Which Price Index Should a Central Bank Employ?

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In the 1970s the United States experienced inflation rates that were high relative to any other decade in the nation's peacetime experience. During that decade the consumer price index doubled, rising at a 7.4 percent average annual rate. At one point in the early 1980s, the CPI inflation rate exceeded 14 percent for a full year. When inflation was that high, the choice of which price index to employ to calculate inflation was a secondary concern for policymakers. As Figures 1 and 2 will indicate later in this article, commonly used price indexes gave the same message: inflation in the 1970s and early 1980s was relatively high.

The situation now is different. At low rates of inflation, differences among price indexes become more important. While it is difficult to imagine the difference between 10.0 and 10.5 percent inflation affecting monetary policy, the difference between 1.0 and 1.5 percent inflation could lead to different policy choices. Yet different price indexes can easily yield inflation rates that differ by that 50 basis-point magnitude. Thus in this period of low inflation, the choice of which price index to use has become an important issue for monetary policy analysis.

This article begins with the premise that a central bank places a high weight on keeping inflation low. Several central banks have adopted a formal inflation target by making a public commitment to achieving a particular goal for inflation, as discussed in Bernanke et al. (1999), for example. Central banks in other countries, including the United States, while not setting formal inflation targets, have nonetheless made it clear that low inflation is an important policy concern.

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Based on that premise, this article explores several considerations that lead to the choice of which price index to employ for setting monetary policy. Several widely used price indexes are discussed, and the author presents evidence that favors one particular index.

1. WHICH PRICE INDEX?

First Choices

Several grounds are given that could be used to choose which price index to employ. As this article progresses, the set of possible choices will be narrowed until one remains.

Credibility

A central bank seeking to maintain low inflation must at some point acquire credibility for being willing and able to take the actions necessary to achieve its goals. As part of a strategy for low inflation, then, that central bank must also employ a price index that itself has credibility. That is, the price index should be the result of a well-grounded statistical program that is not subject to political manipulation. The United States has many credible price indexes produced by the Bureau of Labor Statistics and the Bureau of Economic Analysis.

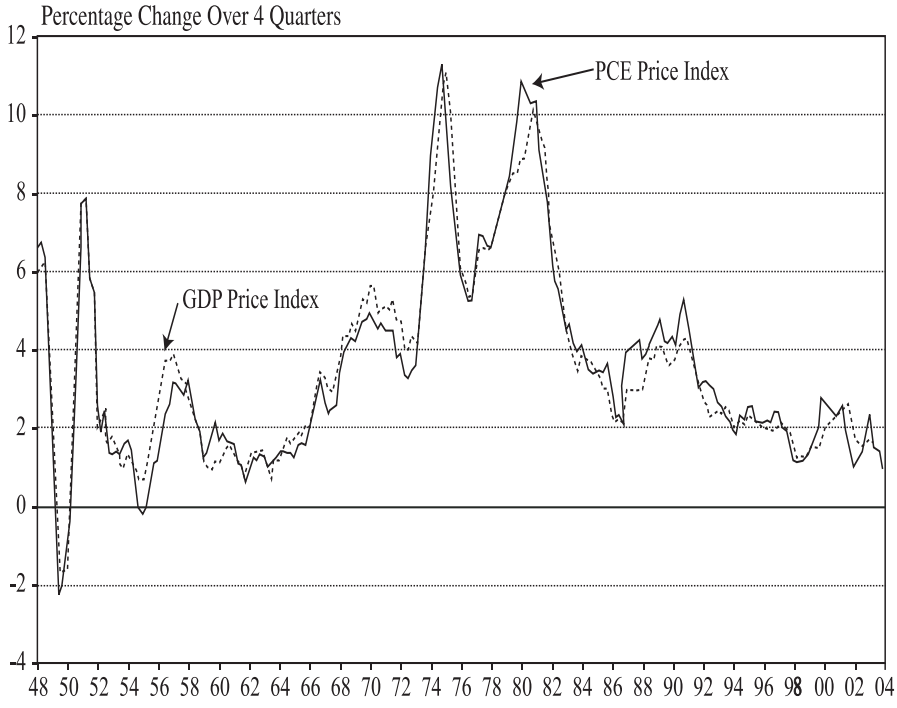
Breadth

The next choice is between a narrow price index, which includes prices of only a few items, or a broad price index with many items. Some analysts have advocated a narrow index of prices of a few raw materials on the grounds that those prices can respond rapidly to changes in monetary conditions. Well-known examples include commodity price indexes that have been published by the Commodity Research Bureau and the *Journal of Commerce*. An important drawback is that those prices can also respond rapidly to supply shifts of individual items, and as a result, movements in the index can reflect relative price changes rather than general price changes. Thus central banks have long given more prominence to broad price indexes in their policy deliberations and have chosen broad price indexes for inflation targets.

Sector

A wide variety of broad price indexes are published, including producer price indexes, price indexes for GDP and its components, and consumer price indexes. Looking at the major broadly based indexes, it is clear that they are highly correlated. Figure 1 shows inflation rates from two indexes that cover different sets of prices. The GDP price index covers goods and services produced in the United States, whereas the price index for personal consumption

Figure 1 Inflation Rates



expenditure (PCEPI) covers consumer spending in the GDP accounts. Since inflation rates calculated from those indexes are very similar, the choice can be based on the need to acquire and maintain credibility with the public. It is probable that members of the public are more likely to accept a monetary strategy for low inflation if they can relate it to their everyday experience. Thus a measure of consumer prices that is believed to be relevant to individual households would be a natural choice. Consequently, every central bank that has an explicit inflation target has chosen a measure of consumer prices.

2. THE CHOICE BETWEEN TWO CONSUMER INDEXES

In the United States, the best-known measure of consumer prices is the Consumer Price Index (CPI)[1] published by the Bureau of Labor Statistics. It has a

[1] Actually two versions of the CPI are published. The CPI-U covers all urban consumers, whereas the CPI-W covers urban wage and salary workers. In practice, the two indexes give virtually identical inflation rates, and thus the two will not be distinguished in the text. The figures in this article include the CPI-U.

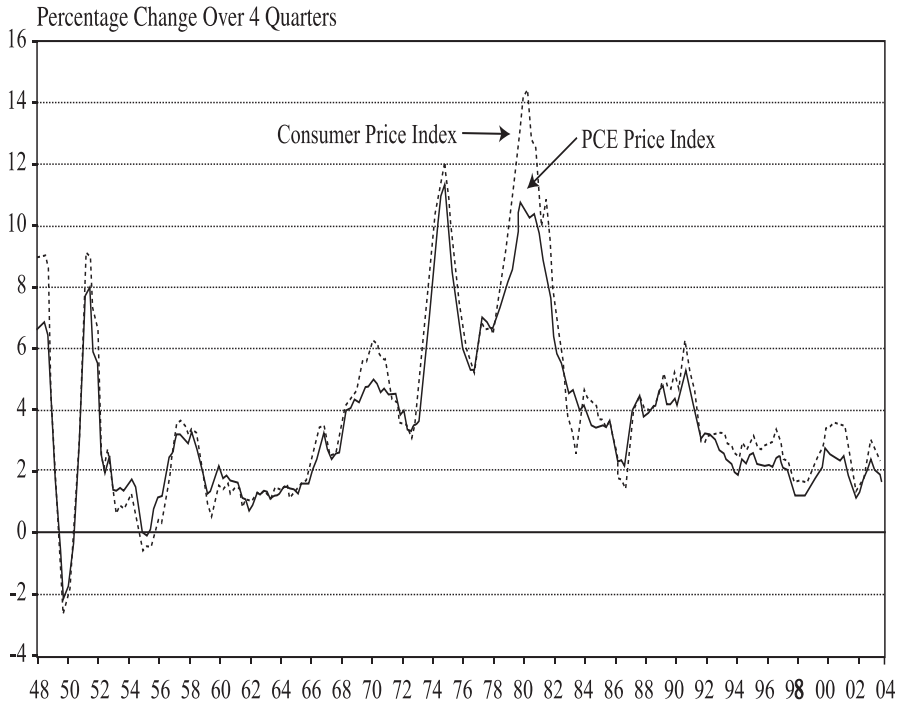
long track record and is widely used as an inflation index in government spending and taxing programs as well as in private contracts. The CPI's credibility has been enhanced by efforts of its producers to make a wealth of technical information readily available to the public on the details of constructing the index. The Bureau of Labor Statistics conducts an active research program that has helped the index adapt to changes in the economy and improve over time.

Setting the index apart from similar indexes in most other countries, the Commissioner of Labor Statistics has made a public commitment to using economic theory to guide important decisions that are made in constructing the index (Abraham 1997). Specifically, the concept of a cost-of-living index is now used as an organizing principle for making decisions concerning the production of the CPI. A cost-of-living index can be defined as the minimum expenditure required in a particular period to attain the same standard of living as was achieved in a reference period, divided by actual expenditure in the reference period. Economic theory tells how a cost-of-living index can be calculated from a consumer's preferences (for example, Diewert 1987), and the resulting index will correctly convert nominal income to real income. Statistical agencies in other countries have apparently shied away from employing cost-of-living methodology because it can be difficult to apply in real-world situations. The alternative, though, is that indexes constructed without that discipline can be hard to interpret. For example, the price of owner-occupied housing is the largest single component, by far, in the CPI; yet the price of owner-occupied housing is totally omitted in consumer price indexes in several other countries. That omission could not be defended in a cost-of-living framework.[2]

Although the cost-of-living concept helps its producers answer practical questions that arise as the index is produced, the CPI is not a cost-of-living index. The Bureau of Labor Statistics did not scrap the existing CPI when it decided to use the cost-of-living index as a benchmark. Instead, there have been incremental improvements to the index since then. In comparing the current CPI with an ideal cost-of-living index, the single most important difference is the formula that is used to construct the CPI. That formula does not account for the possibility of consumers responding to changing relative prices by changing their expenditure patterns. Later in this article there will be a more detailed discussion of the CPI's formula, and the appendix contains a

[2] The perennial question of whether to include asset prices in the CPI can be evaluated in the context of a cost-of-living index. That approach indicates that the price of *services* of consumer durables should be in the index and that there are two valid approaches to estimating the services of consumer durables. One is a Jorgenson (1963) user-cost formula, and the other estimates an imputed flow of services. The latter is currently used in the CPI for owner-occupied housing, which estimates an owner's equivalent rent from rental prices of similar structures. Importantly, the consumption of the services of a durable asset is independent of the method of financing the asset's purchase. That financing decision is thus outside the scope of a cost-of-living index.

Figure 2 Consumer Inflation Rates



numerical example that may help illustrate why the CPI is not a cost-of-living index.

The CPI thus has many positive attributes. If it were the only index of consumer prices available, it could be the basis for a successful monetary strategy aiming for low inflation. However, another index has some advantages over the CPI. The PCEPI attempts to cover the prices of all items consumed by residents of the United States. As Figure 2 indicates, while broad movements in the two indexes are similar, at times the differences have been substantial.

One source for the differences in Figure 2 is the changing methodology that has been used in constructing the CPI. The PCEPI uses a consistent methodology for its entire history; whenever that methodology has been changed, past numbers were accordingly revised. But values of the CPI are not changed after being published.[3] Thus in the late 1970s and early 1980s, housing prices

[3] Since the CPI is widely used to index money payments, fixing previously published values of the index avoids the question of whether payments that were previously made would need to be recalculated each time a methodological change was made to the CPI that altered historical values.

were overstated in the CPI, and inflation rates calculated using the CPI for that period were consequently overstated (Blinder 1980).[4]

More relevant for current monetary policy, there are other differences between the two indexes that affect current values of the indexes. Most important is that while both indexes are weighted averages of prices, two different formulas are used to calculate those averages. The CPI, a Laspeyres index, uses weights for individual prices that represent an item's importance in consumer expenditure at a fixed point in time (in 2003, the weights were based on average spending in the years 1999 and 2000). In symbols, the exact formula is

$$CPI_t = \frac{\sum_i q_{i,b} p_{i,t}}{\sum_i q_{i,b} p_{i,b}}, \tag{1}$$

where CPI_t is the value of the consumer price index at time t, $q_{i,b}$ is the quantity of item i consumed in the base period b ($b \neq t$), $p_{i,t}$ is the price of item i in period t, and $p_{i,b}$ is the price of item i in the base period. In contrast, the PCEPI is a Fisher Ideal index, the geometric average of a Laspeyres index like the CPI and an index that uses current values of spending for the weights on prices. In symbols,

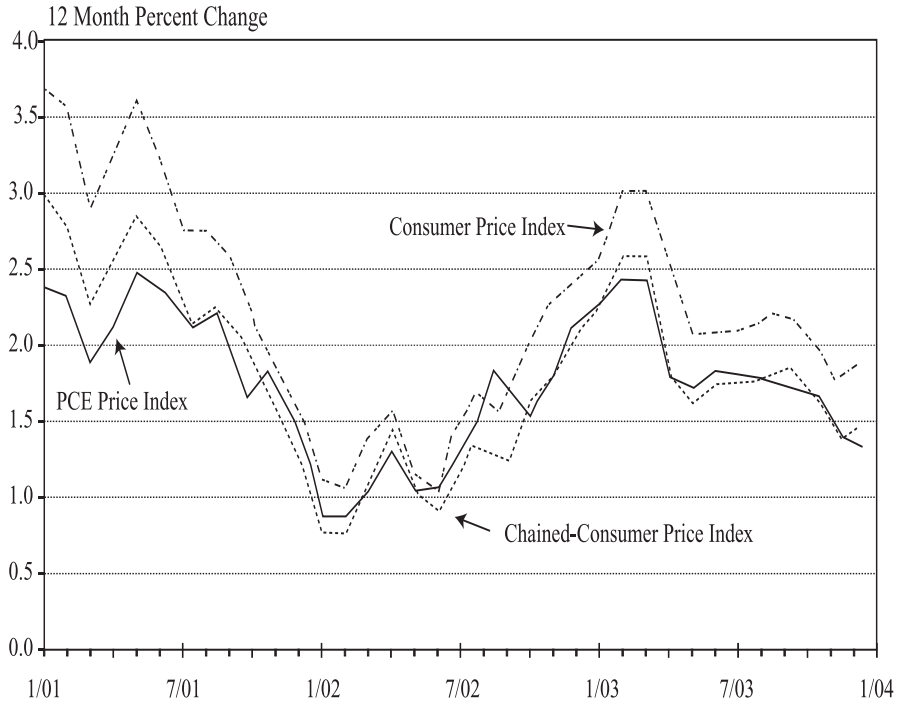
$$PCEPI_t = \sqrt{\frac{\sum_i q_{i,t-1} p_{i,t}}{\sum_i q_{i,t-1} p_{i,t-1}} \frac{\sum_i q_{i,t} p_{i,t}}{\sum_i q_{i,t} p_{i,t-1}}}, \tag{2}$$

where $q_{i,t}$ is the quantity of item i consumed in period t. Note that the formula for the PCEPI includes data on current period quantities $q_{i,t}$ that are omitted from the formula for the CPI. Also, the PCEPI does not have a fixed base period; instead, the index values are calculated using data from the current period and the previous period. Since there is not a designated base period, the index number for one particular period will be set to 100. The formula in (2) is then used to link adjacent periods together.

The difference in formulas is important because the CPI does not routinely allow for changing expenditure patterns in response to relative price changes. This could be particularly important when technical progress results in falling prices of goods such as computers, cellular phones, and television sets. Failure to account for increasing spending on items with falling prices would create a bias in the index that would lead it to rise more rapidly than the true cost of living. The Fisher Ideal index, however, allows for changing expenditure patterns in a manner that allows it to approximate a cost-of-living index especially well and is thus known as a *superlative* index (Diewert 1987).

[4] At that time, the CPI attempted to measure an average price of items purchased by a representative consumer, not the cost of living. It therefore included the purchase price of owner-occupied housing plus a measure of mortgage interest rates. By the mid-1980s, after the damage was done and the index had overstated inflation, the current approach of pricing the service flow from owner-occupied housing was adopted.

Figure 3 Consumer Inflation Rates



The appendix illustrates the construction of a Laspeyres index and a Fisher index in a simple case with a large change in the pattern of expenditure.

It may seem that the difference in formulas would be an example of esoteric trivia; however, at low inflation rates, the magnitude of the difference can be large when compared with the absolute rate of inflation. In order to focus on the difference between a superlative index and a Laspeyres index, it is helpful to consider briefly a new index from the Bureau of Labor Statistics. The Chained-CPI (C-CPI) uses exactly the same price information as the CPI but is based on another type of superlative index, a Tornquist index.[5] Like the Fisher index, the Tornquist index includes information on current period quantities and thereby allows for changing expenditure patterns. Figure 3 shows inflation rates calculated using the CPI, the C-CPI, and the PCEPI.

[5] The formula for the Tornquist Index is $\prod_i (\frac{p_{i,t}}{p_{i,t-1}})^{(\frac{s_{i,t-1}+s_{i,t}}{2})}$ where s_i is the expenditure share of item i, that is, $\frac{q_i p_i}{\sum_j q_j p_j}$. Note that current expenditures enter the formula through the expenditure share term.

There is a noticeable difference between the CPI and the other two indexes. Over this period (the entire period for which the C-CPI is available), the average difference between the CPI and C-CPI was 44 basis points, which is entirely attributable to the different formulas. The average difference between the two superlative indexes was only 5 basis points.

In addition to the different aggregating formulas, the prices and relative importance of various items can differ between the CPI and PCEPI. Most of the individual prices in the PCEPI are identical to those in the CPI. The most notable exception is spending for medical services, where the PCEPI uses information from producer price indexes. Moreover, a few items are covered in one index but not another. Also, the relative importance of a particular item can differ considerably between the two indexes, since completely different sources of information are used to determine relative importance. The PCEPI uses information to construct GDP, such as economic census data and industry trade data. The CPI uses information from periodic Consumer Expenditure Surveys. Some analysts (such as Lebow and Rudd 2001) have viewed the weights in the PCEPI as likely to be more accurate. In the survey data used for the CPI, a member of a household is asked to give information on spending of all members of the household. If items accounting for a small portion of spending tend to be missed or forgotten in the household survey, then the fraction of spending for big-ticket items would tend to be biased upward. Not surprisingly, then, owner-occupied housing has a much larger weight in the CPI than in the PCEPI. To quantify the effect of different weights, Lebow and Rudd compared the published CPI with an alternative CPI using PCE weights. From 1987 to 2000, the average inflation rate was 10 basis points lower when using the PCE weights.

Accordingly, due to the clearly superior formula for computing the index and the probably superior item weights, changes in the PCEPI should provide a better estimate of the true cost of living.

Limitations of Price Indexes

It is important to consider some limitations of both indexes. In a dynamic economy, the items available for purchase are constantly changing, with new items being introduced continuously, some old items being improved, and other old items disappearing from the market. Accounting for new items is a challenge for producers of price indexes. For example, the Boskin Commission Report (1996) noted that although there were 36 million cellular phones in use at the time of the report, there was no price of cell phones in the CPI. Compounding the problem is the typical product cycle, in which a new good initially sells for a relatively high price, but as economies of scale are realized and new competitors enter the market, the price falls rapidly before eventually leveling out. If the price of a new item does not enter a price index promptly,

then the interval of a rapidly falling price can be missed entirely, and the price index would therefore overstate inflation. Since the Boskin report was written, the Bureau of Labor Statistics has reduced—but not eliminated—the time it takes for a new item to enter the CPI.

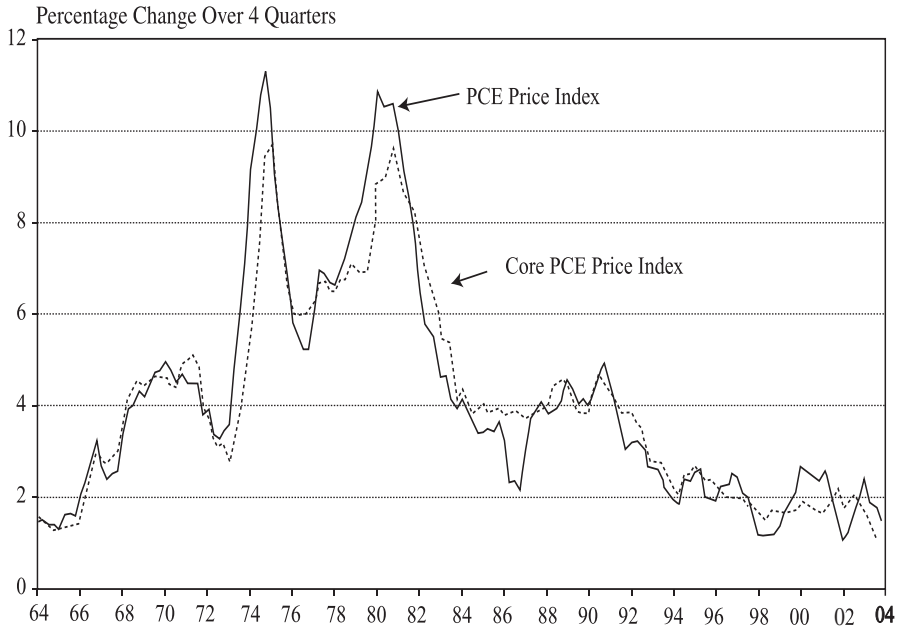
A related difficulty is accounting for quality change. If the greater durability or improved functionality of a product is not taken into account, then a price index will overstate the cost of living. And if quality improvements routinely outweigh quality deterioration, inflation can be overstated. Some detailed studies of particular products have found that accounting for quality change would have made a sizeable difference in recorded prices. Based on many of these studies, the Boskin Commission Report estimated that there was a 60 basis-point upward bias in CPI inflation rates at that time, due to new products and quality change. A more recent estimate by Lebow and Rudd puts the bias at 37 basis points. It should be emphasized that these estimates are subject to a large amount of imprecision. If it were easy for analysts to disentangle the portion of price changes that reflect quality change, it would probably be part of routine price index calculation already. At this time, improving estimates of quality change is an ongoing challenge for statistical agencies.

3. CORE INDEXES

A final choice is between the PCEPI and a measure of *core* inflation. For purposes of monetary policy, it would not be desirable to respond to temporary changes in measured inflation that are likely to be reversed. Thus policymakers in many countries pay particular attention to a core price index that excludes some items that account for a significant amount of short-run volatility in the index but do not have much effect on the long-run trend. For several decades, inflation analysts in the United States have focused on a core price index that excludes food and energy prices. As illustrated in Figure 4, the core PCEPI is less volatile than the overall index; using the core index reduces the variance of inflation rates in that figure by 31 percent. Most importantly, the core index omits some significant fluctuations in the overall index that were soon reversed but could have led to inappropriate monetary policy actions. For example, the core index did not decline significantly in 1986 and did not rise significantly in 2002–2003. In 1986, crude oil prices fell sharply and led to lower retail energy prices. In the latter episode, as energy prices increased sharply in response to the approach of war in Iraq, the overall index signaled rising inflation, but the core index signaled low, falling inflation. Finally, removal of energy and food prices has had a small effect on the long-run trend. Over the 40-year period illustrated in Figure 4, the PCEPI increased at a 4.05 percent annual rate, whereas the core PCE index increased at a 3.95 percent rate.

Most of the countries with full inflation targets have taken a similar approach and employed a core index that omits a few items. Besides food and

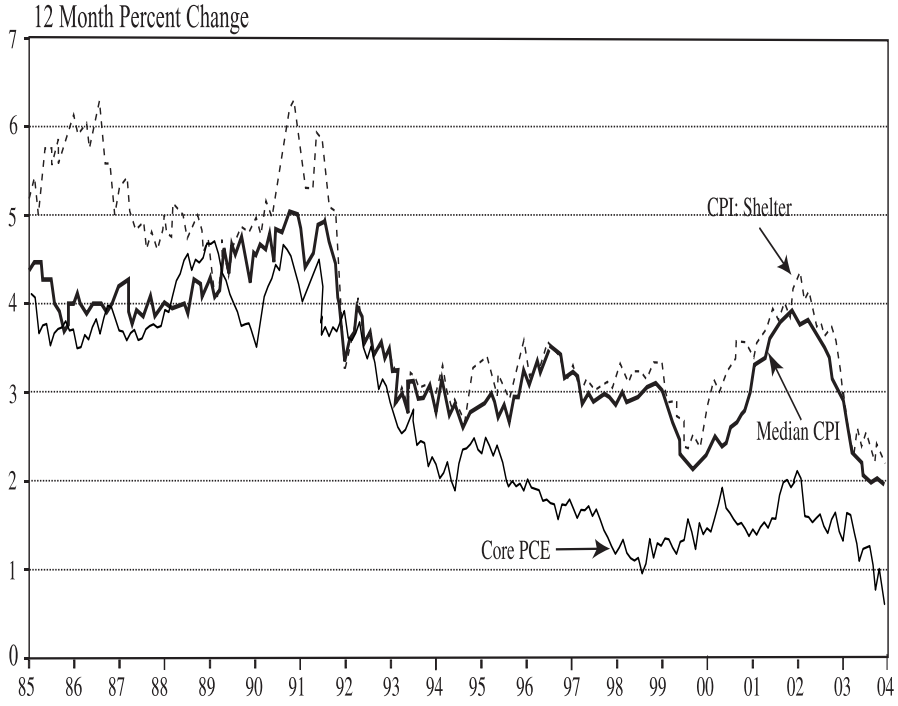
Figure 4 Core Inflation



energy prices, several countries omit indirect taxes. These widely used core indexes were not derived from economic or statistical theory, but were instead based on the judgment that their use would result in better choices of monetary policy actions. Researchers have also examined alternatives that use more elaborate statistical methods for determining core inflation (see, for example, the survey by Johnson 1999). At this point, though, this is only research in progress that has not resulted in a new standard for determining core inflation. The major hurdle for these studies will be to demonstrate that using a proposed method would lead to better monetary policy decisions.

This point can be illustrated with a particular alternative estimate of core inflation. A *median* CPI (Bryan and Cecchetti 1993) is based on the statistical property that a median is not influenced by extreme observations, unlike the arithmetic average used for the CPI and the PCEPI. The Federal Reserve Bank of Cleveland accordingly calculates a median CPI as an alternative measure of core inflation and posts recent and historical values on their web site. Despite that prominence, however, their median CPI has not supplanted the traditional core index. Two observations may explain why. First, due to the large weight

Figure 5 FRB Cleveland's Median CPI, Core PCE Price Index, and CPI: Shelter



placed on housing expenditure in the CPI, the median CPI often simply picks up the behavior of housing prices, as is illustrated in Figure 5. Thus the correlation between the 12-month change in the shelter component of the CPI and the median CPI was 0.90 since 1985 and was even higher before then. In contrast, the correlation between the nonshelter component of the CPI and the median CPI was only 0.48 since 1985. Also, note that from January 2000 to November 2001, the inflation rate calculated from the median CPI *increased* from 2.4 to 4.0 percent, which at face value would indicate an excessively easy monetary policy stance and might signal the need to raise the federal funds rate target. Over that period, however, the economy weakened in 2000 and moved into recession in 2001. Thus it appears that at that time the traditional core price indexes gave a better guide for monetary policy. Accordingly, the 12-month change in the core PCEPI remained below 2.2 percent in 2000 and 2001.

Although the traditional core index has not been supplanted by an alternative, there is a strong case for continued research on alternative measures of core inflation. Given the imperfect nature of macroeconomic statistics, one should always wonder if any particular statistic is giving misleading signals,

and the core PCEPI is no exception. Having well-studied alternatives could thus be valuable to policymakers if at any time the traditional core index were to be in doubt.

4. CONCLUSION

This article studies which price index to use for determining monetary policy actions. The best choice for the United States is currently the core price index for personal consumption expenditure. From 1996 to the end of 2003, the four-quarter change in that index remained within a narrow range, 0.9 to 2.1 percent. Like other macroeconomic statistics, price indexes are not precision tools. Allowing for about a half percentage point of upward bias in the reported inflation rate, the true cost of living has been rising very slowly for several years.

APPENDIX

A numerical example may help clarify the effects of different index formulas. Assume that there are two goods, apples and bananas, denoted with superscripts a and b. There are two time periods, 0 and 1. Money income is y, and utility is u. I assume, $y_0 = \$12.00$, $p_0^a = p_0^b = \$1$ and $u = \sqrt{q^a q^b}$, where p represents a price and q is a quantity. Given the initial conditions, utility is maximized at a level of 6.0 when 6 apples and 6 bananas are consumed. Using the equations in the text, both a Laspeyres index L and a Fisher index F will have values of 1.00 in period 0.

Now, let $y_1 = \$12.00$, $p_1^a = \$1.50$, $p_1^b = \$0.50$, and we can ask if real income has risen, fallen, or remained unchanged. If we divide money income by a cost-of-living index, the real income rises if and only if utility rises. Given the utility function and new prices, the optimal quantities are $q_1^a = 4$ and $q_1^b = 12$, and utility rises to approximately 6.93. In other words, the price changes have allowed utility to increase significantly once quantities are allowed to adjust.

Consider first the Laspeyres formula given in equation 1; substituting the values above gives $L_1 = \frac{6\times1.5+6\times0.5}{6\times1+6\times1} = 1.00$, and, therefore, real income in period 1 is \$12.00. Although utility rose, real income, calculated by using a Laspeyres index, did not change. Now use the Fisher formula of equation 2: $F_1 = \sqrt{\frac{6\times1.5+6\times0.5}{6\times1+6\times1} \times \frac{4\times1.5+12\times0.5}{4\times1+12\times1}} = \sqrt{\frac{3}{4}}$, and real income is approximately \$13.86. Thus the latter index correctly leads to rising real income with rising utility.

Finally, for comparison we can construct a cost-of-living index. We can define the value as exactly 1.00 in period 0. The utility function has the property that utility is maximized when exactly half of income is spent on each item. Using that knowledge, the minimum expenditure in period 1 that achieves the utility level of 6 is $3\sqrt{12}$, or approximately \$10.39, which purchases approximately 3.46 apples and 10.39 bananas. Thus the cost-of-living index for period 1 is $\frac{3\sqrt{12}}{12}$, which in this case is exactly equal to the Fisher index. In both cases, a utility-maximizing consumer would buy more bananas, which became less expensive and, correspondingly, fewer apples, which became more expensive. Both the cost-of-living index and the Fisher index correctly captured that changing expenditure pattern.

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