Quality adjustment of price indexes

Hedonic analysis may provide a viable alternative to other methods currently used to net out the effects of quality change in items in the CPI market basket, so that the desired measure of pure price change is obtained

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As an intended measure of pure price change over time, the Consumer Price Index (CPI) should not incorporate as price changes those differences in prices that may reflect differences in the quality attributes of the goods, as perceived by the consumer. If, for example, a microwave oven is replaced by the manufacturer with a new model that has a larger capacity and a higher price, the value to the consumer of the increase in oven capacity should be subtracted from the observed price difference for purposes of the CPI.

Unfortunately, the assessment of quality change often is difficult. This article addresses the problem of quality change in the CPI, with particular emphasis on the empirical technique of hedonic regression as a method of measuring the value of quality differences in goods and services. The hedonic methodology provides quantitative information on the importance of measurable quality differences. Given certain assumptions, it offers statistical estimates of the value of differences in quality among heterogeneous goods and services. Throughout the following discussion, the valuation of a physical difference in product characteristics will be referred to as a "real quality difference."

The sections below briefly discuss methods of quality adjustment in the CPI, present a general theoretical model for the hedonic methodology, and provide empirical results for a sample of food items typically purchased for home consumption. The data relate to the sample of items used in the CPI for the period January through November 1991.

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Concepts of quality adjustment

The Consumer Price Index, as a measure of price change, is defined within the context of a fixed market basket of goods and services purchased by consumers. Under ideal circumstances, a reference period market basket of specific items would be chosen and, over time, the prices of these exact items would be collected and compared to their reference period prices. Because there is no quality change, such an index would easily provide a measure of pure price change.

In the real world, however, goods and services change over time. These changes may be frequent, as in the case of apparel items, or occasional, such as the replacement of a popular beverage with a new formulation. They may be minor, stylistic changes, such as the neckline of a blouse, or major innovations, such as the introduction of anti-locking brake systems on automobiles. Some of these changes, in some proportion, represent "real quality change"; in other cases, it may be true that the consumer is, other things equal, indifferent between the old and new products. An extreme case of quality change in the market for consumer goods and services is represented by the introduction of new goods—commodities that appear to have few close substitutes and are not simply another step in the gradual evolution of existing products. Examples of such products have included microcomputers, videocassette recorders, home videorecorders, and the like.

In the construction of the CPI, qualitative changes in the market basket for U.S. consumers are subject to methodological rules. When the quality attributes of a good or service change—that is, a specific product or service disappears from the market—a substitution must be made in the market basket. If that substitute has different characteristics, a decision must be made as to its treatment in the CPI. This decision will implicitly, or explicitly, accomplish one of the following: (a) attribute any observed price difference to a pure price difference; (b) attribute any observed price difference to a real quality change; or (c) allocate any price difference in some proportion to both pure price change and real quality change. For practical purposes, the first two alternatives are the easiest to implement because they do not require any additional market information or empirical judgement.

For many items, the quality differences between a disappearing product and others of its kind still on the market are negligible. Examples would be different brands of bran flake cereal or regular grade gasoline. In these cases, a new item—one judged to be the most similar to its predecessor—is directly substituted for the disappearing product. This is called a comparable substitution, and it implicitly attributes any price difference between the two varieties to a pure price difference. In these cases, price differences typically are small or nonexistent, so that an individual substitution has a negligible effect on the CPI. (If a pure price change is implicitly imposed by product "downsizing," this effect is captured as a pure price change. In the case of food items, for which prices are converted to a per-ounce basis, a newly substituted 15-ounce container of an otherwise identical product at the same price as that of the old 16-ounce size will be reflected in the index as a pure price change.)

If the qualitative differences are perceived to be important, then a noncomparable substitution must be made. This can be done implicitly, by overlap pricing, or by one of several methods of more explicit quality adjustment, including direct quality adjustment, the link method, or application of the hedonic technique.[1]

Overlap pricing, which usually is applied when a new variety or revised product is replacing one being phased out by the manufacturer, requires that there be a period during which both products coexist in the market. In a given month, the prices of both products are observed and the difference between the two prices is implicitly ascribed to the differences in quality between products. In that month, say period t, the price change for the old variety with respect to the previous month, period $t-1$, is the CPI price change. In the succeeding month, period $t+1$, the price change for the new variety with respect to the month t is used to represent the price change in the CPI.

The overlap method links the old and new products without any explicit attempt to measure either the quality or price differences between them at any point in time. It thus implicitly ascribes all of the observed price difference to real quality difference. The use of overlap pricing is limited to situations in which old and new products both are available on the market in at least one period for pricing, and may have a downward effect on the index when the price of the old product is discounted in anticipation of introduction of the new product, or when the new product is introduced to the market at a premium price, or both. Items such as apparel and new motor vehicles are subject to this marketing pattern.

Direct quality adjustment involves making an explicit comparison of the old and new items. If the new item has features or additional equipment that were not part of the old item, as is often the case for new model automobiles, data on the manufacturer's costs of these innovations may be used to impute the value of the quality changes. This method assumes that the consumer perceives and values the quality differences by the same amount as the manufacturer's reported cost to produce them. If the manufacturer's reported cost does, in fact, contain some amount of pure price change, this approach imposes a downward effect on the CPI.

This type of quality adjustment has been applied in situations in which product innovations are mandated by government legislation, as in the case of antipollution devices (catalytic converters) on new vehicles. Unfortunately, economic theory does not provide unequivocal guidance for such decisions. If it is assumed that the consumer perceives the additional cost as commensurate with a benefit (such as improved air quality and health), then a quality improvement exists. However, public goods and environmental amenities are beyond the scope of the CPI, which is an index of changes in the cost of private consumption only. Also, in these situations, producers may exercise an incentive to exaggerate the true production cost of the technological amendment, and it is difficult to make an empirical judgement as to the consumer's valuation of such changes to the product.

When neither overlapping prices nor independent information on the cost of quality change are available, the *link technique* is employed. Under this approach, the price change between the old and new products initially is ignored. The (weighted) mean price change for other items in the same item stratum (category of similar goods or services) and geographic area at the time of substitution represents the price change for that stratum. This mean price change between the two periods becomes the imputed value of the difference between the observed current month's price for the new item and the (unobserved) current month's price for the old item. This approach is based on the assumption that pure price movements are likely to pervade an entire stratum of similar goods or services. It allows for some allocation of the observed price difference to both pure price change and real quality change, which may be closer to the empirical truth than attributing the difference entirely to one factor or the other.

Ideally, if market data permitted pure price and quality changes to be distinguished, the consumer's valuation of the quality differences would be used to compare old and new products when substitutions must be made. Although this information is not directly available, the data collected for construction of the CPI do permit some estimation of the value of quality differences among individual products or items to be made. This is possible because price quotes for the CPI are collected for a heterogeneous sample of goods, and information on the quality attributes of the individual products that represent an item category is provided when items are introduced to the sample. Given observations of both price and each item's physical attributes, it is possible to apply the empirical technique of *hedonic regression* to estimate the relationship between a product's price and each of its identifiable quality characteristics.

Under certain theoretical assumptions, the regression coefficients from this technique may be interpreted as estimates of the "implicit prices" of the item quality characteristics.[2] The Bureau of Labor Statistics has applied the hedonic approach in the case of apparel commodities, initially to determine which quality characteristics are most important when selecting substitutes for disappearing products.[3] If, for example, the regression results indicated that consumers pay a substantial, and statistically significant, price premium for wool versus acrylic as the principal fabric in a woman's suit, other things equal, then a major criterion for selection of a substitute product would be that it have the same fabric content as the specific suit being replaced in the index sample.

If the coefficients on the characteristics are stable over time, and over a wide array of product varieties, it might be possible to use these estimates to make direct quality adjustments whenever market basket substitutions are required. Paul Armknecht and Donald Weyback have tested this possibility for women's coats and jackets, and for women's suits.[4] Since 1991, this approach has been in use for these item categories of the CPI.[5]

The hedonic approach

The hedonic, or characteristics, approach offers promise for the problem of quality adjustment in the CPI because it is based on empirical, market information. It thus is almost certainly an improvement over procedures that, at worst, implicitly attribute all of an observed price difference to either pure price change or real quality change or, at best, make imputations based on subjective judgement or averages of price movements for other goods or services. However, the methodology is not easy to define or interpret in the context of microeconomic theory, and requires a large sample of data with detailed information on product characteristics that can be quantified or categorized for statistical analysis.

The hedonic approach relies on the general idea that any good in the marketplace can be interpreted as a bundle, or package, of characteristics. Individual products vary according to presence or absence of characteristics, and also by the amount of each characteristic they embody. The hedonic function, which is the regression equation to be estimated, was introduced to the economics literature in the 1930's as a method of relating an item's price to its characteristics.[6] Several decades later, it was given a theoretical foundation in the context of demand and supply relationships by Sherwin Rosen.[7] His approach assumes that markets are in economic equilibrium and that consumers are fully informed about the prices of goods and their quality attributes. It also assumes that there is a continuous spectrum of varieties of goods—that is, there are many different specific products—offering a large set of choices of characteristics combinations. Under these conditions, the hedonic function defines "the minimum price of any package of characteristics." It does not describe a demand relationship, but rather the budget constraint imposed on the consumer in the context of characteristics. (To construct a demand relationship from the information derived from a hedonic equation,[8] one must have consumer-specific information that usually is lacking.)

Because the relationship between item attributes and prices is a function of both the demand and production sides of the market, economic theory does not provide much guidance as to the functional specification of the hedonic equation. Therefore, the specification usually is made using explicit assumptions to facilitate the given analytical purpose.[9] In most empirical applications, a linear or log-linear form is used because it is relatively easy to estimate. In linear form, the hedonic equation would appear as follows:

$$(1) \qquad P_i = a_{i0} + \sum_{k=1}^{K} b_{ik} z_{ik} ,$$

where P_i is the price of item i, a_{i0} is a constant, b_{ik} is the coefficient on characteristic k of item i, and z_{ik} is the quantity (or presence or absence) of characteristic k in item i. If characteristic k is quantifiable, such as the length or weight of an item, then z_{ik} is a continuous variable. If characteristic k is a categorical variable, then z_{ik} is a dummy variable (that is, it has the value 0 or 1, depending on whether the attribute is present), an example being whether or not an automobile has air conditioning.

The semilogarithmic specification is given by equation (2) below:

$$(2) \qquad \ln P_i = a_{i0} + \sum_{k=1}^{K} b_{ik} z_{ik} ,$$

where $\ln P_i$ is the natural logarithm of the item's price and the other variables are defined as for equation (1). A log-log relationship would be the same as equation (2), except that the characteristics variables would also be expressed in logarithmic form, and these variables would have to be continuous.

Under the hypothesis of the hedonic model, the coefficients of the characteristics variables may be interpreted as "implicit prices" or "shadow prices" of the characteristics.[10] This follows from the assumption that consumers purchase goods, which are bundles of various characteristics, in order to consume these characteristics.[11] Because characteristics cannot be purchased independently, the "prices" of the characteristics cannot be directly observed. They are instead estimated "implicitly" by observing the prices of a spectrum of goods that embody various levels of the relevant characteristics.

In theory, a logical extension of the hedonic approach is to use these implicit prices to construct a price index in the context of characteristics, not goods. The resulting "hedonic index" would seem to obviate the problem of quality adjustment, because quality change is defined as a change in the quantities of characteristics. This approach has been empirically investigated for several categories of commodities such as automobiles[12] and computers,[13] but is more problematic for most other items. Without unrealistically restrictive assumptions, it is not possible to construct an exact, or true cost-of-living, index or its Laspeyres index approximation in terms of characteristics.[14] These assumptions include, first, that the spectrum of varieties of goods on the market be continuous; that is, that enough varieties exist in every period to cover the range of possible combinations of characteristics. Although this may be reasonably assumed for some goods (such as housing units), it is less defensible for others, such as major appliances and automobiles. If the spectrum of varieties is discrete, the hedonic relationship is not the same over all regions of the spectrum of characteristics. In effect, a separate hedonic model would need to be estimated for each variety spectrum of goods on the market at any given time, making the construction of a hedonic index excessively complex. Second, it must be assumed that, in any given period, the consumer consumes more than one of the varieties available for purchase. In the case of durable goods, and even certain nondurables for which "brand loyalty" exists, however, it is likely that only one variety will be consumed.[15] Finally, this approach also assumes that markets are in economic equilibrium, and that consumers have the same preferences, so that a single index is representative of their valuation of quality differences.

The difficulties inherent in the hedonic index approach, however, do not eliminate the usefulness of the methodology for quality adjustment and other issues in the context of market goods and services. Where the variety spectrum is wide, and quality changes are not too large, the implicit prices of the characteristics of goods are probably useful measures of real quality differences. A quantitative quality adjustment, based on the magnitudes of the regression coefficients, could be used for such groups of items as apparel, food at home, and other heterogeneous nondurables. For goods that have a more discrete range of varieties, and for which quality changes may be more pronounced (such as major appliances or electronics), the general hedonic concept may be combined with the household production framework. In this framework, the household is assumed to purchase goods and services and to combine these purchases with its own time and effort to produce household "commodities," analogous to the combination of inputs by manufacturers to produce goods and services. These "commodities" are what yield satisfaction (or utility) to the household, and are produced according to a household technology. An example would be the combination of grocery item purchases, energy for cooking, and time to produce a home-cooked dinner. If a specific model for this process could be described, then it might be possible to construct a "commodity" price index, which is more amenable to the problem of disappearing varieties of items.[16] (Models that can accommodate new goods, an extreme form of quality change, have not yet been fully explored.)

The hedonic method also provides opportunities to extend the scope of price index measures. It can, for example, be used to estimate differences in prices for goods and services across geographic areas at a point in time.[17] By incorporating dummy variables for geographic area and using a semilogarithmic model (as in equation (2)), it is possible to interpret the coefficients of these area variables as bilateral interarea price indexes. It is also possible to include information on outlets in the hedonic model. At present, the CPI database contains categorical information on the type of outlet from which a price quote is collected, based on the principal business of that outlet (for example, chain grocery store, bakery, or beauty salon). The coefficients of outlet type variables would provide some measure of the distribution of prices across outlets. Under a pilot project recently begun at BLS, additional information will be collected on the quality attributes of the outlets as well. This will enable an analysis of those quality attributes that are associated with goods and services purchases, but are not physically attached to them, such as delivery services, ease of the purchase transaction, and choices of payment method.

Analysis of food items

The following analysis demonstrates the hedonic approach for pricing selected food-at-home item categories. These item groups were chosen to include those that are relatively homogeneous (such as ground beef) as well as those that are heterogeneous (canned and packaged soups), and both fresh items (such as apples) and prepared foods (such as cookies). The item categories correspond to the CPI program's definitions of entry level items,[18] with the list comprising: prepared flour mixes (01012), white bread (02011), cookies (02042), ground beef (03011), sirloin steak (03061), fresh apples (11011), candy and chewing gum (15011), cola beverages (17011), roasted coffee (17031), and canned and packaged soups (18011). Variables in the hedonic regression include those quality attributes that could be identified from the CPI data, a set of dummy variables for geographic area, a set of dummy variables for the type of outlet from which the price was collected, the month of the price quote, and a variable to indicate whether the price quote came from a sample newly rotated into the CPI database. The importance of geographic area for price differences has been shown by Diane Primont and Mary Kokoski, and a decrease in the average level of prices for food and energy at sample rotation has been observed by Marshall Reinsdorf.[19]

Information on quality characteristics is provided when a specific product is chosen for inclusion in the CPI sample. This information is supplied on a "checklist" form and accompanies the price data for that particular item in the database. Because the CPI uses a probability sampling approach to select the specific items to be priced, a wide variety of products may represent a given ELI in various outlets in the geographic areas in which prices are collected. For example, cookies may be represented by an array of specific products ranging from bakery-fresh chocolate chip cookies sold by the dozen to factory-produced 12-ounce packages of lemon cream sandwich cookies.

Although more complicated than a specification-pricing approach (wherein a single specific product represents a category of items in all outlets in all areas), the probability sample better represents the consumption patterns of households and, incidentally, provides a wealth of information for analysis of the relationship between quality characteristics and item prices. For some ELI's, the number of quality attributes identifiable from the item checklists may exceed 200. Most of the quality information from the checklists can be used to construct binary variables for inclusion in the regression. In the previous example, a variable for "chocolate chip" can be created, which is equal to 1 if the product is, indeed, this type of cookie, and 0 otherwise; similar variables can be constructed for other cookie types, type of package, size of package, and whether the cookies are sold by the package or dozen, and so forth.

In addition to the quality characteristics that physically describe the item, variables for the type of outlet are included. These are based on the CPI definitions of "type of business"—a set of possible descriptions for the principal commercial activity of the establishment from which the price quote is collected. For food-at-home, the majority of the individual prices are collected from chain grocery stores, but some ELI's are represented by a wide variety of outlet types. These include, for example, convenience stores, membership warehouse outlets, beverage bottling companies, and variety stores. The inclusion of these variables captures any price differences across outlets, but may also be interpreted as capturing some of the quality attributes associated with the purchase of the item. For example, while prices may be generally higher in convenience stores than in chain grocery stores, it is quicker and easier to find and purchase a given item in the (aptly named) convenience store.

Because prices are collected monthly, a set of dummy variables for month is included to control for seasonal effects and trends over time in the prices of the selected food items. The CPI sample used for this research includes 11 months of data for 1991, covering January through November. (The data for December were incomplete at the time this research was begun.) In addition to temporal effects, it is possible that prices vary systematically across geographic areas at any point in time. To account for any interarea price differentials, a set of dummy variables is included for the areas defined by the CPI in its aggregation of prices into indexes. These geographic areas include 32 "self-representing" primary sampling units,[20] and 12 region/city-size class aggregates. A self-representing area is one with a population large enough that only data from that area are used to calculate its price index. Such areas typically correspond to the larger urban metropolitan areas (such as Chicago and Baltimore), but in some cases, such as the New York City area, there are several primary sampling units within a geographic designation. The region/city-size class aggregates are developed from price quotes from a sample of cities of a given size class in the specified region.[21]

In any year, certain primary sampling units are scheduled for sample rotation. This sample rotation process serves to update the sample of outlets and items, based on the Continuing Point-of-Purchase Survey,[22] to better represent the outlets and products actually purchased by consumers in a primarily sampling unit. Since the 1978 revision of the CPI, each area's sample is replaced by a new one every 5 years. In 1991, the areas for which sample rotation was conducted included Pittsburgh, New York City, and Washington, DC, and several smaller urban areas. To account for any effect on the price of an ELI due to a change in the sample (and unexplained by the other variables in the regression), a binary variable was included in the hedonic regression to indicate whether the individual price quote belonged to the new sample.

Thus, the hedonic regression equation for the selected food ELI's can be written as:

$$(3) \quad \ln P_i = b_{i0} + \sum_{k=1}^{K} b_k x_{ik} + \sum_{t=2}^{T} b_t m_{it} + \sum_{l=2}^{L} b_l BSNS_{il} + \sum_{a=2}^{A} b_a AREA_{ia} + b_n NEWSAMP_i + \varepsilon_i,$$

where P_i is the price of individual product i; x_{ik} is a variable for characteristic k of item i; m_{it} indicates whether the price quote for product i is from month t; $BSNS_{il}$ indicates whether the price quote is from outlet type l; $AREA_{ia}$ is a variable indicating whether the price quote is from area a; and $NEWSAMP_i$ is a variable that identifies whether the price quote for product i is from the newly introduced sample. The error term, ε_i, embodies the residual variation in the log of the ELI's price that cannot be explained by the variables in the regression equation.

Three sets of variables—months, outlet types, and areas—are mutually exclusive and exhaustive. Therefore, one member from each must be dropped from the equation to permit estimation of parameters for other members of the variable set. The choice of the variable to be excluded from each set is arbitrary, and, in this case, was made to facilitate the interpretation of the results. January was the excluded month, chain grocery stores was the excluded outlet type, and Philadelphia was the excluded area. The values of the excluded variables then serve as references to which the model-derived coefficients of the remaining variables can be compared. The characteristics variables are binary, or "dummy," variables that could be constructed from the information on the CPI checklists. If a characteristic is present, the respective dummy variable is given a value of 1; if the characteristic is absent, the variable has a value of 0.

The empirical results from this equation for the selected food-at-home ELI's are presented in table 1. Although the coefficient values for most variables are presented, results for the geographic area variables are not presented or discussed here because a more detailed treatment of interarea differences is available elsewhere.[22]

The month in which the price was collected does not seem to have a consistent pattern in terms of the signs of the coefficient estimates, nor are these estimated values statistically significant in general. The variable *NEWSAMP*, indicating the incorporation of a new sample of price quotes (which, although independently selected, may include the very same outlets and products as in the old sample), is statistically significant for most of the ELI's in this study. It is, however, as often negative in sign as positive, which indicates the absence of a systematic effect on prices of introducing a newly rotated sample. Because new samples were rotated into the overall CPI production database in different months in those primary sampling units scheduled for rotation in 1991, this variable is not capturing a seasonal effect. Other studies, which compared prices for rotating samples only, and covered 2 years of CPI data (but did not include characteristics or outlet type variables), have indicated a downward effect on prices resulting from sample rotation.[23] It is also true that most of the primary sampling units for which samples were rotated in 1991 were small urban areas with relatively few price quotes. Therefore, an explanation of the effect of this variable awaits a more comprehensive analysis, incorporating all food-at-home ELI's, and possibly encompassing a period during which more sample rotations can be observed.

The characteristics variables are defined by the specifications on the checklist for each ELI. To facilitate the empirical analysis, the reference (excluded) variable for an exhaustive set of characteristics variables is, unless otherwise indicated, a catch-all category, "other." The exceptions are in-

Text continues on page 44.

Table 1. Price parameter estimates of quality attributes for selected food items, based on a hedonic regression technique

Commodity and model variable	Parameter estimate	t-statistic
Prepared flour mixes		
Intercept	-2.22	-30.95
Additives required:		
Milk	-.15	-6.07
Eggs	-.12	-5.89
Water	-.01	-.48
Packaging:		
Bag	-.42	-7.77
Box	-.30	-6.18
Type:		
Bread mix	.29	6.52
Brownie mix	.45	12.34
Cake mix	.09	2.65
Cookie mix	.66	15.74
Muffin mix	.34	9.67
Pancake mix	-.15	-4.69
Piecrust mix	.29	7.46
Roll mix	.21	3.84
Features:		
With icing packet (Ref. = Fruit topping)	.58	15.48
With nuts (Ref. = Fruit topping)	.49	10.20
Type of outlet:		
Convenience stores	.61	13.82
Commodity oriented outlets, not elsewhere classified	.02	.16
Independent grocery stores	.02	1.28
Produce markets	.21	.39
Warehouse clubs, membership	-.07	-.39
New sample	-.12	-4.04
Month:		
February	-.02	-.78
March	-.02	-1.00
April	-.01	-.40
May	-.00	-.13
June	.00	.21
July	.00	.16
August	.00	.13
September	.00	.02
October	-.01	-.35
November	-.02	-.84
Adjusted R^2	.5149	—
Number of observations	3,883	—
White bread		
Intercept	-2.54	-48.00
Features:		
Buttertop	.19	10.10
Dietetic	.71	16.47
Heat and serve	.07	1.97
Salt free	.45	10.64
Type:		
French	.19	8.37
Italian	-.03	-1.25
Raisin	.48	19.21
Regular	-.38	-18.40
Vienna	.08	2.29
Condition:		
Day old	-.65	-10.90
Fresh	.05	1.20
Frozen	.57	4.82
Refrigerated	.85	5.12
Weight:		
Not prepackaged (Ref. = packaged)	-.04	-1.78
Not available	2.81	102.28
Not labeled—weighed one	-.11	-3.77
Not labeled—weighed two loose	-.10	-2.55
Type of outlet:		
Bakeries	.02	.79
Chain drug stores	.34	2.38
Commodity oriented outlets, not elsewhere classified	-.49	-9.52
Convenience stores	.13	6.22
Cost plus stores	.04	.22
Dairy products stores	-.11	-1.32
Full service department stores	.82	5.90
Gasoline service stations	.12	1.49
Independent grocery stores	.05	3.32
Liquor stores	-.35	-3.04
Meat markets	-.28	-1.31
Outlet types not elsewhere classified	.07	.97
Produce markets	.00	.04
Restaurants and lunchrooms	-.29	-1.51
Retail bakeries	.06	1.27
Warehouse clubs, membership	-.41	-1.69
New sample	.06	2.51
Month:		
February	-.01	-.74
March	-.01	-.76
April	-.01	-.72
May	-.01	-.62
June	-.01	-.59
July	-.02	-.88
August	-.01	-.46
September	-.00	-.21
October	-.01	-.40
November	.01	.65
Adjusted R^2	.8455	—
Number of observations	6,292	—
Cookies		
Intercept	-1.78	-26.72
Type:		
Assortment	-.08	-2.04
Chocolate chip	-.03	-1.32
Oatmeal	-.22	-7.79
Plain sugar	-.10	-2.67
Sandwich	-.26	-9.58
Packaging:		
Bag (Ref. = tin)	.40	11.19
Loose (Ref. = tin)	.46	9.66
Box (Ref. = tin)	.27	6.81
Plastic tray (Ref. = tin)	.17	4.43
Features:		
Iced	-.20	-4.61
Without brand label (Ref. = brand)	-.24	-7.26
Weight:		
Not available	.26	7.47
Not labeled—weighed one	.34	3.23
Not labeled—weighed two	-.07	-1.17
Type of outlet:		
Bakeries	.41	12.35
Chain drug stores	.64	2.77
Commodity oriented outlets, not elsewhere classified	-.96	-1.43
Convenience stores	.07	1.75
Cost plus stores	-.11	-.19

See footnote at end of table.

Table 1. **Continued—Price parameter estimates of quality attributes for selected food items, based on a hedonic regression technique**

Commodity and model variable	Parameter estimate	*t*-statistic
Gasoline service stations	−.66	−4.17
Independent grocery stores	−.00	−.11
Liquor stores	−.59	−3.20
Produce markets	−.20	−1.56
Restaurants and lunchrooms	−.14	−1.33
Retail bakeries	−.26	−5.25
Warehouse clubs, membership	−.18	−.52
New sample	.03	.87
Month:		
February	−.00	−.09
March	−.01	−.16
April	.00	.06
May	.00	.10
June	.02	.53
July	.00	.01
August	.00	.12
September	.00	.00
October	.02	.49
November	.03	.82
Adjusted R^2	.4291	—
Number of observations	3,723	—
Ground beef		
Intercept	−2.25	−16.38
Type:		
Beef with vegetable protein	−.05	−.98
100-percent beef	.08	1.80
Form:		
Loose, not prepackaged	.31	2.36
Loose, prepackaged	.25	1.92
Patties	.31	2.37
Tube	26	2.01
Fat:		
Extra lean	.07	9.16
Lean	−.05	−5.62
Regular	−.10	−13.18
Source:		
Chuck (Ref. = round)	−.10	−15.27
Combination (Ref. = round)	−.23	−32.50
Sirloin (Ref. = round)	.11	12.11
State:		
Frozen (Ref. = fresh)	−.07	−2.33
Type of outlet:		
Commodity oriented outlets, not elsewhere classified	−.30	−5.75
Convenience stores	.08	.96
Discount department stores	−.42	−4.19
Freezer and locker meat providers	−.37	−10.34
Independent grocery stores	−.06	−9.90
Meat markets	−.09	−9.64
Warehouse clubs, membership	−.00	−.01
New sample	−.01	−.99
Month:		
February	−.01	−.69
March	−.00	−.52
April	−.00	−.18
May	.01	.61
June	−.00	−.18
July	−.01	−.87
August	−.01	−.83
September	−.02	−2.13
October	−.02	−2.22
November	−.01	−.94
Adjusted R^2	.5481	—
Number of observations	6,707	—
Fresh apples		
Intercept	−2.83	−131.62
Variety:		
Golden Delicious	−.03	−1.91
Red Delicious	−.04	−2.75
Granny Smith	.03	2.30
Gravenstein	−.19	−4.52
Jonathan	−.18	−8.97
McIntosh	−.05	−3.51
Rome Beauty (Red Rome)	−.03	−2.14
Stayman	−.10	−2.24
Winesap	.06	2.35
York (York Imperial)	.74	11.14
Weight:		
Above 10 pounds (Ref. = 0 to 10 pounds)	.01	.34
Grade:		
Other grade or grade not available (Ref. = extra fancy)	−.01	−2.29
Packaging:		
Multipack (Ref. = loose)	−.25	−29.41
Single item (Ref. = loose)	−.36	−6.86
Size:		
Weighed one multipack	−.06	−3.24
Weighed two apples	−.01	−.68
Type of outlet:		
Commodity oriented outlets, not elsewhere classified	−.38	−10.98
Convenience stores	.06	1.22
Full service department stores	−.12	−1.56
Independent grocery stores	−.07	−9.60
Outlet types not elsewhere classified	−.46	−7.15
Produce markets	−.16	−15.38
New sample	−.04	−3.06
Month:		
February	.03	2.64
March	.04	3.77
April	.05	4.74
May	.10	8.76
June	.15	13.68
July	.18	16.55
August	.20	18.02
September	.17	15.11
October	.01	1.01
November	.03	2.79
Adjusted R^2	.3328	—
Number of observations	9,423	—
Candy and chewing gum		
Intercept	−.54	−7.14
Candy:		
Assorted chocolate candies	.31	5.99
Candy-coated chocolate	−.10	−2.28
Caramels and toffees	.01	.20
Chocolate-covered candy	−.06	−1.37
Cough drops	.96	15.37
Filled hard candy	−.25	−1.15
Jellies, gum drops, fruit	−1.07	−23.77
Licorice	−.47	−3.70
Mints	−.26	−5.40

See footnote at end of table.

Table 1. **Continued—Price parameter estimates of quality attributes for selected food items, based on a hedonic regression technique**

Commodity and model variable	Parameter estimate	*t*-statistic
Nougats	.34	2.99
Other candy	−.17	−3.51
Powdered candy	−.42	−2.94
Solid chocolate	.23	5.61
Solid hard candy	−.14	−3.21
Stick, rock, ribbon candy	−.11	−1.92
Suckers, lollipops	.24	3.97
Taffy	.22	.69
Packaging:		
Bag	−.04	−2.07
Box	−.01	−.37
Bulk	.04	.95
Metal tin	.39	2.85
Roll	.71	14.19
Single piece or bar	−.23	−10.65
Gum:		
Bubble gum	−.06	−1.78
Liquid-center tablet	.05	.69
Stick	.63	16.66
Sugar:		
Dietetic or sugarless (Ref. = regular)	.42	17.05
Origin:		
Domestic (Ref. = imported)	−.42	−10.39
Wrap:		
Individually wrapped (Ref. = not individually wrapped)	−.22	−11.82
Size:		
0 to 2.999 ounces	−.04	−1.38
11 to 16.999 ounces	−.58	−17.31
3 to 6.999 ounces	−.28	−8.06
7 to 10.999 ounces	−.46	−13.87
Type of outlet:		
Candy, nut, and confection stores	.65	20.63
Chain drug stores	.21	7.84
Colleges, universities, and professional schools	−.30	−3.49
Commodity oriented outlets, not elsewhere classified	.21	4.31
Convenience stores	.02	.56
Cost plus stores	−.56	−4.60
Discount department stores	−.08	−2.02
Gasoline service stations	.12	1.28
Hardware stores	.13	1.03
Health clubs or spas	−.31	−1.24
Independent drug stores	−.36	−5.85
Independent grocery stores	.10	4.88
Liquor stores	.14	.57
Mail order houses	.87	9.25
Merchandising machine operations	.05	.19
Outlet types not elsewhere classified	−.19	−1.64
Primary and secondary schools	.85	9.79
Produce markets	−.11	−.76
Refreshment places	−.36	−1.65
Restaurants and lunchrooms	−.34	−6.17
Variety stores	−.41	−10.21
Warehouse clubs, membership	−.87	−7.76
New sample	.02	.49
Month:		
February	.00	.11
March	.02	.81
April	.02	.84
May	.03	1.23
June	.03	1.36
July	.05	2.18
August	.05	2.08
September	05	1.92
October	.06	2.22
November	.06	2.53
Adjusted R^2	.7691	—
Number of observations	4,606	—
Cola beverages		
Intercept	−4.64	−40.35
Type:		
Regular cola (Ref. = flavored)	.03	1.99
Diet cola (Ref. = flavored)	.05	2.82
Packaging:		
Case of 24	−.34	−9.16
Individual	.09	4.43
12-pack	−.18	−7.66
6-pack	.03	1.80
8-pack	−.26	−7.92
Container style:		
Aluminum bottle	.13	1.81
Glass bottle	.25	2.87
Metal can	.17	4.02
Plastic (PET) bottle	.07	.70
Brand:		
Nationally advertised brand	.62	10.42
Regional or store brand	.12	2.00
Deposit legislation:		
Regional or local (Ref. = none)	.10	1.35
Statewide deposit (Ref. = none)	.01	.31
Caffeine:		
Reduced (Ref. = regular)	−.02	−1.13
Container:		
Returnable (Ref. = nonreturnable)	.01	.34
Size:		
1 liter	.34	8.21
1/2 liter or 500 ml	.38	5.63
10 ounces	.70	11.51
12 ounces	.48	4.91
16 ounces	.28	7.35
2 liters	−.05	−2.55
32 ounces	.14	1.19
Type of outlet:		
Chain drug stores	.07	3.39
Colleges, universities, and professional schools	.17	2.16
Commodity oriented outlets, not elsewhere classified	−.13	−1.93
Convenience stores	.25	14.92
Dairy products stores	.23	3.40
Discount department stores	.03	.54
Gasoline service stations	.20	6.47
Independent drug stores	−.13	−2.67
Independent grocery stores	.04	2.96
Liquor stores	.15	5.52
Outlet types not elsewhere classified	.08	1.85
Pet stores	−.24	−1.21
Refreshment places	.64	5.20
Restaurants and lunchrooms	.54	7.76
Service oriented outlets, not elsewhere classified	.25	.93
Soft drink bottling companies	−.48	−5.07
Variety stores	−.25	−3.25
Warehouse clubs, membership	.03	.42
New sample	.05	2.07
Month:		
February	.01	.38

See footnote at end of table.

Table 1. **Continued—Price parameter estimates of quality attributes for selected food items, based on a hedonic regression technique**

Commodity and model variable	Parameter estimate	*t*-statistic
March	−.02	−.98
April	−.03	−1.68
May	−.03	−2.03
June	−.07	−3.50
July	−.10	−5.12
August	−.10	−5.13
September	−.10	−5.22
October	−.07	−3.86
November	−.09	−4.64
Adjusted R^2	.6243	—
Number of observations	5,120	—
Roasted coffee		
Intercept	−1.51	−17.47
Type:		
Bean type unspecified (Ref. = specified)	−.06	−5.24
100-percent coffee (Ref. = with additives)	.01	.19
Packaging:		
Bag	−.38	−15.58
Can	−.25	−8.79
Filter rings	−.23	−4.46
Vacuum-packed bricks	−.31	−10.42
Form:		
Ground	−.00	−.09
High extraction/extended yield	−.03	−.51
Whole bean	.28	5.23
Content:		
Regular	.21	5.19
Decaffeinated	.57	13.79
Size:		
0 to 4.999 ounces	1.02	15.63
14 to 20.999 ounces	.00	.05
21 to 32.999 ounces	−.05	−1.27
33 to 50 ounces	−.24	−6.28
5 to 8.999 ounces	.62	12.74
9 to 13.999 ounces	.02	.61
Type of outlet:		
Chain drug stores	.07	1.49
Commodity oriented outlets, not elsewhere classified	.42	13.10
Convenience stores	.02	.24
Discount department stores	.09	.55
Independent grocery stores	.07	6.69
Liquor stores	.54	8.32
Meat markets	.07	.21
Refreshment places	.19	2.07
Warehouse clubs, membership	−.26	−4.91
New sample	.03	1.33
Month:		
February	.00	.25
March	−.01	−.92
April	−.01	−.57
May	−.02	−1.21
June	−.02	−1.32
July	−.04	−2.54
August	−.06	−3.68
September	−.07	−4.40
October	−.07	−4.48
November	−.08	−5.29
Adjusted R^2	.6274	—
Number of observations	4,457	—

Commodity and model variable	Parameter estimate	*t*-statistic
Canned and packaged soup		
Intercept	−1.47	−23.47
Type:		
Bean	−.01	−.28
Beef	−.15	−5.53
Chicken	−.13	−7.24
Minestrone	−.27	−10.77
Onion	.26	11.69
Tomato	−.56	−25.90
Vegetable with beef	−.03	−1.35
Vegetarian	−.28	−11.95
Form:		
Aseptic	−.08	−.93
Box (Ref. = dried multipack)	.82	38.81
Canned (Ref. = dried multipack)	−.66	−24.02
Dried single (Ref. = multipack)	.55	20.85
Frozen (Ref. = dried multipack)	−.66	−7.53
Location:		
Deli	−.47	−6.00
Freezer	−1.44	−23.05
Gourmet section	−.08	−1.04
Salad bar	−.68	−9.20
Shelf	−.52	−10.31
Other ingredients:		
With bacon	−.11	−1.90
With ham	−.00	−.06
With noodles	−.08	−4.87
With rice	.36	8.63
Brand:		
Regional brand (Ref. = national)	−.22	−7.96
Generic (Ref. = national)	−.49	−9.79
Store brand (Ref. = national)	−.27	−15.09
Features:		
Low calorie	.68	14.30
Low sodium	.17	4.61
Style:		
Full strength (Ref. = condensed)	.19	14.13
Type of outlet:		
Chain drug stores	1.49	8.54
Commodity oriented outlets, not elsewhere classified	.28	3.77
Convenience stores	.60	13.13
Discount department stores	.41	3.45
Independent grocery stores	.05	3.22
Produce markets	.52	1.31
Warehouse clubs, membership	−.32	−3.45
New sample	.08	3.28
Month:		
February	.01	.42
March	.01	.58
April	.01	.39
May	.02	.78
June	.01	.61
July	.04	1.74
August	.04	1.77
September	.04	1.97
October	.04	1.65
November	.03	1.43
Adjusted R^2	.8419	—
Number of observations	6,689	—

NOTE: "Ref." indicates use of a reference characteristic other than that cited in the text. The alternative characteristic is indicated in parentheses.

dicated in table 1 by the parenthetically expressed definition of "Ref." The choice of a reference characteristic is arbitrary, and was made in this study on the basis of the way information is presented on the CPI checklists.

To compare the effects of any two characteristics within a set on the price of the item, one can simply compare the values of the coefficients. For example, in the regression results for prepared flour mixes, a brownie mix is, other things equal, more expensive than a muffin mix, and a cookie mix is more expensive than any other type of mix. Pancake mix is the only mix type less expensive, all else equal, than the reference type "other," because its parameter estimate is negative. In making a quantitative comparison across characteristics, the coefficient estimates are interpreted as the percentage contribution of the presence of a characteristic to the price of the overall item, as defined by the ELI. For example, the inclusion of an icing packet in the prepared flour mix in table 1 adds 0.7 percent to the price of the mix, other things equal. These comparisons are considered valid only if the coefficient estimates are statistically significant—that is, if the t-statistic on the coefficient estimate is greater than or equal to 1.95.

A general examination of the empirical estimates of the regression coefficients for the characteristics variables seems to concur with *a priori* expectations in most cases. For example, in table 1, the coefficient on "day old condition" for white bread is negative and significant, and regular type bread is relatively less expensive than the more specialized types such as Vienna or French. For ground beef, regular fat content is cheaper relative to lean fat content, and extra lean commands a price premium over all other categories of fat content. For cola beverages, the price per ounce is lower if purchased by the case of 24 rather than by the individual container. Colas of a nationally advertised brand command a price premium over generic colas, other things being equal. (Unfortunately, information on brand name is difficult to extract from the checklist for most items.) For other groups of characteristics within some ELI's, such as the type of soup, or its ingredients, it is difficult to form any expectations and to then interpret the coefficients on this basis.

The set of variables that identify the type of business were specified with the reference (or excluded) variable "chain grocery store," which is the most common outlet type in the sample for all food-at-home ELI's. Generally, the coefficient estimates on these variables are consistent with prior expectations and most are statistically significant. To summarize these results, the coefficients on the most common types of outlets that sell food and beverage items are presented separately in table 2, where an asterisk indicates that the estimated value is statistically significant at the 5-percent level.

Purchasing from independent grocery establishments tends to have a significant effect on the price for the selected ELI's, but the direction of the effect varies across ELI's. Convenience stores have higher prices, other things equal, than do chain grocery stores, and purchasing at drug stores generally entails a price premium as well. Of the statistically significant coefficients for membership warehouse clubs, the results indicate that these types of outlets are cheaper than grocery stores. The price effect of purchases at gasoline service stations is a discount for cookies and a premium for cola beverages. (These outlets overlap the convenience store category.) Because the regression specification includes variables for the characteristics of the goods, these outlet effects are not due to differences among outlets in the attributes of the products available that can be measured from the item checklists. Some item attributes, such as nationally recognized brand name for processed foods or beverages, may vary systematically across outlet types, but this information is more difficult to extract from the checklist specifi-

Table 2. **Relationship of outlet type to prices, selected entry level items and outlet types**

Item	Independent grocery	Convenience store	Chain drug store	Independent drug store	Warehouse club	Gas station
Flour mixes	—	*0.58	—	—	* −0.10	—
White bread	*0.05	* .13	*0.34	—	−.41	0.12
Cookies	−.00	.07	* .64	—	−.18	* −.66
Ground beef	* −.06	.08	—	—	−.00	
Fresh apples	* −.07	.06	—	—	—	—
Candy, chewing gum	* −.10	.02	* .21	* −0.37	* −.87	.12
Cola beverages	* .04	* .25	*-.07	* .13	.03	* .20
Roasted coffee	* .07	.02	.08	—	* −.27	—
Canned, prepared soups	* .05	* .60	*1.49	—	* −.32	—

NOTE: Asterisk indicates that the estimated value is statistically significant at the 5-percent level.
Dash indicates that the outlet type was not included in the sample for the commodity.

cations. If one assumes market equilibrium and well-informed consumers, and that the outlet type variable is a reasonable proxy for average outlet quality characteristics, one may attribute some of the outlet coefficient values to outlet quality differences. However, if consumers adjust slowly to changes in the market, or are not fully informed,[24] one may attribute some of these coefficient values to systematic pure price differences across outlets.

THE FOREGOING ANALYSIS of the issue of quality adjustment and the contribution of hedonic methods to this price index problem is based on a set of hedonic regressions for selected categories of food-at-home commodities. Although the regression results are not used here to specify quality adjustment procedures for these food and beverage items, they do provide some insight into the effects on price, or "implicit price," of item characteristics, including the types of outlets where items are purchased.

Empirical analysis of apparel, conducted by Armknecht and Weyback,[25] has shown that the stability of the hedonic regression coefficients over time should not be presumed. Further research will examine the stability of the hedonic relationship for other types of commodities and services, and the importance of the specification of the regression—that is, the importance of variables that may have been omitted or unobserved. In addition, as experimental data become available for a sample of CPI outlets, the analysis will be extended to include quality characteristics of the outlets themselves. □

Footnotes

ACKNOWLEDGMENT: The author acknowledges helpful comments by Paul Armknecht, Marshall Reinsdorf, and Marilyn Manser. The views expressed are those of the author and do not necessarily represent an official position of the Bureau of Labor Statistics.

[1] Paul Armknecht and Donald Weyback, "Adjustments for Quality Change in the U.S. Consumer Price Index," *Journal of Official Statistics*, vol. 5, 1989, pp. 107–23.

[2] Mokoto Ohta and Zvi Griliches, "Automobile Prices Revisited: Extensions of the Hedonic Hypothesis," in Nestor Terleckyj, ed., *Household Production and Consumption*, National Bureau of Economic Research Studies in Income and Wealth, no. 40, Conference on Research in Income and Wealth (New York, Columbia University Press, 1975), pp. 325–90.

[3] See Armknecht and Weyback, "Adjustments for Quality Change."

[4] *Ibid.*

[5] See Paul Liegey, "Adjusting Apparel Indexes in the CPI for Quality Differences," in M. Foss, M. Manser, and A. Young, eds., *Price Measurements and Their Uses*, National Bureau of Economic Research Studies in Income and Wealth, no. 57 (Chicago, University of Chicago Press, 1993), pp. 209–26.

[6] Andrew Court, "Hedonic Price Indexes with Automobile Examples," in General Motors Corp., *The Dynamics of Automobile Demand* (New York, General Motors Corp., 1939), pp 99–117.

[7] Sherwin Rosen, "Hedonic Prices and Hedonic Markets: Product Differentiation in Pure Competition," *Journal of Political Economy*, April 1974, pp. 34–55.

[8] Robert Mendelsohn, "Estimating the Structural Equations of Implicit Markets and Household Production Functions," *Review of Economics and Statistics*, November 1984, pp. 673–77.

[9] Robert Halvorsen and Henry Pollakowski, "Choice of Functional Form for Hedonic Price Equations," *Journal of Urban Economics*, July 1981, pp. 37–49.

[10] See Ohta and Griliches, "Automobile Prices."

[11] Kelvin J. Lancaster, "A New Approach to Consumer Theory," *Journal of Political Economy*, April 1966, pp. 132–57.

[12] Jack Triplett, "Automobiles and Hedonic Quality Measurement," *Journal of Political Economy*, vol. 77, 1969, pp. 408–17.

[13] Jack Triplett, "Price and Technological Change in a Capital Good: A Survey of Research on Computers," in D. Jorgenson and R. Landau, eds., *Technology and Capital Formation* (Cambridge, MA, MIT Press, 1990), pp. 127–213.

[14] Robert Pollak, "The Treatment of 'Quality' in the Cost-of-Living Index," *Journal of Public Economics*, February 1983, pp. 25–53.

[15] Pollak, "The Treatment of 'Quality'."

[16] *Ibid.*

[17] Diane Primont and Mary Kokoski, "Comparing Prices Across Cities: An Hedonic Approach," Working paper no. 204 (Bureau of Labor Statistics, 1990); and Mary Kokoski, "New research on interarea consumer price differences," *Monthly Labor Review*, July 1991, pp. 31–34.

[18] The CPI item structure has four levels of classification. Seven major *groups* are made up of 69 *expenditure classes*, which in turn are divided into 207 *item strata* composed of generally similar items. Within each item stratum are one or more substrata, called *entry level items* (ELI's), of which there currently are 364. The ELI's are the ultimate sampling units for items as selected by the BLS national office. They are the level of item definition at which data collectors begin item sampling within each sample outlet. For more information, see *BLS Handbook of Methods*, Bulletin 2414 (Bureau of Labor Statistics, 1992), pp. 176–225.

[19] See Primont and Kokoski, "Comparing Prices"; and Marshall Reinsdorf, "The Effect of Outlet Price Differentials in the U.S. Consumer Price Index," in M. Foss, M. Manser, and A. Young, eds., *Price Measurements and Their Uses*, pp. 227–54.

[20] A primary sampling unit is a county or group of contiguous counties, except in New England, where the primary sampling unit is commonly a group of cities or towns.

[21] See Primont and Kokoski, "Comparing Prices," for further discussion of area definitions and an analysis of interarea price differences.

[22] The Bureau of the Census conducts the Continuing Point-of-Purchase Survey for BLS. The survey furnishes current data on retail outlets from which urban households make purchases of defined groups of commodities and services.

Data from the survey provide the sampling frame of outlets for food and most services and commodities to be priced in the CPI. The Continuing Point-of-Purchase Survey is the source of the outlet sampling frame for about 90 percent of the commodity and service items by expenditure weight. See *BLS Handbook of Methods*, pp. 176–225, for more information.

[22] See Primont and Kokoski, "Comparing Prices"; and Kokoski, "New research on interarea price differences."

[23] See Reinsdorf, "The Effect of Outlet Price Differentials."

[24] T. Van Hoomissen, "Price Dispersion and Inflation: Evidence from Israel," *Journal of Political Economy*, vol. 96, 1988, pp. 1303–14.

[25] See Armknecht and Weyback, "Adjustments for Quality Change."

Barbara Bailar receives Shiskin Award

Barbara Bailar, Executive Director of the American Statistical Association, received the 14th annual Julius Shiskin Award for Economic Statistics.

Dr. Bailar was cited for her contributions in modernizing, improving, and extending the Census Bureau's statistical programs. In the Census Bureau's Statistical Research Division, then later in the Research Center for Measurement Methods, Dr. Bailar's statistical research and analysis of the Decennial Census of Population and Housing and the Current Population Survey led to major improvements in both of these programs. Later, as Associate Director for Statistical Standards and Methodology, her work in undercount and nonsampling error in the decennial census resulted in major improvements in the quality of U.S. census data.

The presentation was made along with an honorarium at the Washington Statistical Society's annual dinner in June.

The award is named in honor of the ninth U.S. Commissioner of Labor Statistics. It is designed to honor unusually original and important contributions in the development of economic statistics or in the use of economic statistics in interpreting the economy. Participating organizations in the program are the Bureau of Labor Statistics, Bureau of the Census, Bureau of Economic Analysis, Office of Management and Budget, National Bureau of Economic Research, National Association of Business Economists, and the Washington Statistical Society. The late Commissioner Shiskin was associated with all of these organizations in his distinguished career.