Addressing misconceptions about the Consumer Price Index

*A number of longstanding myths regarding
the Consumer Price Index and its methods of construction
continue to circulate; this article attempts to address
some of the misconceptions, with an eye toward increasing
public understanding of this key economic indicator*

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Τhe Consumer Price Index (CPI), published by the Bureau of Labor Statistics (BLS), has generated controversy throughout its history. A soon-to-be-published article by Marshall Reinsdorf and Jack Triplett discusses the many past reviews of the methods and data used in the CPI's construction.[1] Beginning with an advisory committee appointed by the American Statistical Association in 1933,[2] and continuing through the recent National Research Council panel chaired by Charles Schultze,[3] panels and commissions have identified and discussed what is now a well-known set of issues affecting the measurement of consumer prices: consumer substitution behavior, change in the quality of products, the introduction of new types of goods and services, and the appearance of new categories of stores and new channels of product distribution. Given the large number of private and public uses of the CPI, and especially its important role in determining Federal Government revenues and payments, it is natural that each of those issues has been the subject of intense public attention.

Within the past several years, commentary on the CPI has extended well beyond the circle of economists, statisticians, and public officials. The strongest criticism of

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BLS methodology has not been concentrated in a single profession, academic discipline, or political group, but comes instead from an array of investment advisers, bloggers, magazine writers, and others in the popular press. Also, whereas in the past the CPI frequently was held to be *overstating* inflation, recent criticism has focused on supposed *downward* biases.

Appearing as they do in national media and in the age of the Internet, these criticisms probably have been more widely quoted and circulated than most academic journal articles and panel reports on CPI issues. Although the BLS welcomes comments and regularly discusses and debates measurement issues with its advisory committees and at professional meetings of researchers in economic measurement, the recent criticisms of the CPI have been directed not so much to the BLS itself as to the public at large. This article is an attempt to correct some of the misunderstandings underlying those criticisms.

The article begins with a brief background section on what the CPI is, how it is used, and what some of its major methodological changes have been. Three measurement issues that have been the subject of greatest misunderstanding—consumer substitution, quality adjustment, and homeownership costs—are

then discussed, followed by reviews of two issues that relate to almost all current commentary on the CPI: the specification of a "core" index and the differences between the CPI and perceived inflation. The penultimate section specifically addresses a widely cited estimate of presumed upward bias resulting from BLS methods, and the article ends with some summary remarks.

Along the way, special attention is paid to four common misperceptions, or myths, about the CPI: (1) that the BLS lowers the CPI to reflect consumers' substitutions of hamburger for steak; (2) that the use of hedonic quality adjustment has substantially decreased the growth rate of the CPI; (3) that the 1983 change in the way the BLS measures homeownership costs lowered the rate of increase of the CPI; and (4) that Social Security payments are indexed to a CPI that does not include food or energy. The analysis demonstrates that the improvements to the CPI described in this article are consistent with international standards and guidelines for the construction of price indexes.

Background

As stated in the BLS fact sheet *Understanding the Consumer Price Index: Answers to Some Questions*, the CPI is a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services.[4] In simple terms, when prices change, the goal of the CPI is to measure the percentage by which consumers would have to increase their spending to be as well off with the new prices as they were with the old prices. For example, if the price of every product went up by 5 percent, consumers would have to increase their spending by 5 percent to remain at the same standard of living, assuming that everything else stayed the same. To deal with practical questions that arise in the construction of the CPI, the BLS uses the economic theory of the cost-of-living index as a framework.[5] Among those practical questions are how to compute the overall CPI when not all prices change at the same rate and how to deal with the introduction of new types or models of products.

The all-items CPI is constructed from approximately 8,000 basic indexes, which correspond to 38 geographic areas and 211 item categories. Apples in Chicago and gasoline in San Francisco are examples of these basic CPIs. Since 1978, the BLS has published CPI series that reflect the inflation experiences of two different population groups. The *CPI for all urban consumers* (*CPI-U*) and the *CPI for urban wage earners and clerical workers* (*CPI-W*) differ only in the relative weights that are attached to the basic item-area index components. For example, the

CPI-W has a somewhat higher weight for gasoline than does the CPI-U, because the population of urban wage earners and clerical workers allocates a higher share of its consumption to gasoline than do urban consumers as a whole.

To construct each of the basic CPIs, the BLS periodically asks consumers where they shop, picks specific items from those "outlets," and then tracks the prices of those items over time. Implementing that process requires a number of surveys. The Census Bureau administers a Telephone Point-of-Purchase Survey in which consumers are asked where they recently purchased goods and services. The BLS uses data from this survey to select a sample of grocery stores, service stations, doctors' offices, and other locations at which to collect prices. At each of these "outlets," the BLS uses probability sampling methods to select a representative sample of particular items. Once the sample is selected, prices of those items are collected regularly by BLS staff, usually on a monthly or bimonthly basis. Separately, rental prices are collected from a sample of houses and apartments to measure prices of shelter services. The individual item-area indexes are averaged together with the use of weights created from the Consumer Expenditure Survey (CE), which, like the Telephone Point-of-Purchase Survey, is conducted for the BLS by the Census Bureau. In the CE, consumers report how they allocate their spending across the 211 CPI categories of items, such as apples, gasoline, rent, and physicians' services. All these categories are designed to make sure that the CPI reflects the inflation experiences of U.S. consumers as a whole.[6]

The all-items, or overall, CPI-U is the CPI that is reported most widely in the media each month when the index is released. Both the CPI-U and CPI-W, however, have important uses in indexation. The CPI-W is the index used in the determination of the annual Social Security and Federal retirement cost-of-living adjustments. It also is used extensively for periodic wage adjustments in collective bargaining agreements. The CPI-U is used for indexation of tax brackets, personal exemption amounts, and many other quantities in the Federal tax system. In addition, the CPI-U is used by the Federal Government to calculate adjustments to the principal values of Treasury Inflation-Protected Securities, also known as TIPS, which have been issued since 1997 to provide a constant inflation-adjusted return to investors.[7]

Another important use of CPI data is in the construction of the National Income and Product Accounts (NIPA), published by the Commerce Department's Bureau of Economic Analysis (BEA). Numerous CPI component indexes are critical inputs into the NIPA Personal Consumption

Expenditures (PCE) price index and into the calculation of real, or constant-dollar, gross domestic product (GDP). Therefore, although the primary focus of the Federal Reserve's monetary policy is the PCE price series, rather than the CPI itself, the basic CPIs are important to anyone who follows Federal Reserve policy decisions.

In 2002, the BLS began publishing a third monthly CPI: the *chained Consumer Price Index for all urban consumers (C-CPI-U)*, created to more closely approximate a cost-of-living index by reflecting consumer substitution among item categories. The C-CPI-U applies to the same population group as the CPI-U, but employs a different formula to combine basic indexes. In part because C-CPI-U values are revised in each of the 2 calendar years following their initial publication, that index does not have any prominent uses in indexation. Consequently, those who criticize the CPI-U and CPI-W have paid relatively little attention to C-CPI-U methods, and accordingly, the focus in the discussion that follows is almost exclusively on the CPI-U and CPI-W.

It is important to recognize that the CPI is a measure of inflation as experienced by consumers; other price indexes may be appropriate for different purposes. Several other indexes, produced by the BLS or by other government agencies, measure different aspects of inflation. For example, the BLS Producer Price Index (PPI) measures price change at earlier stages of production and marketing, before consumers enter the picture, and the NIPA GDP price index measures inflation experienced by governments and businesses, as well as by consumers. These differences in purpose have important effects on what prices are included in the index; for instance, the PPI and the GDP index include steel, heavy trucks, and other nonconsumer-spending price categories that are not found in the CPI.

The BLS continuously reviews and enhances the data and methods used in generating the CPI. For the purposes of this article, three methodological changes have been especially significant. The first was a fundamental change in the measurement of the cost of shelter for homeowners. In late 1981, on the basis of considerable research, the BLS announced that it would change the treatment of homeownership in the CPI-U from an asset-based approach to rental equivalence, effective January 1983.[8] The same change was implemented in the CPI-W in January 1985. A second major change took effect in January 1999, when the BLS adopted a geometric mean formula in the calculation of most CPI basic indexes. The purpose was to reflect the demonstrated ability of consumers to shift away from products whose prices had increased relative to the prices of other products in the same basic CPI component—for

example, away from apples whose prices had increased more, or decreased less, than the prices of other apples in Chicago. The third change took place over a period of years beginning in 1998, as the CPI program expanded the use of hedonic regression models for quality adjustment, previously confined to housing and apparel, to a number of additional series, such as computers, televisions, and refrigerators. Each of these three methodological changes continues to generate criticism from outside the BLS.

Substitution

Among all the criticisms leveled at the CPI, its use of the geometric mean formula to reflect consumer substitution behavior is undoubtedly the most frequently misunderstood and mischaracterized. Members of the general public are naturally concerned when critics charge that, in using the geometric mean, the BLS is subtracting from the CPI a certain amount of inflation that consumers can "live with" by reducing their standard of living. Some critics have incorrectly claimed, for example, that the BLS assumes that consumers are no worse off when they substitute hamburgers for steak. That is not, however, what the geometric mean does, and such an interpretation is hard to reconcile with the fact that the geometric mean is widely used by statistical agencies around the world. One of two formulas recommended by the International Monetary Fund[9] and approved by the Statistical Office of the European Communities (Eurostat) for use in those countries' Harmonized Indexes of Consumer Prices (HICP),[10] the geometric mean is used by 20 of 30 countries as a primary formula for computing the elementary indexes in their HICP's.[11] This section attempts to allay the public's concern by reviewing the general justification for the formula, as well as the impact of its use on the CPI.[12]

To begin, it must be stated unequivocally that the BLS does not assume that consumers substitute hamburger for steak. Neither the CPI-U, nor the CPI-W used for wage and benefit indexation, allows for substitution between steak and hamburger, which are in different CPI item categories.[12] Instead, the BLS uses a formula that implicitly assumes a degree of substitution *among the close substitutes within an item-area component of the index*. As an example, consumers are assumed to respond to price variations among the different items found within the category "apples in Chicago." Other examples are "ground beef in Chicago," "beefsteaks in Chicago," and "eggs in Boston."

There can be no doubt that consumers exhibit shifts in their purchasing patterns toward items that have fallen in relative price. This behavior is an observable feature of

everyday life, not just a theoretical economic principle. Consider a carton of orange juice, which is a typical product found within the CPI item category "nonfrozen noncarbonated juices and drinks." Suppose that a store lowers the price of one brand of orange juice, while leaving all other prices the same. In response, some consumers will consume more orange juice; some will buy the affected brand of orange juice rather than other brands; some will buy orange juice at this store rather than other stores; some will purchase orange juice instead of grapefruit juice; and some will buy orange juice now rather than later, using the opportunity to stock their refrigerators with a larger-than-usual supply of orange juice. There will be some consumers who do not increase their consumption of that particular brand of orange juice, but almost certainly, the aggregate purchases by all consumers will rise.[14]

There is also no dispute among economists that the price index formula used in all of the basic CPIs prior to 1999 (called the Laspeyres formula) tends to overstate changes in the cost of living; specifically, the change in a Laspeyres index is an "upper bound" on the change in the cost of maintaining a standard of living.[15] This fundamental result is found throughout books on cost-of-living indexes, as well as in economics textbooks.[16] It long predates the BLS decision to switch to a geometric mean formula for computing most of the basic CPIs.[17]

A simple, if extreme, example suffices to get the point across. Suppose that a person buys four candy bars each week: two chocolate bars and two peanut bars. The bars cost $1 each, so her total spending per week on candy bars is $4. Now suppose that, for some reason, the price of chocolate bars quadruples to $4, while peanut bars remain at $1. The goal of the CPI is to measure how much the consumer needs to spend each week to consider herself just as well off as she was before the price increase. A Laspeyres price index calculates the cost of the original purchase quantities: two candy bars of each type. Therefore, the answer according to the Laspeyres formula is that the consumer would need $10 to be as well off as before.[18]

The Laspeyres answer is correct, however, only if the consumer is completely unconcerned with changes in price and always chooses to purchase chocolate and peanut bars in equal numbers, regardless of which is cheaper. The Laspeyres answer is called an upper bound because the right answer cannot be greater than $10; the consumer certainly will be at least as well off as she was before if she can continue to purchase two bars of each type. At the other extreme, the right answer cannot be lower than $4. In the unlikely case that the consumer is entirely indiffer-

ent between types of candy bar, she could respond to the increase in the price of chocolate bars by buying four peanut bars instead of two of each type, and she would be no worse off than she was before, even if she still had only $4 to spend. Of course, neither the Laspeyres upper-bound answer of $10 nor the lower-bound answer of $4 is realistic. In the real world, people make tradeoffs on the basis of both price and their preferences, and the actual answer lies in between the two bounds. With $7, for example, our consumer could afford to buy seven peanut bars, one for every day of the week. Thus, $7 might be sufficient to make her as satisfied at the new prices of candy as she was with $4 at the old prices. Put another way, we can be confident that, for some consumers, the Laspeyres result of $10 would overstate the amount they need to maintain their original level of candy satisfaction. The geometric mean formula adopted by the BLS for use in most CPIs gives a somewhat lower answer than the Laspeyres formula, because it puts less weight on the prices that have increased the most (in this case, the price of chocolate bars) and more weight on the prices that have increased less. As it turns out, the geometric mean would say that $8 is the amount needed to keep the average consumer at the original satisfaction level. With $8, the consumer could purchase one chocolate bar and four peanut bars, offsetting the reduced number of chocolate bars by an increase in the total number of candy bars.[19]

It is important to note two things about this example. First, the geometric mean estimate of required spending increased sharply, albeit by less than that of the Laspeyres index. Second, the objective is to calculate the amount of money necessary to maintain a *constant* level of satisfaction, or what one might term a constant standard of living. Critics of the BLS often erroneously assert that reflecting substitution behavior in the CPI amounts to tracking a *declining* standard of living. Their argument can be summarized as follows: "the BLS assumes that if steak becomes too expensive, consumers will shift to buying hamburger, so the CPI reflects a tradeoff of hamburger for steak, not steak for steak." The trouble is that that logic fails to recognize the point made at the beginning of this section: that the BLS employs the geometric mean formula only within basic CPIs, such as the index for ground beef in Chicago. Still, despite the fact that it is wrong, the idea that the CPI's use of the geometric mean reflects substitution between hamburger and steak has attained the status of a sort of urban legend, repeated by numerous bloggers and commentators.

When the price of a certain type of beefsteak rises, CPI-U and CPI-W methods allow only for substitution to other types

of beefsteak, not to hamburger or other, cheaper alternatives to steak. A 1998 article in the *Monthly Labor Review* emphasizes, "the geometric mean formula will not be used to combine the basic indexes in the CPI, such as those for ice cream products and apples, into the overall index."[20] As mentioned earlier, those indexes are combined into the overall CPI-U or CPI-W under the assumption that there is no substitution between ice cream products and apples or between steak and hamburger.

In addition, the critics' argument takes as its premise that steak, the more desirable product, is getting "too expensive." As has been noted, the CPI's assumption about substitution is that consumers shift their purchases toward items *whose prices are rising less* (or falling more), not necessarily toward less desirable goods. For example, within the CPI category "ice cream and related products," the assumption is that if the price of premium ice cream falls relative to the prices of cheaper store brands, consumers will shift toward the premium brands. Within the beefsteak category, the CPI implicitly assumes that, on average, consumers would shift *up* from flank steak toward filet mignon if flank steak prices rose by a greater amount (or fell by a lesser amount) than filet mignon prices. If all prices change proportionately, then no substitution is assumed. So, if, for example, a rising cost of beef caused filet mignon and flank steak prices both to increase by 10 percent, the geometric mean formula would *not* assume any substitution toward flank steak.

The quantitative impact of the CPI's use of the geometric mean formula also has been grossly overstated by some, with one estimate exceeding 3 percent per year.[21] It is difficult to identify real-world circumstances under which geometric mean and Laspeyres indexes could differ by such a large amount. The two index formulas will give the same answer whenever the prices used in an index all change by the same percentage. The bigger the differences in price changes, the more the Laspeyres index will tend to exceed the geometric mean. For the growth rate of the Laspeyres index to exceed the growth rate of a geometric mean index by 3 percentage points, however, the differences in individual price changes have to be quite large.

To see this point, consider another very simplified example. Suppose that the CPI sample for ice cream and related products in Boston consisted only of an equal number of prices for ice cream and frozen yogurt[22] and that, between one year and the next, all the prices of ice cream in Boston rose by 8.6 percent while all the frozen yogurt prices fell by 4.2 percent. In that case, the geometric mean estimate of overall annual price change would be 2.0 percent, only slightly less than the Laspeyres es-

timate of about 2.2 percent.[23] In order to come up with a difference of 3 index points, one has to assume a much more dramatic divergence between ice cream and frozen yogurt prices than the one hypothesized. For example, if ice cream prices rose *30 percent* in one year, while frozen yogurt prices fell by *20 percent*, the overall geometric mean index would still rise by 2 percent, but the Laspeyres index would rise 5 percent, for a difference of 3 index points. However, such a large annual divergence would be quite uncommon within CPI basic indexes—between ice cream and yogurt, between types of candy and gum, between types of noncarbonated juices, or between varieties of ground beef. Moreover, for a 3-percentage-point divergence to continue year after year, the divergence between the individual component prices would have to continue to widen. For example, if, by contrast, during the next year ice cream prices increased by the *same* amount as frozen yogurt prices, then the two index formulas would give the same inflation estimate for that year. Although such a divergence might plausibly occur in one component for 1 year, it is beyond belief that such sharply divergent price behavior would continue year after year across the whole range of CPI item-area components.

Finally, and most importantly, there is rigorous empirical evidence on the actual quantitative impact of the geometric mean formula, because the BLS has continued to calculate Laspeyres indexes for all CPI basic indexes on an experimental basis for comparison with the official index. These experimental indexes show that the geometric mean led to an overall decrease in CPI growth of about 0.28 percentage point per year over the period from December 1999 to December 2004,[24] close to the original BLS prediction that the impact would be approximately 0.20 percentage point per year.[25]

Quality adjustments and hedonic models

The BLS has been faced with two types of criticisms, one general and one specific, of the way in which quality adjustment is carried out in the CPI. The first criticism argues, explicitly or implicitly, that no adjustment should be made for the difference in quality between an item that is no longer sold and its replacement. That position appears to be based on a misunderstanding of the purpose of the CPI, and it also is impractical, given the rapidly changing consumer marketplace. The second criticism is that, by expanding the use of hedonic quality adjustment over the past 10 years, the BLS has imposed arbitrary estimates of the "pleasure" consumers derive from new products, severely distorting the CPI as a result. This criticism is a

fundamental misunderstanding of the hedonic method, and it ignores the fact that the introduction of all hedonic quality adjustments since 1999 has had only a very small impact on the overall CPI.

Americans will be understandably concerned if they are told that the BLS bases the CPI on subjective and exaggerated assumptions about product quality improvements. They also will be suspicious if told that the BLS manipulates nonscientific models to estimate the value of quality change. On the contrary, in every aspect of CPI construction, the BLS goal is to use objective, rather than subjective, methods wherever possible. As stated in a 1998 paper coauthored by the Commissioner of the BLS,

> For the BLS, the primary task is...to employ the most accurate methods available for dealing with quality change and with new goods and outlets. Those methods must be rigorous, objective and reproducible, minimizing the role of analyst judgment.[26]

Why does the BLS adjust for quality change at all? Many of the challenges associated with producing a CPI arise because the number and types of goods and services found in the market are constantly changing. Over time, the goods and services in the CPI samples are being replaced by new products or by new models of existing products. Consequently, if the BLS tried to maintain a fixed and unchanging sample for the CPI, that sample would quickly shrink to the point where it became unrepresentative of what consumers were purchasing. Each time an item in the CPI sample permanently disappears from the shelves, the BLS has to choose another item and then has to make some determination about the relative qualities of the old and replacement items. If it tried to avoid making such quality determinations and adjustments—for example, if it treated all new items as identical to those they replaced—significant upward or downward CPI biases would result. As stated in the international CPI manual published by the International Labor Office (ILO), "Statistical offices must pay close attention to the treatment of quality change and try to make explicit adjustments whenever possible."[27]

To take the most straightforward example of quality adjustment, which the CPI handles automatically, suppose the maker of a 1.5-ounce candy bar selling for 75 cents replaces it by the same brand of candy bar, still selling for 75 cents, but weighing only 1.0 ounce. If the shrunken size is ignored, it looks like the price hasn't changed. The CPI, however, prices candy and most other food items on a per-ounce basis and would automatically record a 50-percent increase in the quality-adjusted price of the item, from 50 cents per ounce to 75 cents per ounce.

Another example of how the need for quality adjustment arises is a hypothetical (but plausible) situation in which the CPI has been tracking the price of a specific model of 32-inch standard-definition color television at a certain store. If the store no longer sells that model, the CPI data collector will find a replacement model to price each period thereafter. In the event that the store has decided to sell only high-definition televisions (HDTVs), one of those will necessarily be selected as the replacement. In that case, the replacement television may cost 4 times the price of the previous standard-definition model. It would be unreasonable to treat this rise in price as a sudden fourfold increase in cost, given that the HDTV model has a larger screen size, a higher resolution picture, and other enhanced features. The BLS must make *some* estimate of how much of the price difference is due to the improved quality associated with the HDTV model.

The BLS uses a number of methods for quality adjustment in the CPI, ranging from the simplest (for example, ignore the difference in quality if the new and old items are sufficiently similar), to the indirect (assume that the quality-adjusted price change is the same as the average change observed for other items in the sample), to the complex (for example, use manufacturers' production cost information to adjust automobile prices each year when new models are introduced).[28] For a small number of CPI components, the BLS employs hedonic regression models in dealing with product replacements. Each method can and does lead to quality adjustments in either direction, because the new items in the sample can be of either higher or lower quality than the products they replace, as the aforementioned candy bar and television examples demonstrate.

Perhaps because of its name, hedonic regression modeling has received the fiercest criticism from outside the academic community. In attacking hedonics, however, some commentators seem actually to be objecting to the entire concept of quality adjustment in the CPI. That line of attack may be based on a false impression that, prior to the introduction of hedonic models, the BLS essentially ignored quality improvements and new goods.[29] The commentators do not aim their criticism at the hedonic method of estimating quality differences; instead, they criticize the BLS for taking estimated quality differences into account at all. When they object to the BLS "hedonic" adjustments, they usually make no reference to how the hedonic modeling is carried out, even in general terms.

To repeat, the difference in quality between old and new items must be addressed in producing a CPI, and he-

donic modeling is just one method that the BLS uses to determine what portion of a price difference is viewed by consumers as reflecting quality differences.

The concepts behind hedonic adjustment have been frequently misconstrued, and some authors seem to focus on the term "hedonic," which is derived from the Greek word for pleasure. These authors associate the method with a sort of calculation of the pleasure arising from the use of a good. Certainly, when the hedonic method was developed in the 1930s, it would have been helpful if a more descriptive name had been chosen.[30]

In fact, hedonic regression has nothing to do with calculating or estimating the amount of pleasure a consumer receives by using an item. Actually, the term refers to the use of a statistical procedure called *multiple regression analysis*, in which the market valuation of a feature is estimated *by comparing the prices of items with and without that feature*. For example, the CPI hedonic analysis of television prices calculates, at a given point in time, the percent difference in market prices associated with an additional inch of screen size. Then, if a television is replaced by one with a larger screen, the CPI commodity analyst for televisions can adjust the observed price difference by estimating what the old television would have cost had it had the larger screen size. The process of estimating these market values is somewhat technical, and it can require a significant amount of work assembling and processing data on product prices and characteristics, but many of the dismissive reactions to the hedonic method probably are based on its name rather than on an understanding of the actual process. The ILO's international CPI manual states, "The hedonic approach to quality adjustment can provide a powerful, *objective* and scientific method of evaluating changes in quality for certain kinds of products."[31]

Moreover, quality adjustment, whether based on hedonic methods or not, adjusts prices between the old and new good *only to the degree that they differ in quality*. Contrary to what some have claimed, it does not amount to "zeroing out" a price change because quality increased. When prices are adjusted for quality, there is no reason to believe that the price change has been eliminated, and the quality-adjusted price change can be either less than or greater than the unadjusted price change, depending on whether quality increased or decreased. That statement holds true regardless of the method used to adjust for quality changes.

Critics often have dramatically misinterpreted both the extent and the impact of the CPI's expansion of hedonic analysis over the last decade. The total CPI weight for all products subject to hedonic adjustment is about 32 percent, but almost all of this total is accounted for by shelter and apparel items, for which the BLS has used hedonic models for roughly two decades. Personal computers, microwave ovens, televisions, and other commodities for which hedonic models were more recently introduced have a combined weight of only about 1 percent in the CPI.

It is also important to emphasize that the BLS makes hedonic adjustments for declines, as well as improvements, in quality. The CPI price indexes for shelter include hedonic adjustments for the gradual aging of the rental housing units in the CPI sample, and those adjustments regularly *increase* the rate of change of the indexes by at least 0.2 percentage point per year.[32] The hedonic adjustments in apparel have had both upward and downward impacts at different points in time and for different categories of clothing.[33] As discussed in an article in the *Monthly Labor Review*,[34] the BLS estimates that the hedonic quality adjustments introduced since 1998 have had an upward impact in five item categories and a downward impact in five. The overall impact of these newly introduced hedonic models has been quite modest and in an upward, not downward, direction. To be precise, the use of the models has increased the annual rate of change of the all-items CPI, but by only about 0.005 percent per year.[35] It is clear, therefore, that those who maintain that the BLS uses hedonic adjustment to keep the measured rate of inflation in an acceptably low range are wrong about the impacts, as well as the motives, of BLS actions.

One last criticism often heard is that hedonic quality adjustment is inappropriate when a consumer places no value on the enhanced features of a new product and would be equally happy with the old, disappearing good. This criticism, typically expressed in the context of personal computers,[36] might be stated as "The BLS adjusts the price of new computers because they are faster, but I don't need the extra speed. So the BLS is adjusting the price for a supposed quality improvement that is worthless to me, but that I am forced to purchase."

So long as new products are successful because they offer improvements that are valued by most consumers, it would be inappropriate for BLS simply to ignore those improvements. Some might argue, for example, that when an inexpensive black-and-white television disappears from the market, the CPI should treat the full difference between its price and the price of a color television as a price increase. This approach would be no more reasonable, however, than incorporating a large price *decrease* into the CPI when the Concorde supersonic transport

stopped flying and consumers were forced to switch to slower transatlantic flights.

The extreme case of a consumer who places no value on improvements does, however, point to a fundamental and unavoidable problem affecting the CPI of every nation. This problem results, not from hedonic modeling or any other type of quality adjustment, but from changes in the variety of products that are available to consumers. A hypothetical consumer who does not value any extra processing speed may prefer a computer with a slower and less expensive processor even if the new computer is cheaper than the old computer, because a new computer with the less expensive processor would be cheaper still. The inability to purchase that slower, cheaper computer is a loss to that consumer. The problem can be seen more clearly when a product is no longer sold and no easy replacement exists, thus reducing the variety of products that consumers may purchase. For example, when a soft drink such as Pepsi Edge or Coca-Cola C2 disappears from the market, purchasers are worse off than they would be if the product were still available, and this type of loss is not accounted for in any CPI.

By the same token, an increase in product variety is a benefit to consumers that also is not accounted for by any CPI. The Boskin commission pointed to the increased variety of restaurants as an example of a consumer benefit that does not enter into the calculation of the CPI. The introductions of new classes of products such as MP3 players or DVD players are additional examples. Consumer losses and consumer benefits do not occur only when the BLS makes quality adjustments; rather, they occur anytime the variety of available products increases or decreases. Whether the change in variety leads the CPI to overstate or understate changes in the cost of living depends on whether product variety, broadly defined, has decreased or increased.

Rental equivalence

In 1983, the BLS shifted the treatment of homeownership in the CPI-U to rental equivalence. The rental equivalence method is grounded in economic theory, receives broad support from academic economists, and is the most widely used method among the member nations of the Organization for Economic Cooperation and Development (OECD).[37] The U.N. System of National Accounts 1993 guidelines recommend using the method for measuring household consumption, and it is also used in constructing international comparisons of living standards.[38] Nevertheless, on the surface, measuring homeowner costs by rental equivalence is somewhat counterintuitive, leading some to be concerned that the CPI is mismeasuring

shelter price inflation.

The CPI for owners' equivalent rent of primary residence (OER) is based on estimating the market rents for owner-occupied housing units.[39] The cost of homeownership is treated as what economists call an opportunity cost: the amount owner-occupants would receive if they did not consume the services of their homes, but instead rented the homes out. In essence, the BLS measures the value of shelter as the amount of money people give up by using it. For renters, that means the amount they pay for renting the home. For homeowners, it means the amount they lose by not renting out their house. Although most CPI critics of rental equivalence have not set forth alternatives for how the homeownership component should be constructed, they all object to the exclusion of house prices from the CPI.

Using house prices instead of rents to measure homeowner cost is known as the *asset*, or *acquisitions*, approach.[40] Such an approach has some intuitive appeal and is similar to the treatment of any other CPI commodity. Its long-recognized flaw, however, is that owner-occupied housing combines both consumption and investment elements—and does so to a much greater degree than it does other goods and services in the CPI. As has routinely been noted by magazine writers, creators of television commercials, and investment advisers, a house is frequently a family's major investment. The CPI is designed to exclude investment items, and real estate is one of these exclusions, along with stocks, bonds, and whole-life insurance. The logic behind excluding house prices from the CPI is suggested by the fact that homeowners are often pleased when the price of their housing assets increases, as they are when stock prices rise, whereas consumers are seldom pleased when the prices of food, energy, or other consumer goods rise. Currently, the squeeze many homeowners feel as home values decline while the prices of food and gasoline rise is evidence that simply inserting home prices in the CPI-U—which would lower the estimated rate of inflation—would be inappropriate.

Nearly a half-century ago, the Price Statistics Review Committee (commonly referred to as the Stigler Committee, in honor of its chair, Nobel Prize-winning economist George Stigler) of the National Bureau of Economic Research concluded, "If a satisfactory rent index for units comparable to those that are owner-occupied can be developed, this committee recommends its substitution in the CPI for the asset approach for prices of new houses and related expenses."[41]

Since then, rental equivalence has continued to be supported by each of the prominent panels and agencies that

have reviewed the CPI since the Stigler Committee. In 1996, the General Accounting Office (now the Government Accountability Office) wrote,

> We asked 10 experts their views on whether the rental equivalence method made the CPI more [suitable] or less suitable as a cost-of-living index. All 10 were expert in measuring housing costs and were very familiar with the CPI housing component. All of the housing measurement experts agreed that the adoption of the rental equivalence method made the CPI more suitable for use as a measure of the cost of living.[42]

The 1996 "Boskin Commission" supported the rental equivalence approach to homeownership, even arguing that the CPI treatment of owner-occupied housing should be extended to automobiles and all other durable goods.[43] More recently, the 2002 report of the National Research Council panel states, "for long-lived items like automobiles or houses...one must use not the purchase price but the consumption price" and "as is the current practice with housing, we believe that using rental rates is probably the best option."[44]

It is often incorrectly assumed that the introduction of OER lowered the growth rate of the shelter index in the CPI-U. Chart 1 compares the CPI-U with the CPI-W, which continued to employ the old homeownership approach until January 1985. Primarily because interest rates moved sharply downward during 1983 and 1984, the increase in the cost of homeownership as measured by rental equivalence in the CPI-U was *greater* than the increase as measured by the old approach used in the CPI-W.

Although no one can accurately reconstruct an index under the old approach, it is frequently asserted that the CPI series for OER understates the long-run growth of homeownership costs.[45] Evidence to the contrary is found in the National Association of Realtors (NAR) series on the monthly principal and interest payment required to purchase a median-priced existing home in the United States. That series is used in the construction of the NAR's well-known *housing affordability index*. Like the pre-1983 BLS methodology, it goes beyond a simple house price measure by reflecting the powerful effect of interest rate movements.[46] Between the years 1983 and 2007, the NAR monthly payment series rose by 79 percent, much less than the CPI OER series increase of 140 percent. Of course, any series reflecting home prices will be more volatile than OER and likely will move differently from OER over any given period. In the long run, however, there is no evidence that OER is downwardly biased relative to some reasonable alternatives for measuring the cost of shelter for homeowners.[47]

As mentioned in a later section of this article, some of the criticisms of the CPI may arise from a distinction between the express goals of that index and the uses that some critics wish to make of it. During periods such as the recent real-estate boom, commentators observed the rapid runup in housing prices relative to the prices of other investments, and some may have been frustrated that this asset's inflation did not immediately or directly affect the CPI, which is the most closely followed overall measure of inflation. The fact that the rise and fall of house prices will affect the CPI only indirectly, through rents, is not an indication of a flaw in BLS methodology, however; rather, it flows from the CPI's objective of measuring changes in the cost of living.

Core inflation

The widely repeated idea that Social Security and other Federal Government benefits are updated by an index that does not include food and energy is simply not true. This misconception arises because of the heavy emphasis that policymakers, the media, and other economic observers place on the CPI-U for all items less food and energy, which has been published by the BLS since 1977. This index is widely referred to as the "core" CPI-U. For convenience, we will sometimes use that term here, but "core" is almost never employed by the BLS in its press releases and published tables. Although, as of March 2008, their long-run levels were almost identical, the core CPI-U rose by less than the all-items index in 7 of the 9 years beginning in 1999.[48]

The BLS publishes thousands of indexes each month, including the headline all-items index and the index for all items less food and energy. As stated earlier, it is the all-items index that is used in all significant Federal outlay and revenue programs, including Social Security cost-of-living adjustments and Federal income tax provisions. The Federal Reserve Board makes use of core inflation to predict future price changes under the belief that food and energy prices are volatile and are subject to price shocks that cannot be damped through monetary policy. Although some people question the value of the core index in times of rapidly increasing food and energy prices, it is nonetheless appropriate for the BLS to publish the data and let members of the public and agencies, including the Federal Reserve, decide which indexes are most useful for their purposes.[49]

Occasionally, someone will erroneously suggest that the core is meant to replace the all-items CPI-U or that the focus of reported inflation shifts back and forth between the two

Chart 1. CPI-U shelter index and CPI-W shelter index, January 1980–December 1985

Index
(January 1980 =100)

Index
(January 1980 =100)
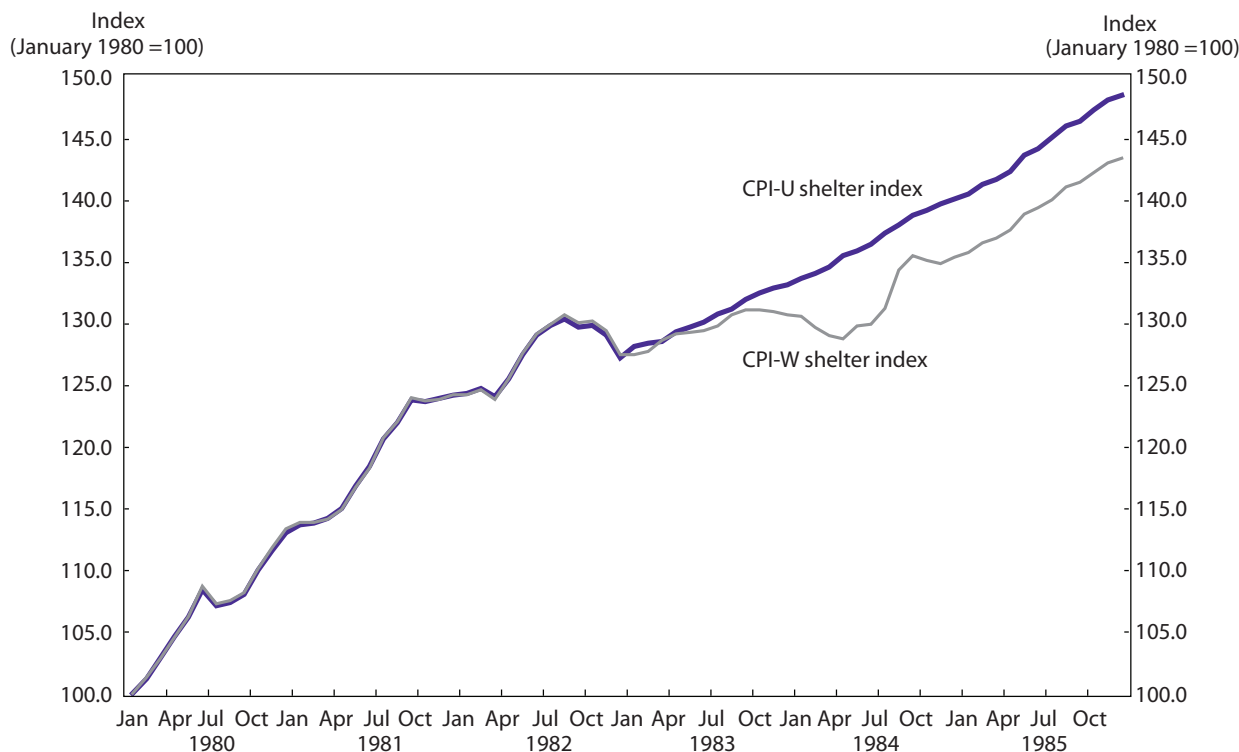
NOTE: The OER measure of owner-occupied housing was introduced into the CPI-U in January 1983 and into the CPI-W in January 1985.

series, depending on which gives a more favorable reading. It is easy, however, to verify from the BLS Web site that the formats for CPI releases and tables vary only slightly from month to month. Page 1 of the CPI news release for March 2008 is typical.[50] After paragraphs on the monthly and annual movements of the all-items CPI-U, CPI-W, and C-CPI-U, respectively, a paragraph discusses the movements of three major aggregates—energy, food, and all items less food and energy—in the CPI-U. Energy, the cost of which increased 1.9 percent in March 2008, is mentioned first, followed by food and all items less food and energy, both of whose costs increased 0.2 percent. Table A on page 1 shows monthly, quarterly, and annual movements on the basis of the same three-way breakdown, as well as for eight major groups; that table's format is identical each month. Obviously, then, the BLS does not "spotlight" one statistic or another each month in an attempt to suppress high or volatile inflation rates. Moreover, the relevant formats of CPI tables are the same as those used during periods such as 1991–98, when the all-items CPI usually rose less than the index for all items less food and energy.

Although the CPI-U for all items less food and energy has been the subject of numerous books and of many arti-cles in academic journals, one crucial point to recognize is that the BLS makes no claims about the predictive or ana-lytical value of that index.[51] It is just one of many special indexes published by the BLS each month, such as indexes for all items less medical care, commodities less food, and services less rent of shelter. Each of these indexes likely serves the needs of some CPI users, but the BLS has no position on which of its published indexes, if any, serves as the best measure of underlying inflation or the best pre-dictor of future movements in the CPI-U.

Finally, it must again be emphasized strongly that none of the prominent legislated uses of the CPI excludes food or energy: each year, Social Security and Federal retire-ment benefits are updated for inflation by the all-items CPI-W. Individual income tax parameters and TIPS returns are indexed by the all-items CPI-U.

The CPI and perceived inflation

The previous sections have attempted to clear up some mis-conceptions about the methods employed in constructing the CPI. However, criticism often appears to arise primarily from a writer's perception that movements in the CPI are

inconsistent with his or her own observation of inflation. This section examines several reasons for these apparent inconsistencies between the index and people's perceptions.

Some commentators have complained that measured inflation is lower in the United States than in other countries, offering this difference as evidence that the growth rate of the U.S. CPI is understated. On its face, the argument that one can gauge the accuracy of U.S. inflation measures by comparing the change in the U.S. CPI with inflation rates in other countries seems wrong because each nation's inflation experience is the result of its unique economic circumstances. Still, for argument's sake, the very assertion that U.S. rates are unreasonably low compared with those of other developed countries is wrong. In fact, as shown in the following tabulation, between 1997 and 2007 the U.S. CPI-U rose faster than the CPIs of 16 of the other 29 OECD nations and faster than the CPIs of all of the other G-7 nations:[52]

Country	Inflation rate
Total	2.9
G–7 nations	1.9
Organization for Economic Cooperation and Development	3.7
Turkey	33.5
Hungary	7.5
Mexico	7.3
Slovak Republic	6.5
Poland	4.5
Iceland	4.2
Ireland	3.6
Greece	3.4
Czech Republic	3.3
Korea	3.2
Spain	3.0
Portugal	2.9
Australia	2.8
United States	2.6
Italy	2.2
New Zealand	2.2
Netherlands	2.2
Luxembourg	2.2
Canada	2.1
Denmark	2.1
Norway	1.9
Belgium	1.9
Austria	1.8
United Kingdom	1.6
France	1.6
Finland	1.5
Germany	1.4
Sweden	1.2
Switzerland	.8
Japan	−.2

Similarly, between the first quarters of 2007 and 2008 the U.S. CPI-U rose by more than the CPIs of 20 of the other 29 OECD nations and by more than all of the other G-7 nations.[53]

Earlier, it was mentioned that the CPI is just one of many indexes that can be used to measure different aspects of inflation. As a measure of the change in consumer prices, the CPI by design excludes many products from its scope, such as industrial goods and investment assets. Also, the CPI's fundamental purpose is to measure current price change and not to measure underlying or incipient inflationary pressure. Consequently, the CPI does not reflect all inflation signals, such as may be found in futures market prices or public announcements of planned price increases. Finally, the CPI is based on average consumer expenditures, and no single index can meet every need or provide a totally accurate measure of the inflation faced by every individual. Often, criticism of the CPI implicitly relates to these aspects of the index's design, rather than to the ways in which the BLS collects or processes price data.

Many consumers feel that their personal inflation experiences are not reflected in the movements of the CPI-U. These experiences can actually be borne out because some consumers spend more than others on items with rapidly increasing prices. The CPI-U is constructed from expenditures averaged over many consumers; as a consequence, some consumers will face a lower rate of inflation than that indicated by the CPI-U, and others will face a higher rate of inflation. For example, earlier it was noted that the wage earner and clerical worker families represented in the CPI-W allocate a higher-than-average share of their expenditures to gasoline. Partly for this reason, the CPI-W rose 4.3 percent over the 12 months ending March 2008, compared with 4.0 percent for the CPI-U. Further, BLS data from the CE show that low-income households spend a greater-than-average percentage of their expenditures on food at home and on gasoline and motor oil. By income quintile, from lowest to highest, 15.3 percent, 14.1 percent, 13.0 percent, 12.1 percent, and 9.2 percent of expenditures are devoted to food at home and to gasoline and motor oil.[54] These statistics provide some evidence that the typical household in one of the lower income quintiles may be more adversely affected by current inflation than a typical household in one of the upper quintiles.[55]

Another reason for the potential difference between the CPI-U and a consumer's experience of inflation is that the prices of many frequently purchased items, especially necessities such as food and gasoline, recently have been rising more rapidly than the CPI as a whole. Because the

CPI is an average of the inflation rates of many different items, if some prices are growing more rapidly than the CPI, then other prices must be growing more slowly. In many cases, the most slowly rising prices are in the categories of consumer durable goods and apparel. In fact, the CPI for durables, which include such items as televisions and computers, fell slightly over the year ending March 2008, as did the index for apparel. Of course, by their nature, those items are purchased less frequently than food and energy items. For a family that had no immediate plans to purchase a new television or computer in March 2008, the price declines of those products over the previous 12 months probably would be less important than the 26.0-percent increase in the price of gasoline, the 48.4-percent rise in the price of fuel oil, the 14.7-percent price increase for bread, and the 13.3-percent price rise for milk. Similarly, although most families purchase apparel during any given year, in many weeks their purchases will be concentrated in food and fuel, and in those weeks they probably experienced price increases higher than the increases reported for the all-items CPI. Nevertheless, the BLS cannot exclude items from the CPI simply because they are purchased infrequently: *all* goods and services contribute to the CPI in proportion to consumer spending on them, as described earlier.

Another possibility explaining individual differences in the experience of inflation is "loss aversion," described succinctly by David Leonhardt in a recent *New York Times* editorial:

> Price increases are simply more noticeable—more salient, as psychologists would say—than price decreases. Part of this comes from the notion of loss aversion: human beings dislike a loss more than they like a gain of equivalent size. If you have to sell your house for less than you bought it for, you're really unhappy. You hate that ground chuck now costs $2.83 a pound, but you didn't notice that oranges are 31 percent cheaper than they were a year ago.[56]

Leonhardt's account seems possible, although a search of the literature failed to turn up any research specifically addressing the degree to which perceptions about the CPI are affected by loss aversion.

Does the CPI understate inflation?

Up to now, this article has addressed each of the major recent criticisms of the CPI and has argued that those criticisms are based on misunderstandings of the methods

used to construct the index. Each of the improvements made to the CPI over the years is based on sound economic theory and years of research by academicians and BLS economists. The methods continue to be reviewed by outside commissions and advisory panels, and they are widely used by statistical agencies of other nations.

This section examines the large quantitative impacts that some writers have attributed to the changes in CPI methodology that have been adopted over the years. One widely cited alternative index is based on an estimate that changes to the CPI since 1983 have lowered its growth rate by at least 7 percentage points per year. The use of the geometric mean alone is stated to have lowered the CPI growth rate by 3 percentage points, and other BLS changes, such as the use of hedonic models and OER, supposedly have lowered the growth rate by an additional 4 percentage points.[57]

Each of these estimates of the impact of BLS changes is inconsistent with the empirical evidence. As noted earlier, the BLS has computed indexes showing that the use of the geometric mean formula has reduced the growth rate of the geometric mean of the CPI by only -0.28 percentage point per year, not 3 percentage points. Also discussed earlier, BLS analyses have shown that if the implementation of hedonic adjustment models since 1999 has had any net downward effect, it is very small. Hedonic adjustment models implemented subsequent to 1983, but prior to 1999, have almost certainly had an upward effect. Among the methodological changes examined in this article, that leaves only the shift to rental equivalence, and it is entirely implausible that its impact could be as large as 4 percentage points per year. Earlier, it was shown that from 1983 to 2007 the CPI for OER rose *faster* than an alternative index that, like the pre–1983 BLS homeownership index, is based on both house prices and interest rates. Another piece of evidence comes from an analysis published in the *Monthly Labor Review* in 1999 in which BLS economists Kenneth J. Stewart and Stephen Reed compared the historical published CPI-U with an index created in accordance with current BLS methodologies.[58] For the years 1978–82, a period that witnessed very rapid increases in both house prices and interest rates, Stewart and Reed estimated that the use of rental equivalence would have had an average annual impact on the CPI-U of only –0.86 percentage point. Moreover, with house prices now declining in many parts of the country, one would expect that if the BLS were using the pre-1983 homeownership method, it would yield a *lower*, not higher, current measure of shelter inflation.

Another way of evaluating the purported 7-percent difference is by comparing it with other information. If the

CPI were understated by 7 percentage points annually, then, from April 1998 to April 2008, prices would have risen by 155 percent, not 32 percent as reported by the CPI-U. Table 1 shows that a 7-percent difference implies unrealistic changes in price and income. First, the table presents examples of average prices published by the BLS from each of the six CPI grocery store food groups, along with four energy series. For example, the average price of a gallon of whole milk was $2.67 in April 1998 and $3.80 in April 2008. If the price had increased by 155 percent over that period, it would now be $6.81 per gallon. Similarly, if the average price of 2 liters of nondiet cola had increased by 155 percent over those 10 years, it would now be $2.72, more than twice as high as the actual April 2008 average price of $1.33. Of the 10 average prices listed in table 1, only two—gasoline and fuel oil—increased by such a large percentage.

Unfortunately, similar price comparisons cannot be made in other sectors, because the BLS publishes average price levels only for food and energy. Nevertheless, while no one would claim that *all* consumer goods and services increased by 155 percent between 1998 and 2008, the validity of the purported 7-percent difference is called into question by the fact that most prices actually rose by much less than 155 percent, even within the food and energy components, in regard to which inflation recently has been a major public concern.

Table 1 also examines the growth rate of two measures of homeowner costs: the NAR measures of median single-family house prices and the monthly principal and interest payment on the median house. The table shows that both measures rose by much less than 155 percent. That is, although some have cited the fact that the CPI does not reflect rapidly rising house prices as a major flaw in CPI methodology, the alternative index *for goods and services as a whole* rises much faster than the NAR measures of both house prices and mortgage cost.

Finally, table 1 presents two measures of real, inflation-adjusted incomes in the United States: the BLS measure of real average weekly earnings of production and nonsupervisory workers, and the BEA measure of real per-capita personal disposable income. The last column shows the hypothetical effect of deflating that income by 155 percent.[59] The implied result is an extremely severe decline in real income between 1998 and 2008. For example, one would conclude that real per-capita personal disposable income declined by more than 40 percent over the 10 years examined. This is an entirely unrealistic conclusion; by comparison, the BEA reports that real per-capita personal disposable income declined by just 26 percent during the Great Depression.

IT IS HOPED THAT THIS ARTICLE HAS PUT TO REST some of the misconceptions and myths about the CPI. It is a myth that the BLS reduced the growth rate of the CPI by assuming that hamburger is substituted for steak. It is a myth that the use of hedonic quality adjustment has substantially reduced the growth rate of the CPI. It is a myth that the 1983 adoption of owner's equivalent rent systematically reduced the growth rate of the CPI shelter index. Finally, it is a myth that Social Security payments are updated by a CPI that does not include food or energy.

A number of other points also can be made. First, the sizes and effects of the changes implemented by the BLS have been overestimated by critics. The introduction of the geometric mean formula to account for product substitution has decreased the rate of change of the CPI by less than 0.3 percentage point annually, not by 3 percentage points annually as some have claimed. In the case of owner's equivalent rent, it is not at all clear that the long-run impact has even been in a downward direction. Hedonic quality adjustments introduced in the last 10 years have had a very small impact on the all-items CPI.

Second, the changes implemented by the BLS that some critics construe to be a response to short-term political pressure were, in fact, the result of analysis and recommendations made over a period of decades, and those changes are consistent with international standards for statistics. The problem of how to adjust for quality differences when new goods appear was recognized by the BLS Commissioner when consumer price indexes were first published.[60] The solution known as hedonic estimation was developed no later than 1939, and its use in the CPI was recommended in 1961. Five of the G-7 nations use hedonic estimation, as do at least 11 of the OECD nations.[61] The BLS approach is consistent with guidelines developed by the OECD.[62] The geometric mean price index was developed in 1865, was recommended by the International Labor Office, and was being evaluated for use in the U.S. CPI well before the Boskin Commission was formed.[63] It is widely used by Eurostat and OECD countries. The use of owner's equivalent rent was recommended in 1961 by the Stigler Committee and later by the General Accounting Office; according to the OECD, owner's equivalent rent is the most common method that its member countries use to measure the cost of shelter for homeowners.

Third, the BLS routinely publishes details about its methods and about changes to those methods. In the *BLS Handbook of Methods*, the chapter on the CPI contains information on the index's methods of construction, as well as on its history, uses, limitations, precision, and other top-

Table 1.   Comparisons of prices and incomes, April 1998 and April 2008

Price and income	Reported values		April 2008 updates of 1998 values, assuming a 155-percent price increase
	April 1998	April 2008	
BLS average food prices:			
Bread, white, pan,[1] per lb.	$0.863	$1.373	$2.20
Milk, fresh, whole, fortified, per gal.	2.668	3.799	6.81
Tomatoes, field grown, per lb.	1.398	1.773	3.57
Peanut butter, creamy, all sizes, per lb.	1.808	1.980	4.62
Cola, nondiet, per 2 liters	1.065	1.329	2.72
All uncooked beefsteaks, per lb.	3.665	5.283	9.36
BLS average energy prices:			
Gasoline, all types, per gal.	1.106	3.491	2.82
Fuel oil #2, per gal.	.915	3.875	2.34
Utility (piped) gas, 100 therms	65.874	142.727	168.25
Electricity, per 500 kwh	45.739	62.149	116.82
National Association of Realtors housing costs:[2]			
Median price of single-family house	132,300	200,700	337,907
Principal and interest payment on median-priced house	719	966	1,836
Real incomes:[2]			
Bureau of Economic Analysis disposable personal income per capita, quarter 1, 1998, dollars (1998 and 2008 figures are for quarter 1)	22,753	27,530	13,532
BLS average weekly earnings, April 1998 dollars	441	454	236

[1] Bread baked in a pan for a specific shape of loaf (for example, sandwich bread).
[2] All 2008 values are preliminary and subject to revision.

SOURCES: Bureau of Labor Statistics, National Association of Realtors, and Bureau of Economic Analysis publications and authors' calculations.

ics. In addition, the CPI Web site includes a wide variety of specialized information, such as articles on hedonic regression models in apparel, guidelines for new-vehicle quality adjustment, fact sheets on the methods used to generate selected CPI components, details about the use of intervention analysis in seasonal adjustment, and a comparison of the CPI and the PCE price index. The BLS also maintains information offices at both its national and regional offices in order to respond to questions from the public.

Finally, the CPI is not, and can never be, a perfect index. Moreover, all of the topics raised in the recent commen-tary on the CPI—including the methods for dealing with consumer substitution, quality change, and owner-occu-pied housing—are critically important to the accuracy of the index. The very existence of the CPI methodological changes discussed here attests to the fact that the BLS must always be working to enhance the index. The BLS benefits from the work of academics and others who identify ways in which the CPI can be improved. The BLS also benefits when the public understands how the CPI is constructed and what the index's strengths and limita-tions are. It is hoped that this article will help increase that public understanding.   □

Notes

[1] Marshall Reinsdorf and Jack Triplett, "A Review of Reviews—Ninety Years of Professional Thinking About the Consumer Price Index," in Erwin Diewert, John Greenlees, and Charles Hulten, eds., *Price Index Concepts and Measurement* (Chicago, University of Chicago Press, forthcoming).

[2] See, for example, Margaret H. Hogg, "Revising the Wage Earn-ers' Cost-of-Living Index," *Journal of the American Statistical Associa-tion*, March 1934, pp. 120–24.

[3] The Panel on Conceptual, Measurement, and Other Statistical Issues in Developing Cost-of-Living Indexes. Part of the Committee on National Statistics of the National Research Council, the panel pro-duced the volume *At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes*, edited by Charles L. Schultze and Christo-pher Mackie (Washington, DC, National Academy Press, 2002).

[4] The publication is on the Internet at **www.bls.gov/cpi/cpifaq.htm** (visited Aug. 28, 2008).

[5] See *BLS Handbook of Methods* (Bureau of Labor Statistics, June 2007), chapter 17, pp. 2–3, on the Internet at **www.bls.gov/opub/hom/pdf/homch17.pdf** (visited Aug. 28, 2008).

[6] The description in this paragraph necessarily ignores certain exceptions and special cases. The CPI sample for airline fares, for example, is selected with data from the Department of Transportation, not the Telephone Point-of-Purchase Survey.

[7] A description of the TIPS program can be found at **www.treasurydirect.gov/instit/annceresult/tipscpi/tipscpi.htm** (visited Aug. 28, 2008).

[8] BLS research on this topic is reported by, for example, Robert Gillingham, "Measuring the Cost of Shelter for Homeowners: Theoretical and Empirical Considerations," *Review of Economics and Statistics*, May 1983, pp. 254–65, and Robert Gillingham and Walter Lane, "Changing the treatment of shelter costs for homeowners in the CPI," *Monthly Labor Review*, June 1982, pp. 9–14, on the Internet at **www.bls.gov/opub/mlr/1982/06/contents.htm** (visited Aug. 28, 2008).

[9] *Data Quality Assessment Framework* (International Monetary Fund, August 2006), on the Internet at **dsbb.imf.org/vgn/images/pdfs/dqrs_cpi.pdf** (visited Aug. 29, 2008); see especially p. 20.

[10] *Compendium of HICP reference documents* (Luxembourg, Eurostat, February 2001), p. 59, on the Internet at **epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-AO-01-005/EN/KS-AO-01-005-EN.PDF** (visited Aug. 28, 2008). Many European nations produce both a CPI and an HICP, with some differences in scope and methodology. Notably, HICP coverage excludes owner-occupied housing.

[11] The 30 countries are the 27 members of the European Union, plus Iceland, Norway, and Turkey. The national HICP practices are available on the Eurostat Web site, on the Internet at **epp.eurostat.ec.europa.eu/portal/page?_pageid=2714,1,2714_61582099&_dad=portal&_schema=PORTAL#SDDS** (visited Aug. 28, 2008). A 2002 study of 27 countries from the Organization for Economic Cooperation and Development (OECD) showed that, at that time, 12 (including the United States) used the geometric mean as the exclusive or primary formula in their national CPIs. (See *Comparative Methodological Analysis: Consumer and Producer Price Indices*, Volume 2002, Supplement 2 (OECD, 2002), pp. 42–43, on the Internet at **www.oecd.org/dataoecd/60/61/1947731.pdf** (visited Aug. 28, 2008).)

[12] The focus here is on the BLS's primary justification that the geometric mean takes into account consumer substitution behavior. There are, however, other statistical justifications for the formula that do not involve substitution. (See, for example, Brent R. Moulton, "Basic components of the CPI: estimation of price changes," *Monthly Labor Review*, December 1993, pp. 13–24; on the Internet at **www.bls.gov/opub/mlr/1993/12/contents.htm** (visited Aug. 28, 2008).)

[13] As discussed in the previous section, it is the C-CPI-U that reflects observed substitution across CPI item categories, but critics have focused their attention on the CPI-U and CPI-W.

[14] For more examples of substitution, see "Planned Change In The Consumer Price Index Formula April 16, 1998" (Bureau of Labor Statistics, Oct. 16, 2001), on the Internet at **www.bls.gov/cpi/cpigm02.htm** (visited Aug. 28, 2008).

[15] Due to data constraints, the formula used in the CPI prior to 1999, and still used within some item categories, is a modified version of the textbook Laspeyres formula.

[16] Two examples are Robert Pollak, *The Theory of the Cost of Living Index* (New York, Oxford University Press, 1989), p. 13, and P. R. G. Layard and A. A. Walters, *Micro-Economic Theory* (New York, McGraw-Hill, 1978), p. 157. For a more recent statement of the result in an introductory textbook, see Paul A. Samuelson and William D. Nordhaus,

Economics, 18th ed. (New York, McGraw-Hill/Irwin, 2005), p. 441.

[17] The geometric mean price index was first described in 1865 by William Stanley Jevons in "On the Variation of Prices and the Value of the Currency since 1782," *Journal of the Statistical Society of London*, June, pp. 294–320, appendix pp. 1–4. Studies of the bias that is introduced into a price index by not considering substitution include Marilyn E. Manser and Richard J. Macdonald, "An Analysis of Substitution Bias in Measuring Inflation, 1959–85," *Econometrica*, July 1988, pp. 909–30; Steven D. Braithwait, "The Substitution Bias of the Laspeyres Price Index: An Analysis Using Estimated Cost-of-Living Indexes," *American Economic Review*, vol. 70, no. 1, 1980, pp. 64–77; and Nicholas N. Noe and George M. von Furstenberg, "The Upward Bias in the Consumer Price Index Due to Substitution," *Journal of Political Economy*, vol. 80, no. 4, 1972, pp. 1280–86.

[18] Expressed as an index set originally at 100, the Laspeyres index after the price increase would equal 100 × (10/4), or 250.

[19] The geometric mean index in this example would be 100 × (8/4), or 200. Implicitly, the geometric mean formula assumes no change in the shares of spending on the different items. Thus, both before and after the price change, the consumer spends half of her funds on chocolate bars and half on peanut bars.

[20] Kenneth V. Dalton, John S. Greenlees, and Kenneth J. Stewart, "Incorporating a Geometric Mean Formula into the CPI," *Monthly Labor Review*, October 1998, pp. 3–7; on the Internet at **www.bls.gov/opub/mlr/1998/10/contents.htm** (visited Aug. 28, 2008). That article also discusses the CPI components for which the BLS did *not* adopt the geometric mean formula. The judgment was made that, within those components, such as hospital services and utility natural gas, consumers were less likely to shift their purchases in response to price changes.

[21] See subsequent section "Does the CPI understate inflation."

[22] This component of the CPI actually includes many other products, such as sherbet, sorbet, and popsicles. The example also ignores many computational details, such as the sample weighting of individual prices.

[23] Assuming that the base value of the index is 100, the Laspeyres index for the second period will be one-half the sum (the arithmetic average) of (100 + 8.6) and (100 – 4.2), or 102.2. The geometric mean index would be the square root of the product of (100 + 8.6) and (100 – 4.2), or 102.0.

[24] David S. Johnson, Stephen B. Reed, and Kenneth J. Stewart, "Price measurement in the United States: a decade after the Boskin Report," *Monthly Labor Review*, May 2006, pp. 10–19; on the Internet at **www.bls.gov/opub/mlr/2006/05/contents.htm** (visited Aug. 28, 2008). Unpublished results for the longer period from December 1998 to December 2007 show an average difference of 0.27 percentage point per year.

[25] *Ibid.*, p. 3.

[26] Katharine G. Abraham, John S. Greenlees, and Brent R. Moulton, "Working to Improve the Consumer Price Index," *Journal of Economic Perspectives*, winter 1998, pp. 27–36.

[27] *Consumer Price Index Manual: Theory and Practice* (Geneva, International Labor Office, 2004), paragraph 1.255, on the Internet at **www.ilo.org/public/english/bureau/stat/guides/cpi/index.htm** (visited Aug. 28, 2008).

[28] For a detailed description of BLS quality adjustment procedures, see Brent Moulton and Karin E. Moses, "Addressing the Quality Change Issue in the Consumer Price Index," *Brookings Papers on Economic Activity,* vol. 28, no. 1, 1997, pp. 305–49; or John S. Greenlees, "Consumer Price Indexes: Methods for Quality and Variety Change," *Statistical Journal of the United Nations Economic Commission for Europe*, vol. 17, no. 1, 2000, pp. 59–74.

[29] This particular misconception has been frequent in the history of commentary on the CPI, as discussed, for example, by Jack E. Triplett,

"Quality Bias in Price Indexes and New Methods of Quality Measurement," in Zvi Griliches, ed., *Price Indexes and Quality Change: Studies in New Methods of Measurement* (Cambridge, MA, Harvard University Press, 1971), pp. 180–214.

[30] The term apparently was introduced by Andrew Court, "Hedonic Price Indexes with Automotive Examples," in *The Dynamics of Automobile Demand* (New York, The General Motors Corporation, 1939), pp. 99–117.

[31] International Labor Office, *Consumer Price Index Manual*, paragraph 1.253, emphasis added.

[32] Louise L. Campbell, *Updating the Housing Age-Bias Regression Model in the Consumer Price Index*, CPI Detailed Report (Bureau of Labor Statistics, November 2006), on the Internet at **www.bls.gov/cpi/cpiagebias.pdf** (visited Aug. 28, 2008); and Robert Poole, Frank Ptacek, and Randal Verbrugge, *Treatment of Owner-Occupied Housing in the CPI* (Bureau of Labor Statistics, December 2005), on the Internet at **www.bls.gov/bls/fesacp1120905.pdf** (visited Aug. 28, 2008).

[33] Craig Brown and Anya Stockburger, "Item replacement and quality change in apparel price indexes," *Monthly Labor Review,* December 2006, pp. 35–45; on the Internet at **www.bls.gov/opub/mlr/2006/12/contents.htm** (visited Aug. 28, 2008).

[34] Johnson, Reed, and Stewart, "Price measurement in the United States."

[35] *Ibid.*, p. 15. This estimate excludes personal computers; in 2003, the CPI program implemented a new approach that derives the values of computer attributes from information on the Internet, rather than from estimated hedonic regressions. (See "How BLS Measures Price Change for Personal Computers and Peripheral Equipment in the Consumer Price Index," on the Internet at **www.bls.gov/cpi/cpifaccomp.htm** (visited Aug. 28, 2008).)

[36] As noted earlier, the BLS stopped using hedonic quality adjustments for new computers in the CPI in 2003.

[37] The OECD, which is composed mainly of industrialized, developed countries, recently reported that 13 of its 30 members use rental equivalence in their national CPIs. The next-most-frequent alternative is simply leaving owner-occupied housing out of the index (8 countries). (See Ane-Kathrine Christensen, Julien Dupont, and Paul Schreyer, "International Comparability of the Consumer Price Index: Owner-occupied housing," paper prepared for the OECD seminar "Inflation measures: too high—too low—internationally comparable?" Paris, June 21–22, 2005, p. 9, on the Internet at **www.oecd.org/dataoecd/14/18/34987270.pdf** (visited Aug. 28, 2008).)

[38] International Labor Office, *Consumer Price Index Manual*, paragraph 10.14.

[39] An alternative to rental equivalence is the user cost of capital, defined by the OECD as "the unit cost for the use of a capital asset for one period—that is, the price for employing or obtaining one unit of capital services. The user cost of capital is also referred to as the 'rental price' of a capital good, or the 'capital service price.'" (See "Annex 1: Glossary of Technical Terms Used in the Manual," *Measuring Capital: OECD Manual* (Paris, OECD, 2001), p. 96, on the Internet at **www.oecd.org/dataoecd/61/57/1876369.pdf** (visited Aug. 28, 2008).)

[40] This approach also would include the costs of additions and alterations, as well as other costs.

[41] *The Price Statistics of the Federal Government* (Cambridge, MA, National Bureau of Economic Research, 1961), p. 48.

[42] *Consumer Price Index: Cost-of-Living Concepts and the Housing and Medical Care Components*, GAO report GGD–96–166, August 1996, p. 17, on the Internet at **www.gao.gov/archive/1996/gg96166.pdf** (visited Aug. 28, 2008).

[43] *Final Report of the Advisory Commission to Study the Consumer Price Index*, Print 104–72, 104 Cong., 2 sess. (U.S. Senate, Committee on Finance, 1996), p. 53.

[44] Panel on Conceptual, Measurement, and Other Statistical Issues in Developing Cost-of-Living Indexes, *At What Price?* p. 72.

[45] The previous method had several widely recognized problems. (See, for example, "Measurement of Homeownership Costs in the Consumer Price Index Should Be Changed," PAD–81–12 (General Accounting Office, 1981), on the Internet at **archive.gao.gov/f0202/114922.pdf** (visited Aug. 28, 2008).)

[46] For recent values of the affordability index, see **rodomino.realtor.org/Research.nsf/Pages/HousingInx** (visited Aug. 28, 2008).

[47] For recent comparisons of rental equivalence and other alternative homeowner cost indexes, see Randal Verbrugge, "The Puzzling Divergence of U.S. Rents and User Costs," manuscript; and Thesia I. Garner and Randal Verbrugge, "The Puzzling Divergence of U.S. Rents and User Costs, 1980–2004: Summary and Extensions," BLS Working Paper 409, on the Internet at **www.bls.gov/ore/abstract/ec/ec070080.htm** (visited Aug. 28, 2008).

[48] The comparison of yearly movements uses December-to-December changes. The levels for the all-items and core CPI-Us in March 2008 were 213.528 and 214.866, respectively, on a 1982–84 = 100 basis.

[49] The Federal Reserve Board also makes use of food and energy prices in its deliberations. See, for example, Ben S. Bernanke, "Inflation Expectations and Inflation Forecasting" (Board of Governors of the Federal Reserve System, July 10, 2007), on the Internet at **www.federalreserve.gov/newsevents/speech/Bernanke20070710a.htm** (visited Aug. 28, 2008).

[50] Visit **www.bls.gov/news.release/archives/cpi_04162008.pdf** (visited Aug. 28, 2008).

[51] Examples of such research include Otto Eckstein, *Core Inflation* (Englewood Cliffs, NJ, Prentice-Hall, 1981); Mick Silver, "Core Inflation: Measurement and Statistical Issues in Choosing among Alternative Measures," *IMF Staff Papers*, vol. 54, June 2007, pp. 163-90; and Theodore M. Crone, N. Neil K. Khettry, Loretta J. Mester, and Jason A. Novak, "Core Measures of Inflation as Predictors of Total Inflation," Federal Reserve Bank of Philadelphia Working Paper 08–9, May 2008.

[52] The list of nations whose CPIs rose more slowly than the U.S. CPI includes Canada, America's largest trading partner, whose average annual inflation rate over the 1997–2007 period was 2.1 percent, compared with 2.6 percent for the United States.

[53] Historical CPI data are available on the OECD Web site, on the Internet at **stats.oecd.org/wbos/Index.aspx?querytype=view&queryname=221** (visited Aug. 28, 2008).

[54] Derived from Consumer Expenditure Survey, Table 1, "Quintiles of income before taxes: Average annual expenditures and characteristics, 2006," on the Internet at **www.bls.gov/cex/2006/standard/quintile.pdf** (visited Aug. 28, 2008).

[55] This evidence cannot be taken as conclusive, however. For example, high- and low-income households may shop at outlets with different patterns of price changes. Also, the shares of spending on other products with high recent inflation, such as airline fares and college tuition, may be positively correlated with income.

[56] David Leonhardt, "Seeing Inflation Only in the Prices That Go Up," *The New York Times*, May 7, 2008; on the Internet at **www.nytimes.com/2008/05/07/business/07leonhardt.html** (visited Aug. 28, 2008).

[57] Visit the Web site **www.shadowstats.com/alternate_data** (visited Aug. 28, 2008).

[58] Kenneth J. Stewart and Stephen Reed, "CPI research series using current methods, 1978–98," *Monthly Labor Review*, June 1999, pp. 29–38; on the Internet at **www.bls.gov/opub/mlr/1999/06/contents. htm (**visited Aug. 28, 2008). The BLS periodically updates that research index, which also is available on the Internet, at **www.bls.gov/cpi/ cpirsdc.htm** (visited Aug. 28, 2008).

[59] The BEA deflates per-capita disposable personal income by its PCE price index, whereas the BLS deflates average weekly earnings by the CPI-W. However, the differences in measured price change among the CPI-U, CPI-W, and PCE index are very small in comparison to a price movement of 155 percent.

[60] Royal Meeker, "The Possibility of Compiling an Index of the Cost of Living," *American Economic Review*, March 1919, pp. 108–17.

[61] Information on the use of hedonics was obtained primarily from the International Monetary Fund's dissemination standards bulletin board, on the Internet at **dsbb.imf.org/Applications/web/sddshome** (visited Aug. 28, 2008).

[62] *The Handbook on Hedonic Indexes, and Quality Adjustments in Price Indexes: Special Application to Information Technology Products,* Science, Technology and Industry Working Paper 2004/9 (Paris: Organization for Economic Cooperation and Development, Oct. 8, 2004), on the Internet at **www.sourceoecd.org/10.1787/643587187107** (visited Aug. 28, 2008).

[63] The geometric mean is compared with other computational formulas in Ralph Turvey, *Consumer Price Indexes: an ILO manual* (Geneva: International Labor Office, 1989), pp. 88–92 and Appendix 7. Some of the advantages and disadvantages of the geometric mean price index were described from a BLS perspective in 1993 by Moulton, "Basic components of the CPI." available on the Internet, at **www.bls.gov/cpi/ cpirsdc.htm** (visited Aug. 28, 2008).