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# ON THE TREATMENT OF SEASONAL COMMODITIES IN CPI: THE ISRAELI EXPERIENCE

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## Abstract

The treatment of seasonal products in a Producer or Consumer Price Index is presented in Chapter 22 of the new international manuals on PPI/CPI. In this paper we attempt to execute many of the solutions proposed in measurement of seasonal products by inserting "real" market data from the Israeli CPI. The paper has three objectives: (1) to summarize Chapter 22 on the treatment of seasonal products; (2) to describe some of the methods used in the Israeli CPI to overcome seasonal fluctuations (and bias) in a month to month index, (3) compare results using real CPI data with those from the artificial data set in the manuals.

## I. Introduction

1. The treatment of seasonal products in a Producer or Consumer Price Index is presented in Chapter 22 of the new international manuals on PPI/CPI (*the most updated version may be found at* http://www.imf.org/external/np/sta/tegppi/ch22.pdf[1]). Items are defined as being (a) *strongly seasonal* when they are not available in the marketplace during certain seasons of the year or (b) *weakly seasonal* when they are available throughout the year but feature regular fluctuations in prices or quantities that are synchronized with the season or the time of the year. Strongly seasonal items are most challenging for index compilers since having different bundles of items in the CPI basket in the months (or quarters) being compared leads to a break down of traditional bilateral index number theory. Several solutions are proposed to overcome these limitations, however these are of simulative nature based on artificial datasets designed in the "laboratory"[2] and as of yet to be based on real CPI data. In this paper we attempt to execute many of the solutions proposed in Chapter 22 by inserting "real" market data from the Israeli CPI. The structure will be as follows: in section II we present a quick summary of Chapter 22[3]; in section III we describe the main treatment of seasonal items in the Israeli index; in section IV we present findings from the Israeli CPI using several methods proposed in Chapter 22 and in section V we analyze the change in our findings, as a result of small modifications introduced to our dataset, in order to make it more consistent with the artificial one. Formulae for the many methods of treatment of seasonal products have been defined in the official manual, and we summarize them in Appendix 3.

## II. The treatment of seasonal products – summary of Chapter 22

2. Section A of Chapter 22 presents the problem of seasonal commodities. Strong seasonality and weak seasonality are defined; strongly seasonal items pose the greatest challenge for price statisticians as prices to be compared may exist in only one of the two months (quarters). Two main sources of seasonal fluctuations in prices and quantities are introduced: climate and custom. Climate is when fluctuation in temperature, precipitation and hours of daylight cause fluctuations in the demand or supply for many commodities; e.g., summer versus winter clothing, summer and winter fruit, demand for light and heat, vacations, etc. Custom is connected to special consumption habits for holidays; e.g., active retail buying before Christmas, turkeys on Thanksgiving, fireworks on Independence Days, etc. Two categories of approaches are presented in Chapter 22 to deal with strong seasonality: the traditional approaches to computing month to month indices (along with their limitations) and annual approaches which take advantage of the fact that while seasonal items may not appear in each month, they will usually appear in parallel months in consecutive years. Attempts are made to estimate monthly changes based on these annual indices.

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[1] Written by W. Erwin Diewert (University of British Columbia) and Paul Armknecht (IMF).
[2] Diewert modified Turvey's (1979) artificial data set to allow many of the complex computations in Chapter 22.
[3] The authors strongly recommend reading Chapter 22 of the new international manuals as a prerequisite.

3. In section B a modified version of Turvey's artificial data set for computing seasonal items is introduced. This set includes data for 5 seasonal commodities (apples, peaches, grapes strawberries and oranges) for 4 years (48 months). Modifications of this set were made as follows: the data for grapes were adjusted to emphasize the differential between annual Laspeyres and Paasche indices; the monthly inflation rate for the data in the fourth year was doubled compared to the average of the first three years.

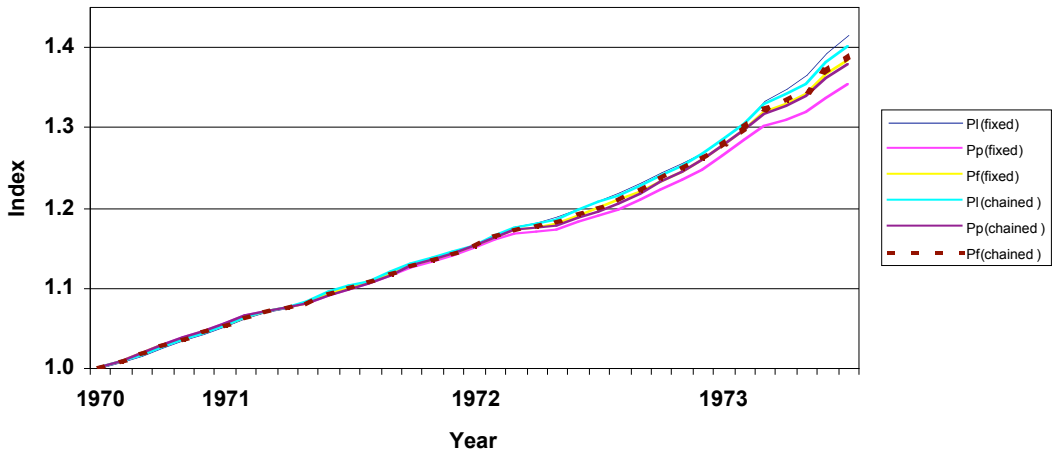
4. Section C presents the concept of year over year comparison vs. month to month. A way of dealing with strongly seasonal commodities is to change the focus from short-term month-to-month price indices to year over year price comparisons for each month. As even strongly seasonal commodities may reappear in the same months each year, overlap of commodities will be maximized in these year over year monthly indices. The remainder of section C is dedicated to comparisons of year over year monthly fixed base indices using Laspeyres, Paasche or Fisher formulae (or *approximate* fixed base indices as currents weights are usually not available at time of computation); and year over year monthly-chained indices (or their approximates). It was found that use of chained indices tends to reduce the spread between Paasche and Laspeyres indices compared to their fixed base counterparts. Since both Paasche and Laspeyres indices are equally plausible and since an approximate Fisher is just as easy to compute as an approximate Paasche or Laspeyres, it is recommended that statistical agencies make the Fisher indices available to the public[4].

5. Section D moves on from a year-to-year monthly index to a year over year annual index. When using such a method, the true annual fixed base Fisher can be very closely approximated by the corresponding approximate Fisher index (or a Geometric Laspeyres index) which can be computed using the same information set that is normally available to statistical agencies. In addition, *chained* annual indices substantially reduce the substitution (or representativity) bias of Laspeyres and Paasche indices. However, again if using the approximate method instead of the "current" method, we can construct the approximate Fisher which is preferable to the Laspeyres or Paasche indices.

6. In section E the notion of rolling year indices is exhibited. In the previous section, the indices were limited to a calendar year. Rolling year indices are computed for Laspeyres, Paasche and Fisher; Approximate Laspeyres, Paasche and Fisher – once for a fixed base period and once for a chain index (all in all 12 types of indices were computed. The fixed base indices can be viewed as a seasonally adjusted annual CPI that offer statistical agencies an objective and reproducible method of seasonal adjustment that can compete with existing time series methods

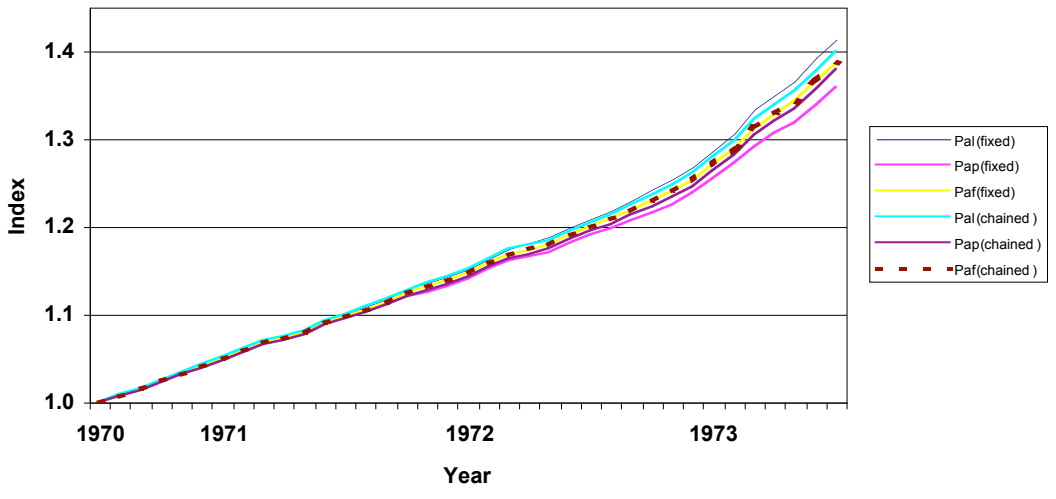
[4] Since both the year over year monthly Laspeyres and Paasche indices fail the time reversal test (Laspeyres with an upward bias and Paasche with a downward bias).

**Figure 1: Rolling Year Fixed Base and Chained Laspeyres, Paasche, and Fisher Indices**




of seasonal adjustment. The use of rolling chain indices substantially reduces the substitution (or representativity) bias of Laspeyres and Paasche indices. The chained rolling Fisher is considered as the target seasonality adjusted annual index. This type of index is also suitable for central banks to use for inflation targeting purposes. In general, the year over year monthly indices and their transformation into rolling indices performed very well on the Turvey data set; like is compared to like and the existence of seasonal commodities does not lead to erratic fluctuations in the index. The drawback of these indices is, however, their lacking of presenting short-term month-to-month fluctuations in prices. This is most evident if seasonal baskets are totally different for each month. The following section F in Chapter 22 will show how a year over year monthly index may be used to predict a rolling year index that is centered at the current month.

**Figure 2: Rolling Year Approximate Laspeyres, Paasche, and Fisher Price Indices**

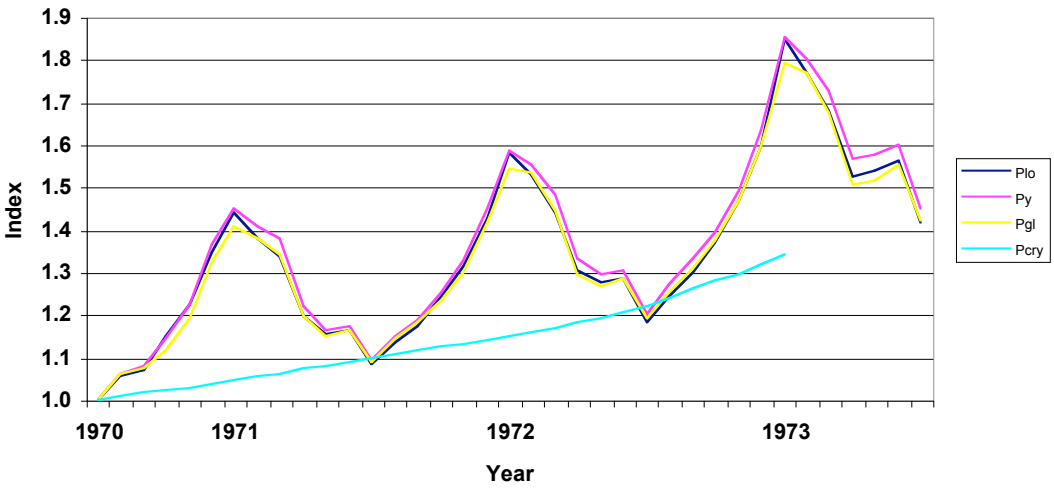


7. In section F it is shown that under a regime where the long run trend in prices is smooth, the current month year over year monthly index along with last month's year over year monthly index, can successfully predict or forecast a rolling year index that is centered around the current month. In other words, statistical agencies can use information on year over year monthly inflation to predict reasonably well the (seasonally adjusted) rolling year inflation rate for a rolling year that is centered on the last two months. While more sophisticated methods are usually executed by the agencies (like Arima X-12 and Henderson) they lack the reproducibility exhibited in the rolling year concept.

8. Section G is the first of four that examine the treatment of seasonality in the traditional month-to-month approach. This section looks at the "maximum overlap month to month price index method" in which we determine the set of commodities that are present in the marketplace in both months of comparison; for this maximum overlap set of commodities chained Laspeyres, Paasche and Fisher indices are computed. When all of the strongly seasonal items are included, the indices suffer from a serious downward bias for the artificial data set. The items are introduced at high prices but are only include in the index as their prices decrease. While some manipulation is performed on the artificial data (erratic strongly seasonal items are removed) the downward bias still exists. Thus if the purpose of the month to month CPI is to indicate changes in general inflation, statistical agencies should be cautious about including commodities that show strong seasonal fluctuations in prices in the month to month index.

9. In section H annual basket indices with carry forward of unavailable prices are compared using the Lowe, Young and Geometric Laspeyres formulae. These are compared to the fixed base Laspeyres centered rolling year index. As can be seen in figure 3 below, these indices have a considerable amount of seasonality in them and do not at all approximate their rolling year counterparts. Also noted is the regularity of the seasonal movements of the month-to-month indices.

**Figure 3: Lowe, Young, Geometric Laspeyres, and Centered Rolling Year Indices with Carry Forward Prices**

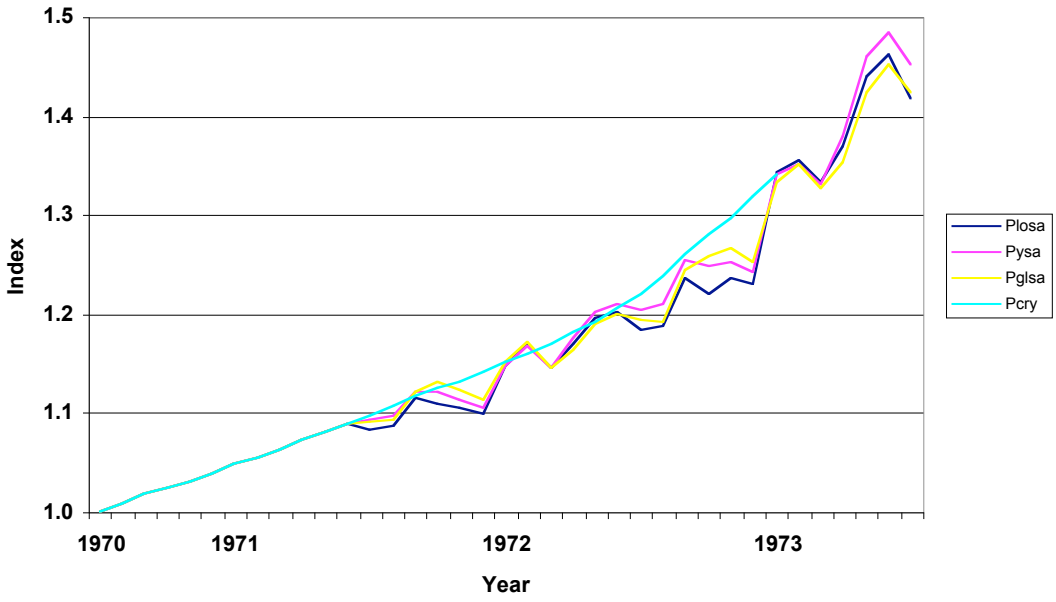


10. Section I replicates the previous one, however imputed prices are computed rather than using the "carry forward" method. This method led to indices that were higher than their carry forward counterparts and with lower variability. However the Lowe, Young and Geometric Laspeyres indices still suffered from a huge amount of seasonality and do not closely approximate their rolling year counterparts.

11. In section J the final month-to-month index is considered: the Bean and Stine Type C or Rothwell type index. In these indices prices and quantities may change in a month-to-month comparison; therefore the month-to-month movements are a mixture of price and quantity changes. These indices exhibited smaller seasonal movements than the Lowe index and were less volatile in general. However, they still suffer from a substantial amount of seasonality and may not be suitable for general inflation measurement without some sort of seasonal adjustment.

12. Section K presents an attempt to forecast rolling year indices using month-to-month annual basket indices. A seasonal adjustment factor is computed for the Lowe, Young and geometric Laspeyres indices based on the centered rolling year index. Figure 4 below shows that the predicted values of these "seasonally adjusted" indices are fairly close to the corresponding target index values.

**Figure 4: Seasonally Adjusted Lowe, Young, Geometric Laspeyres, and the Centered Rolling Indices**




It may also be stated that computing these indices with imputed prices (vs. carry forward) led to better results. In addition the Geometric Laspeyres came closer to the target indices than the Lowe indices.

13. Section L states some of the tentative conclusions of Chapter 22: (1) year over year monthly indices and rolling year indices should be computed by the statistical agencies, at least as an analytical series belong side the month to month series; (2) annual basket indices can be successfully used in the context of seasonal commodities, however users will still be interested in some form of the seasonally

adjusted version, whether by traditional approaches or those suggested in section K; (3) Laspeyres and Paasche indices are of equal importance, therefore a Fisher type index is preferable; (4) the spread between a Laspeyres and Paasche index may be reduced by using a chain index, however these should be checked against their year over year counterparts to avoid chain drift (5) A Geometric Laspeyres is an alternative to the approximate Fisher index that uses the same information; (6) when current period expenditures do not differ from base period ones, the "approximate" versions that use normal statistical agency available data sets can replace the "current" versions that may not be available; (7) the maximum overlap method for month to month indices may suffer from substantial bias.

## III. The main treatment of seasonal items in the Israeli index

14. Many seasonal commodities can be found in the CPI: several food items, alcoholic beverages, clothing and footwear items, water, heating oil, electricity, flowers and garden supplies, vehicle purchases and operations, entertainment and recreational expenditures, insurance, weddings, air travel and tourism expenditures, toys and games, etc. All of these amount to nearly one fifth of the expenditures represented in the CPI. In this section we will describe the methods used in the Israeli CPI month-to-month computation of clothing and footwear and fruits and vegetables; in addition seasonally adjusted indices and trend indices are computed for nearly all of the seasonal items as part of the mainstream CPI procedure.

15. ***Clothing and Footwear***: This main consumption group represents 2.9% of total expenditure in the Israeli CPI. The weights of the consumption group and specific items in this category are obtained according to the percentage of the average monthly expenditure on them in the base year, out of the average monthly expenditure on the total basket. The data source is the Household Expenditure Survey, conducted annually by the Central Bureau of Statistics. The price indices are computed according to the Lowe formula, e.g., the base period for the weights is price updated to the base period of the CPI.

16. The price indices for items which have disappeared due to seasonality are imputed by the average weighted percentage change in the price indices of all clothing (or footwear) items that are present in the market. When the seasonal items reappear, "true" price indices are computed for them in that month. These indices correct the estimates made during the months when the items ran-out in the market.

17. The price indices of clothing and footwear items are computed like the price indices of other items, by the method of chaining – comparing prices with the previous month and not base period prices. This method is liable to cause downward bias in the index of clothing and footwear as will be shown.

18. Clothing and footwear are usually fashion items. The frequent changes in fashion cause many changes in the goods, whether they are seasonal or not. These changes often occur after the end of seasonal sales, which take place twice yearly: at the end of the summer season (usually in August-September) and at the end of the winter season (usually in February-March). The items are then sold at large discounted prices. This is especially true for fashion items, which may not be

remarketed in the new season and will probably be replaced by other items. The "normal" computation of the index will lead to a downward bias. Why?

19. The price indices for these items are decreasing, due to the end of season sales, as they are leaving the market. If a replacement item in the following season were to inherit the index level of these items, we will find ourselves with near to zero indices after a few seasons. In order to overcome this problem[5] in the index, it is necessary to see that once every few months these biased price indices should be corrected. How is this conducted? The price indices of these items are corrected in June and December; these months are chosen since they are mid-season months with the highest percentage of representative items in the market. Usually there will not be disappearing of goods due to fashion change. The correction process is done by a three-stage computation method.

20. In the first stage, the price indices of seasonal goods are computed with a year over year comparison (December over December or June over June) and the prices of the other items (that can be found throughout the year like underwear) are computed with a 6-month comparison (December vs. June in December and June vs. December in June).

21. In the second stage, since there are many goods, which may have been replaced during the 12-month or even 6-month period, these goods will not be able to participate directly in the correction process (since comparisons are not like with like). They, in turn, will be corrected by the percentage change of all items that directly participated in the process i.e., their indices will be increased by the average percentage change of the other items that were able to be compared over an annual or 6 month period.

22. In stage three an item index may now be computed by the normal method: averaging indices of all goods that represent the clothing or footwear item. This method was introduced in the CPI in 1989 and on average has "saved" an annual downward bias in the Clothing and Footwear index of 3%. It should be stated that in the first half of the nineties, we experienced inflation rates of 12-14% and in the second half of the nineties the inflation rate was lowered to about 7% annually. During the last four years inflation has decreased to about 2% on average.

23. ***Fruits and Vegetables***: This main consumption group represents 3.5% of total expenditure in the Israeli CPI. The weights of the consumption group and specific items in this category are obtained according to the percentage of the average monthly expenditure on them in the base year, out of the average monthly expenditure on the total basket. The data source is the Household Expenditure Survey, conducted annually by the Central Bureau of Statistics.

24. The price indices were computed according to the Rothwell formula until 1987. As of January 1988 these indices are computed according to the annual basket month-to-month Lowe formula. Missing prices were inserted using the imputed prices method (vs. the carry forward or maximum overlap methods). The main

[5] Hedonic methods may be used to solve this problem – see working paper #6 submitted by the US-BLS for the 2003 ECE/ILO meeting on CPI.

argument for this transition was that in recent years most fruit and vegetable items were consumed during all months of the year. Research, conducted by our Bureau over the past decade, has not been conclusive whether this transition led to an "improved" index. This motivated our simulation of year over year methods, described in the section II summary of Chapter 22 above, with findings to be presented in section IV below.

25. ***Seasonal adjustment methods in the Israeli CPI***: The prices of goods whose consumption is affected by seasonality are usually prone to large seasonal fluctuations. So the month-to-month price index includes not only trends, but also seasonal price changes. Various tests for seasonal adjustment methods were conducted in the CPI in the mid-eighties and early nineties. Seasonal adjustment was conducted, at first, by Arima X-11 and at present updated to Arima X-12. The estimation of the trend is conducted by Symmetric Henderson Moving Averages. The Bureau of Statistics publishes every month seasonally adjusted indices for the 9 following series: Total CPI, CPI excluding housing, CPI excluding housing and fruits and vegetables, fresh fruit, fresh vegetables, clothing, footwear, recreation and vacation and travel abroad. In addition trend indices are published monthly for the three series: Total CPI, CPI excluding housing, CPI excluding housing and fruits and vegetables.

## IV. Simulating methods from Chapter 22 in the Israeli CPI

26. CBS Israel conducts a monthly CPI and an annual Household Expenditure Survey (the HES is annual from 1997). The HES consists of 6,200 households (over 500 a month) investigated over the calendar year. Therefore we have two excellent sources for extracting price and quantity data (expenditure weights) to simulate the various annual and monthly methods described in Chapter 22 of the international manuals. We built two data sets using actual CPI and HES data for the five-year period of 1997-2002 (72 monthly observations): (1) **fresh fruits**[6] – lemons, apricots, avocado, watermelon, persimmon, grapefruits and bananas; (2) **fresh vegetables**[7] – cabbage, cauliflower, cucumbers, potatoes, carrots, lettuce and eggplants. The fresh fruits have *strong seasonality* (many months with zero prices) and the fresh vegetables have *weak(er) seasonality* (the items are present throughout the year but with large price fluctuations). We computed all the methods in Chapter 22 for both the fresh fruits and fresh vegetables, however, in order not to exhaust the reader with 54 tables and 16 figures that may be compared with the ones presented in Chapter 22– we will present here only part of the findings that are connected to the tentative conclusions in section II paragraph 13 above. In addition, we will examine the results of fresh fruits only (due to the weaker seasonality of fresh vegetables, the methods were always more successful for this group).

27. Can the "approximate" methods, which use data normally at the disposal of statistical methods at the time of computation, replace the "current" methods? In **Table 1** below we compare the year over year "current month" fixed base Fisher index ($P_F$) with the approximate monthly fixed base Fisher index ($P_{AF}$).

[6] See appendix 1 for price and expenditure weight data.
[7] See appendix 2 for price and expenditure weight data.

**Table 1: Ratio Between Year over Year "Current Month" Fixed Base Fisher and Approximate Fixed Base Fisher Indices ($P_{AF}/P_F$)**

| Month/Year | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|
| **1** | 1.00 | 1.01 | 0.99 | 0.99 | 1.02 | 0.98 |
| **2** | 1.00 | 1.00 | 1.01 | 1.00 | 1.00 | 1.00 |
| **3** | 1.00 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 |
| **4** | 1.00 | 1.00 | 0.98 | 1.01 | 1.00 | 1.02 |
| **5** | 1.00 | 0.99 | 1.04 | **1.05** | **1.27** | 0.97 |
| **6** | 1.00 | 1.01 | 1.00 | 1.01 | 1.01 | 1.03 |
| **7** | 1.00 | 1.01 | **1.16** | 1.01 | **1.06** | 1.02 |
| **8** | 1.00 | 0.99 | 1.02 | 1.00 | 1.04 | **1.05** |
| **9** | 1.00 | **1.77** | **1.83** | 1.04 | **1.82** | **1.58** |
| **10** | 1.00 | 1.01 | 1.00 | 1.01 | 1.01 | 0.96 |
| **11** | 1.00 | 0.99 | 0.98 | 0.99 | 0.98 | **0.94** |
| **12** | 1.00 | 1.01 | 0.99 | 1.00 | 1.00 | **0.93** |

28. In 1997 the same data are used for both methods. Therefore, the relevant comparison is for 1998-2002. In 11 out of the 60 months being compared, the differential is 5 percent or more. However, only 6 of these months are really extreme (four of them in the month of September). Only the Fisher formula is compared, since if approximate methods may be used, Fisher is preferable to Laspeyres or Paasche in order to reduce the upward or downward bias.

29. In **Table 2** below the same comparison is made, this time for year over year monthly chained Fisher indices:

**Table 2: Ratio Between Year over Year "Current" Monthly Chained Fisher and Approximate Monthly Chained Fisher Indices ($P_{AF}/P_F$)**

| Month/Year | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|
| **1** | 1.00 | 1.01 | 0.98 | 0.99 | **1.05** | 1.01 |
| **2** | 1.00 | 1.00 | 1.03 | 0.99 | 1.00 | 1.00 |
| **3** | 1.00 | 1.00 | 1.00 | 1.02 | 1.03 | 1.04 |
| **4** | 1.00 | 1.00 | 0.98 | 1.03 | 1.01 | **1.07** |
| **5** | 1.00 | 0.99 | **1.09** | **1.12** | **1.58** | **1.32** |
| **6** | 1.00 | 1.01 | 1.00 | 1.00 | 1.00 | **1.06** |
| **7** | 1.00 | 1.01 | **1.14** | 1.01 | **1.06** | 1.02 |
| **8** | 1.00 | 0.99 | 1.01 | 1.00 | **1.05** | 1.04 |
| **9** | 1.00 | **1.77** | **1.82** | **1.23** | **1.75** | **1.77** |
| **10** | 1.00 | 1.01 | 1.02 | 1.01 | 1.02 | **1.07** |
| **11** | 1.00 | 0.99 | 0.99 | 1.02 | 1.01 | 0.99 |
| **12** | 1.00 | 1.01 | 1.01 | 1.01 | 1.01 | 0.99 |

30. The chained indices are not approximated as well as the base period indices. In sixteen observations the differences are 5 percent or more. September seems to be an "outlier" month in both comparisons.