresponds to the base period; months 1 - 12 correspond to the current periods.



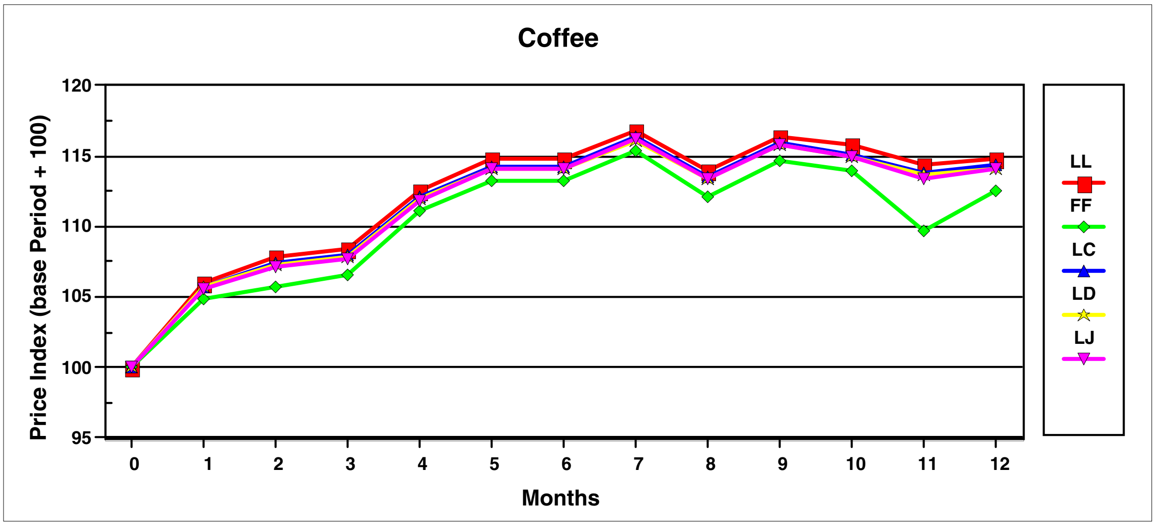




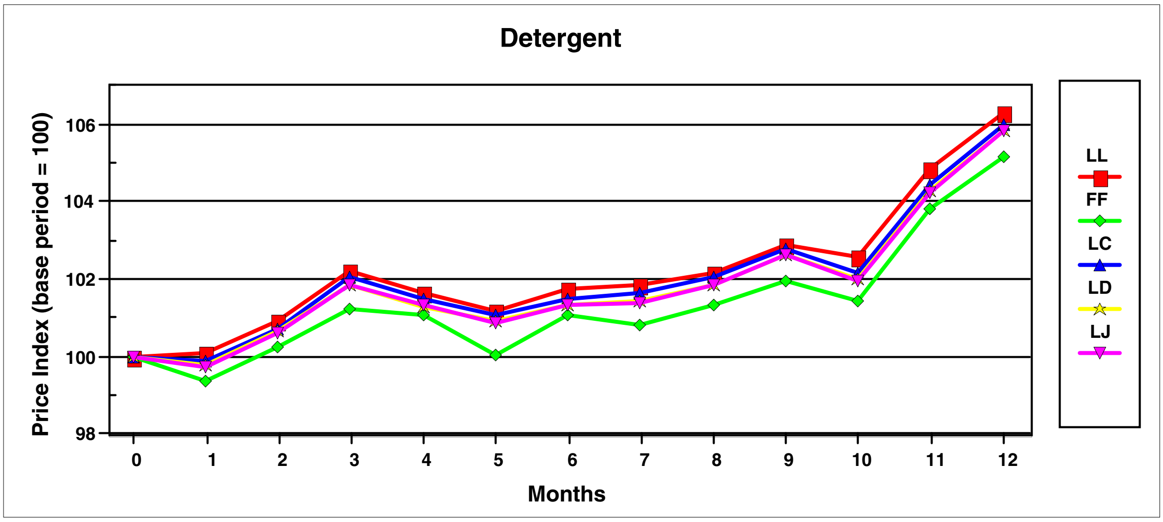
Butter
Price Index (base period = 100)
103
102
101
100
99
98
97
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LC
LD
LJ

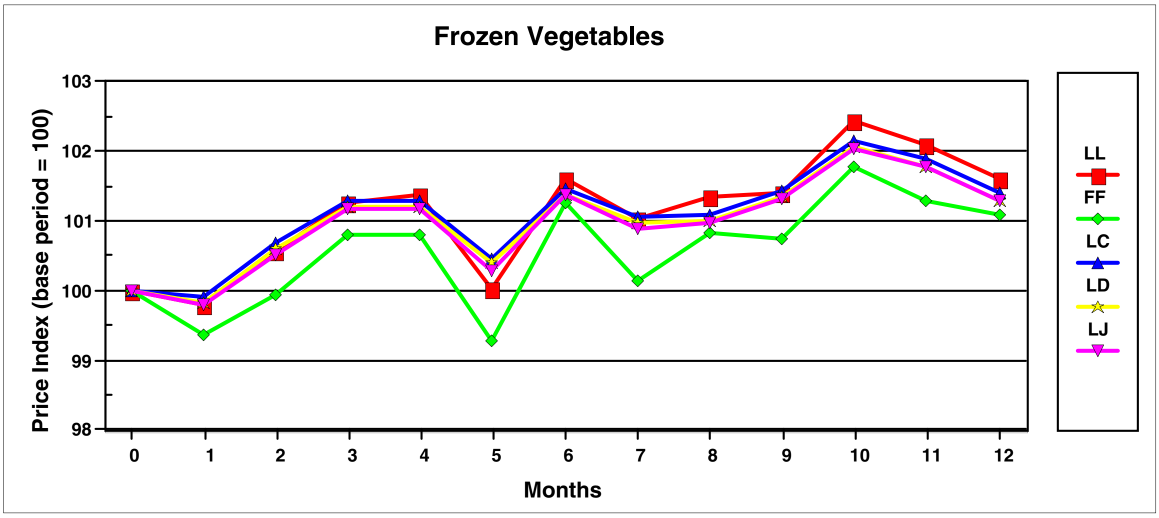


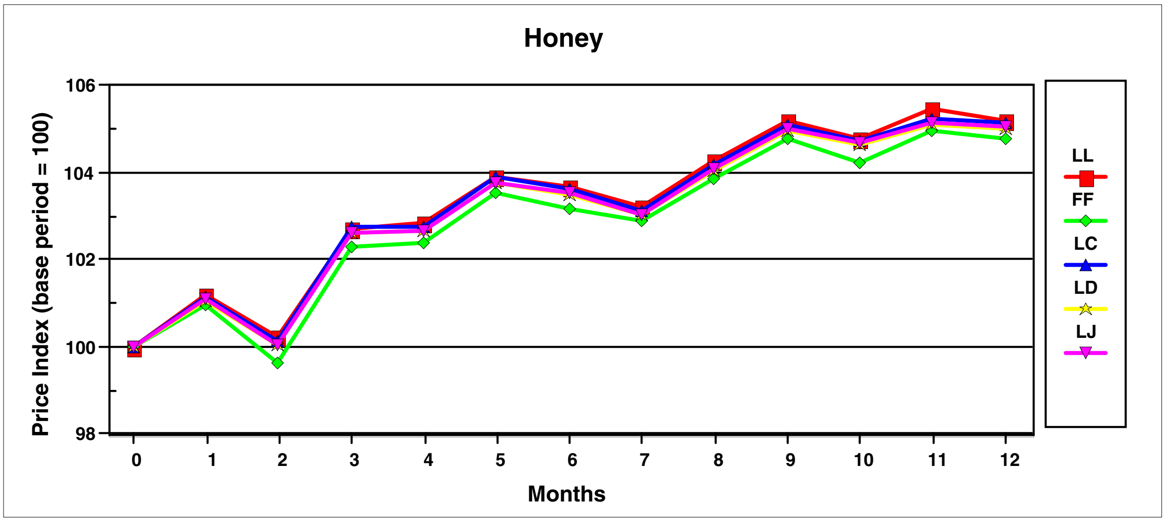
Cereal
Price Index (base period = 100)
105
104
103
102
101
100
99
98
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LC
LD
LJ

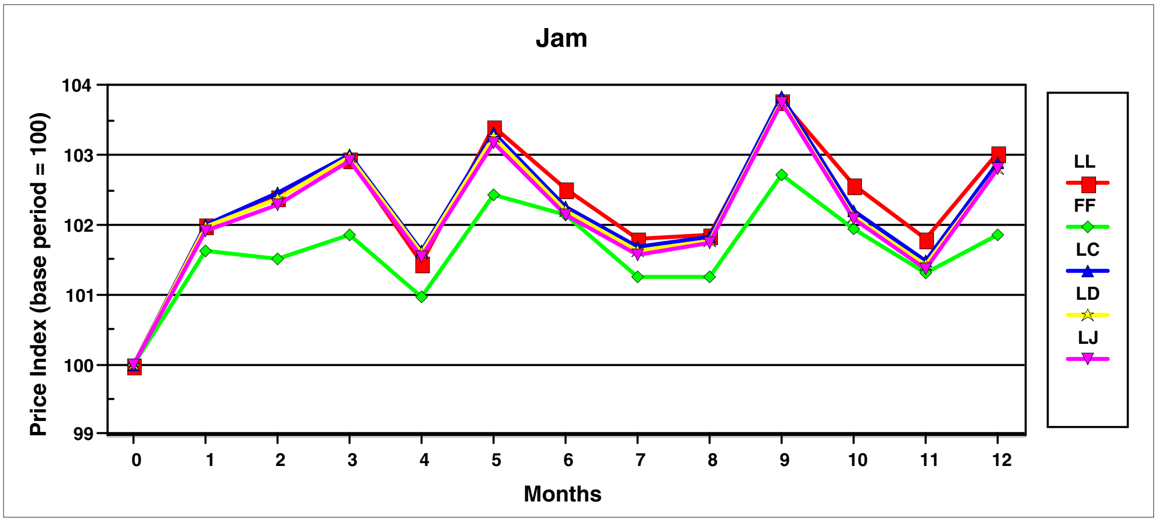


Coffee
Price Index (base Period + 100)
120
115
110
105
100
95
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LC
LD
LJ

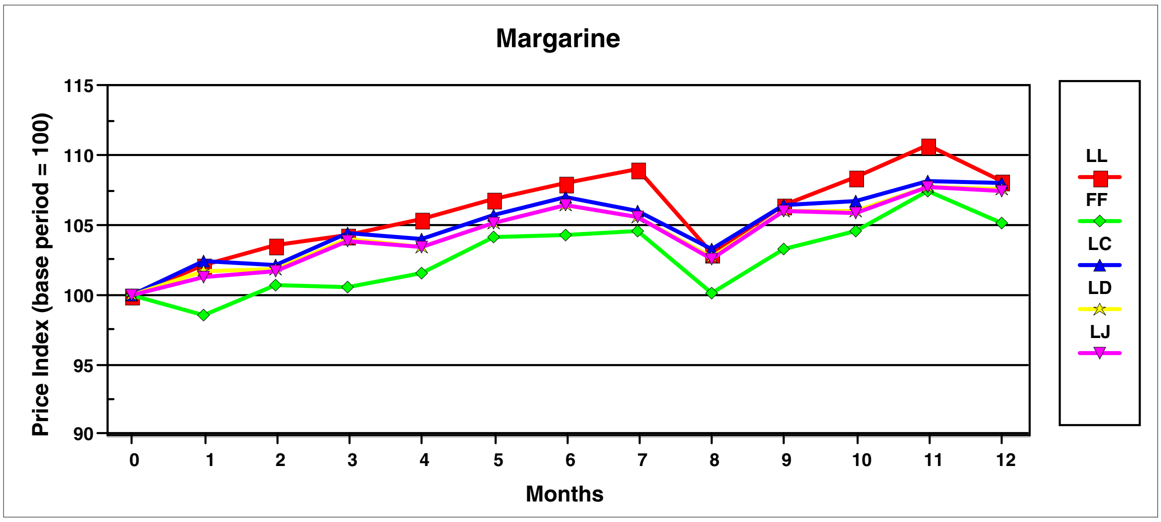

Detergent
Price Index (base period = 100)
98
100
102
104
106
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ

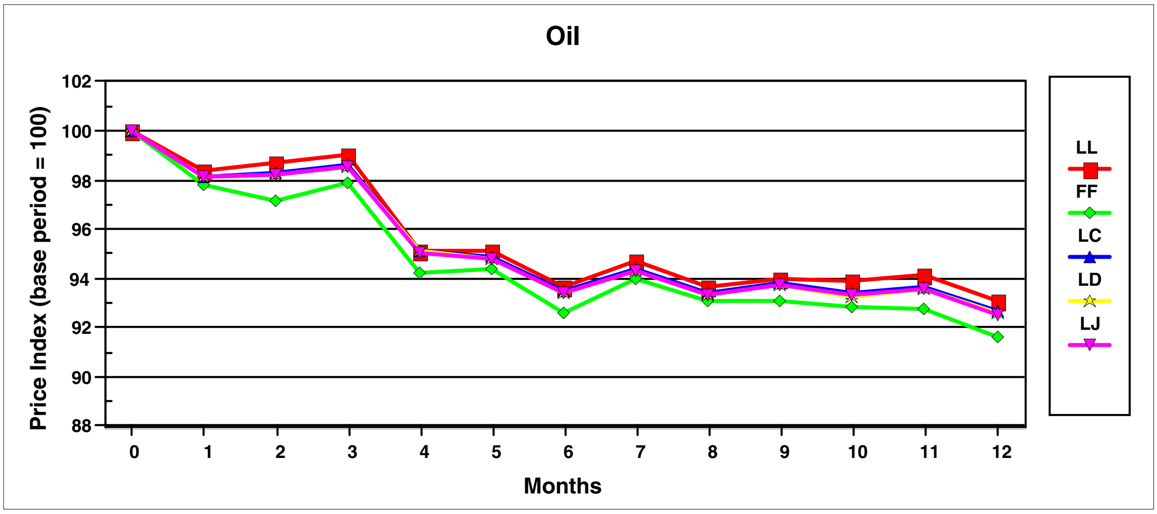

Frozen Vegetables
Price Index (base period = 100)
98
99
100
101
102
103
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ

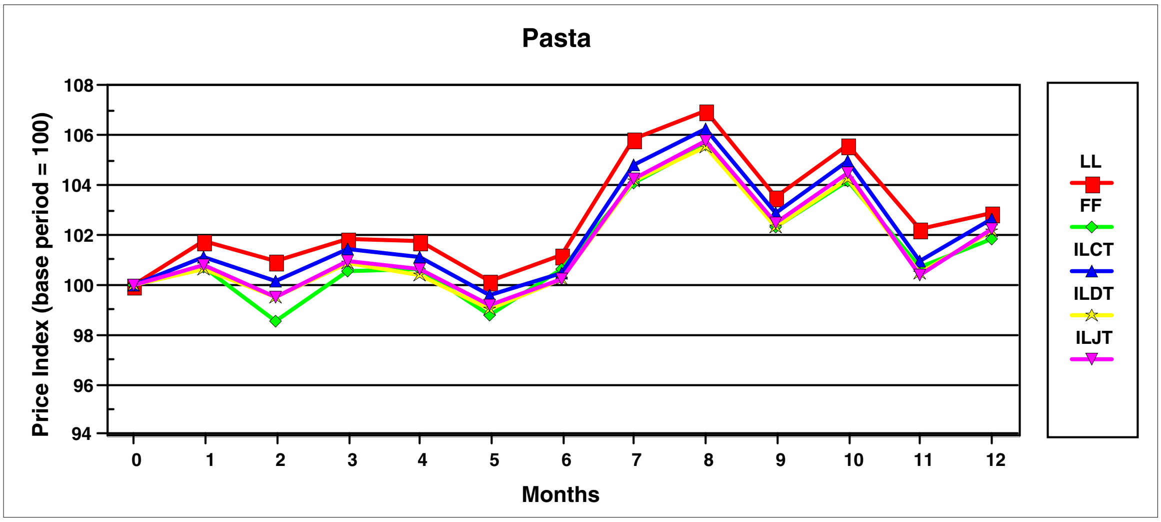

Honey
Price Index (base period = 100)
98
100
102
104
106
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ

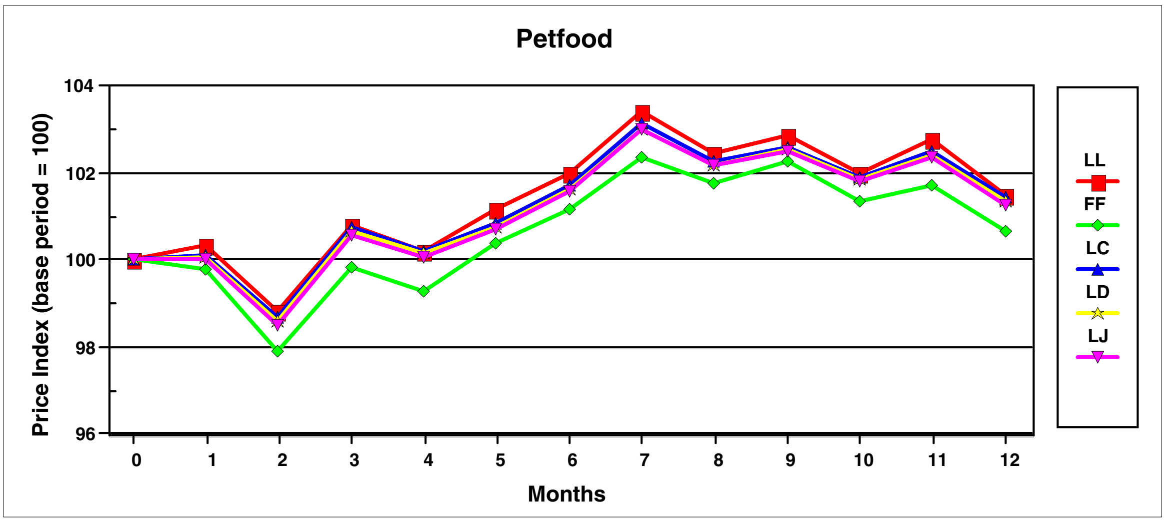

Jam
Price Index (base period = 100)
104
103
102
101
100
99
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ

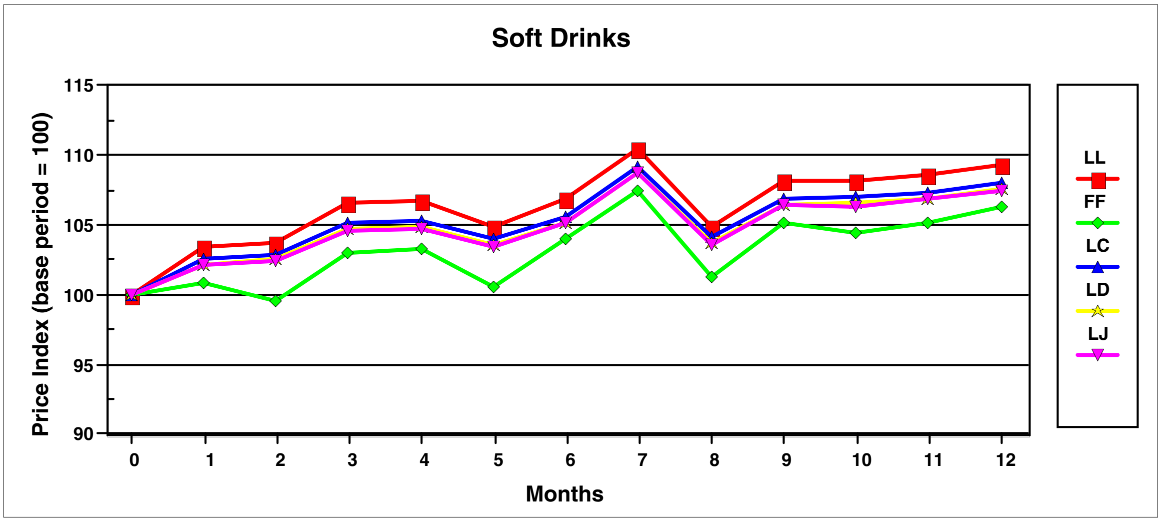

Juices
Price Index (base period = 100)
105
104
103
102
101
100
99
98
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ

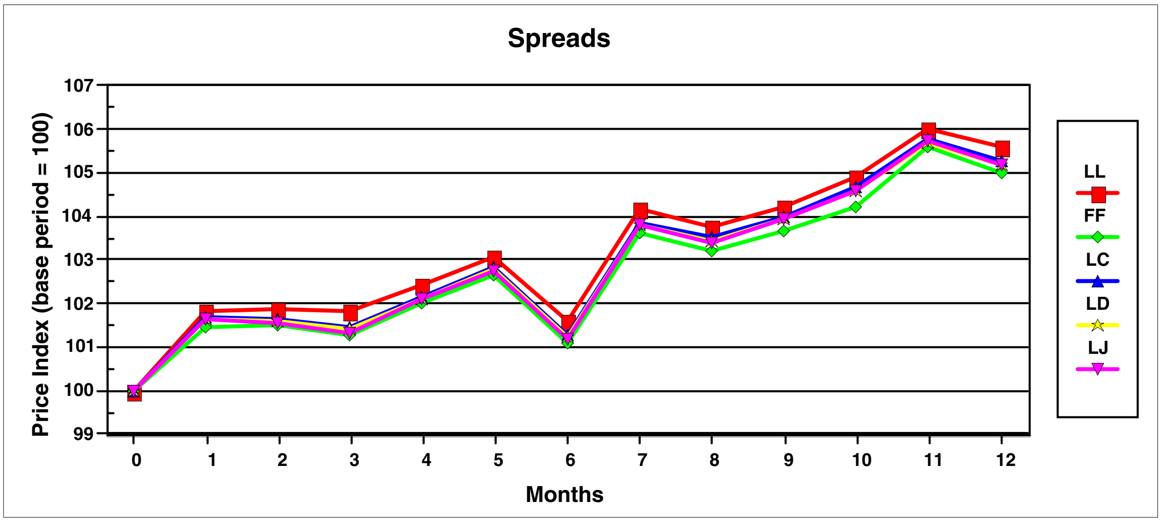

Margarine
Price Index (base period = 100)
115
110
105
100
95
90
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ

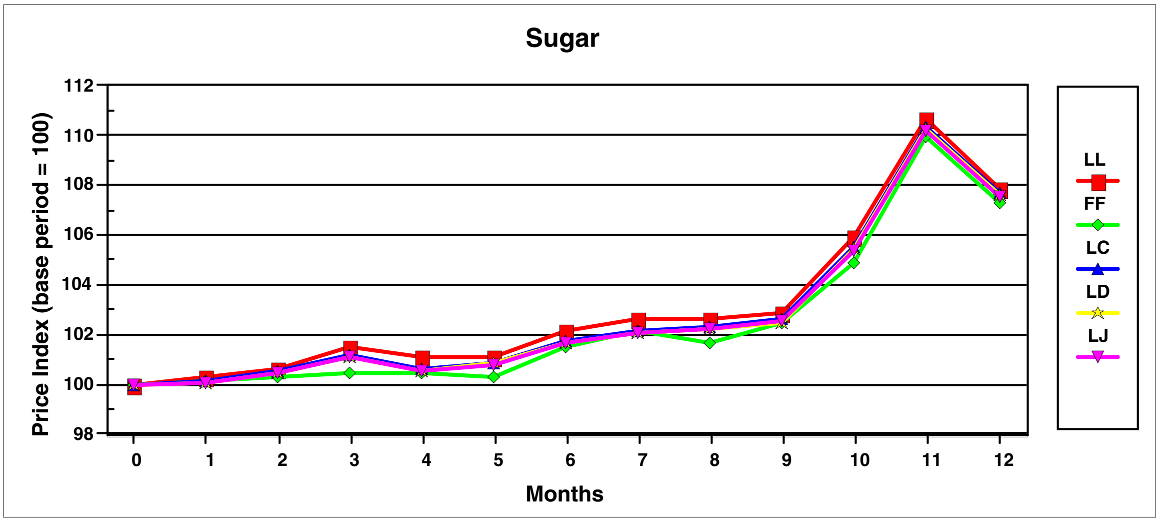

Oil
Price Index (base period = 100)
102
100
98
96
94
92
90
88
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LC
LD
LJ

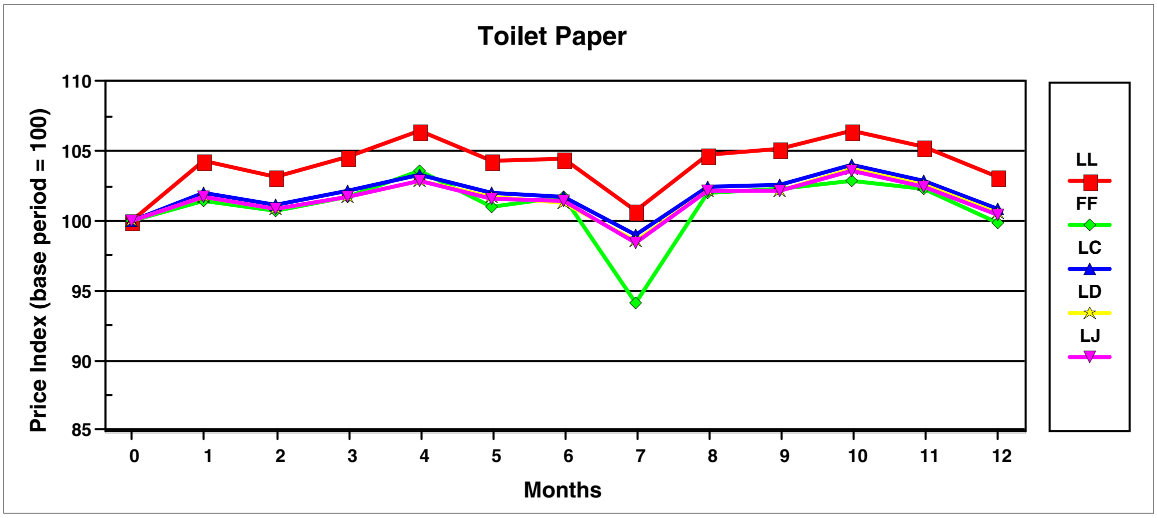

Pasta
Price Index (base period = 100)
108
106
104
102
100
98
96
94
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
ILCT
ILDT
ILJT

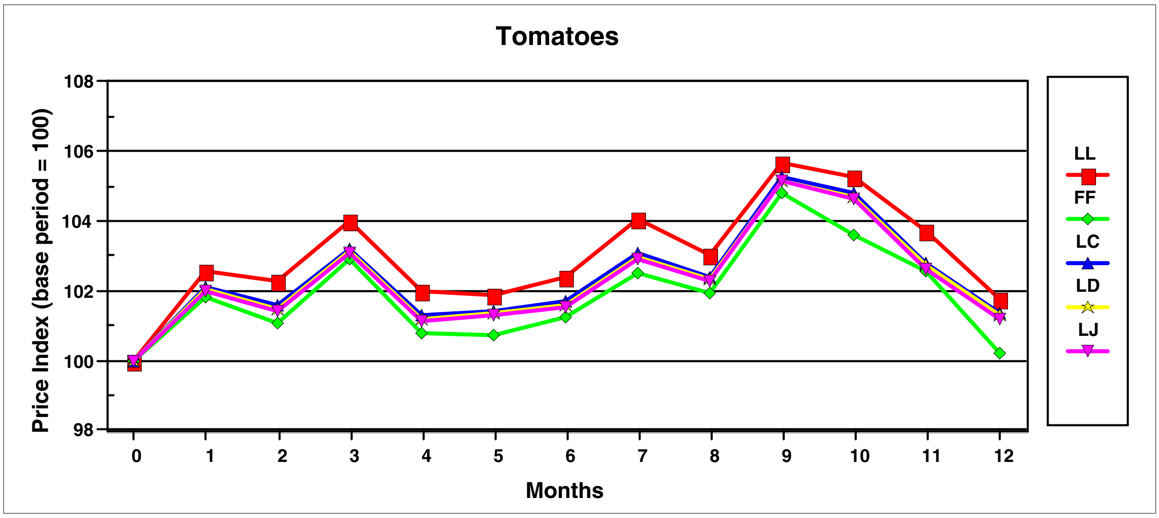

Petfood
Price Index (base period = 100)
104
102
100
98
96
0 1 2 3 4 5 6 7 8 9 10 11 12
Months
LL
FF
LC
LD
LJ


Soft Drinks
115
110
105
100
95
90
Price Index (base period = 100)
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ


Spreads
107
106
105
104
103
102
101
100
99
Price Index (base period = 100)
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ


Sugar
112
110
108
106
104
102
100
98
Price Index (base period = 100)
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ


Toilet Paper
Price Index (base period = 100)
110
105
100
95
90
85
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ


Tomatoes
Price Index (base period = 100)
108
106
104
102
100
98
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
LL
FF
LC
LD
LJ