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# 6 Adjusting Apparel Indexes in the Consumer Price Index for Quality Differences

Paul R. Liegey, Jr.

The consumer price index (CPI) measures the average change in the prices paid by urban consumers for a fixed market basket of goods and services. One of the more difficult conceptual problems faced in constructing the price index is the accurate measurement and treatment of quality change that arises from frequent changes in product specifications. This paper examines the effect on apparel indexes of adjustments for differences in quality between substitute items. The adjustments are based on parameter estimates developed with hedonic regression techniques.

The sample of prices that compose the CPI is for goods and services such as food, shelter, apparel, transportation, and entertainment: goods and services that people buy for everyday living. Price change is measured by repricing essentially the same market basket of goods and services at regular intervals and comparing current prices with prices of the previous period. The CPI is designed to measure price change, holding constant the quality of the goods and services priced. When an item that is priced in the index is no longer available for consumer purchase, it must be replaced by another item of the same quality in order to maintain the integrity of the CPI. However, in practice, substitute items of comparable quality are not always available.[1]

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1. Triplett's (1971) notion of quality most clearly embodies the notion of quality used in this paper. He contends that "quality itself is, in some ultimate sense, not a variable or measurable entity at all. But it is a kind of shorthand reference to the characteristics [of the good or service], and characteristics are, in principle, observable and measurable. Furthermore, even if there is no objective phenomenon identifiable as 'quality,' the employment of the notion of characteristics,

Finding replacement apparel commodities with the same level of quality as discontinued ones is a particularly serious problem in the CPI because of frequent and widespread variation in fashions and styles. Almost 70 percent of apparel commodities in the CPI are marketed seasonally, with new items introduced at the beginning of the fall/winter and spring/summer fashion seasons. Such commodities are usually introduced at high regular prices and subsequently discounted at "sale" prices throughout their season or selling life. Since these items seldom undergo price increases after introduction, it is when they are introduced into the markets that the manufacturer and retailer pass along any price increases.[2]

The CPI should measure only price change of apparel commodities of constant quality. Price increases passed along to the consumer by apparel manufacturers and retailers are not directly reflected in the CPI when replacement items with different quality levels are selected for discontinued items. Instead, an imputed price change is used to bridge the gap between discontinued and replacement items. This imputed price change is equivalent to the average price change of all commodities within the same stratum that have quality characteristics similar to the substitute item in the current period. Many of the price changes that are used in the imputation process are for items sold year round (over 30 percent of the sample) that show little or no price change from month to month. About half the sample for seasonal items (almost 35 percent) cannot be used for imputation because the items are not available for pricing (e.g., fall/winter items are not in stores during the spring/summer selling season). Price changes for seasonal items that are used for imputation and still available in the current season (e.g., in-season items that do not require substitution) reflect discounted "sale" prices because these items were left over from the previous fashion year. Therefore, replacing large price increases by manufacturers and retailers with the average of relatively small or no price changes from previously priced items may introduce an index bias.

An approach to eliminating this price index bias caused by low-price replacement items (called substitutions) is to attempt a measurement of the quality difference between items. One direct way to implement this approach would be to collect information from producers about the retail value of changes in each specific characteristic of each product. However, the large number of products and producers makes this impossible to accomplish in the time span required for producing a monthly price index. The use of a hedonic regression to measure the implicit price of a quality change is more feasible.

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and the idea that 'quality' involves the disaggregation of goods into constituent characteristics, permits us to say meaningful and useful things about situations which are usually felt to involve quality comparisons and which, without this approach, are difficult to subject to analysis" (p. 14). Further discussion may be found in Triplett (1986).

2. For more detailed discussions of rates of product substitution in the CPI and the pricing practices of U.S. apparel manufacturers and retailers, see Armknecht and Weyback (1989), Armknecht (1984), and Pashigian (1988).

Griliches justifies the hedonic model: "The 'hedonic,' or, using a less value-loaded word, characteristics approach to the construction of price indexes is based on the empirical hypothesis (or research strategy) which asserts that the multitude of models and varieties of a particular commodity can be comprehended in terms of a much smaller number of characteristics or basic attributes of a commodity and that viewing the problem this way will reduce greatly the magnitude of the pure new commodity or 'technical change' problem, since most (though not all) new 'models' of commodities may be viewed as a new combination of 'old' characteristics" (1971, 4).

In the CPI, recent investigations on the use of hedonic modeling have concentrated on the apparel area. The empirical findings from hedonic models for apparel items have led to two types of enhancements that have increased the number of constant quality price comparisons used in index calculations. (1) The collection documents, known as checklists, have been revised to enable field representatives to better capture a complete set of measurable quality characteristics for each item priced. This procedural change alleviated a previously troublesome problem regarding the identification of comparable quality substitutes for some discontinued apparel commodities. (2) The decision rules used to determine whether an item is a comparable quality substitute have been improved by incorporating information from the hedonic models on the importance of item characteristics.[3]

This paper builds on this earlier work at the Bureau of Labor Statistics (BLS) by extending the hedonic regression techniques to develop measures of price change for substitute items of different quality that approximate market price changes better than current BLS methodology. Section 6.1 outlines the methodology. Section 6.2 compares the published CPI apparel indexes with those calculated in this study. Concluding remarks are presented in section 6.3.

## 6.1 Methodology

The price adjustments for substitute items of different quality developed in this study are based on hedonic parameter estimates, or implicit prices, calculated for characteristics found in two strata of women's apparel. These strata are labeled in the CPI as *women's coats and jackets* and *women's suits*. The choice of these strata was motivated both by index behavior reflecting minimal and even declining price changes over a long period and by the presence of more substitutions with dissimilar-quality items in these strata than in other apparel strata.[4]

3. Prior to this study, another investigation was conducted, culminating in Georges and Liegey (1988). Other internal studies involving the use of hedonic regression techniques have been undertaken and are currently under investigation for a number of CPI goods and services.

4. Consumer price indexes are primarily published at the stratum level, which consists of groupings of similar items. The regression models have usually been constructed at lower levels for

### 6.1.1 Data Source

The characteristics and prices used in the study were collected by BLS field staff on checklists. Checklists are designed for a particular genus of goods or services and specify a broad range of characteristics. When data are collected for an individual item, characteristics on the checklist that are applicable to the item are noted and serve as a description of the item. This checklist permits the BLS field representative (in the next data collection period) to locate the same item or, if it is discontinued, to locate a suitable substitute item. Both strata of women's apparel in this study use the checklist format enhanced by hedonic regression to improve the probability of selecting a comparable-quality replacement if substitution is necessary. To facilitate the choice of comparable-quality substitutes by field staff, the specified characteristics on this type of checklist are divided into three groups or "tiers." The first tier contains major price-determining characteristics, the second tier minor price-determining characteristics, and the third tier product identifiers.[5]

### 6.1.2 The Hedonic Model and Parameter Estimates

The hedonic approach to deriving implicit prices for characteristics of a commodity is as follows. The price of an item ($P$) is expressed as the sum of the product of implicit characteristic prices ($b_i$) times the quality characteristics ($X_i$):

$$P = b_o + \Sigma\, b_i X_i + e_i.$$

The functional form used in this study is the semilog form. The dependent variable is the natural logarithm of price so that the $b_i$ coefficients measure the ceteris paribus percentage change in price caused by a unit change in the quality characteristic, $X_i$. The intercept, $b_o$, is the value of the base, or fundamental, model of the item excluding the additional quality characteristics.[6]

The data cover March and April 1989.[7] The fiber content of an apparel item

individual classes called *entry level items* (ELIs) or smaller subclasses called *clusters*. The apparel commodities chosen for this study happen to consist of one cluster per ELI. Additionally, these two ELIs are the only ELIs in their respective strata. The task of quality adjusting all eligible substitutions for a multiclustered ELI, a stratum with more than one ELI, or both requires the formulation of hedonic regression models at the cluster level.

5. For more information about tiered checklists, consult Armknecht and Weyback (1989).

6. The disturbance term, $e_i$, is assumed to satisfy the basic properties of classic regression models constructed by the method of ordinary least squares.

7. Armknecht and Weyback explain how data bases for (apparel) commodities are created. Basically, "two months [of cross-sectional data] are needed to include all local areas in the CPI because apparel is priced bimonthly in many areas. Characteristics and prices were integrated into a database containing the entire sample (separate databases were created for each stratum in this study). Any imputed prices as well as 'sale' prices were then replaced by the item's last regular reported price using historical price data. This approach enables both fall/winter and spring/summer seasonal items to be fully and equally represented" (1989, 15). Another study is currently under consideration in which at least two or more cross-sectional samples would be pooled together to create one data base. Differences in time periods would be accounted for by dummy variables. As more tiered checklist data become available, this option of calculating parameter estimates on the basis of pooled cross-sectional samples will become more viable.

is represented by continuous variables with discrete values from 0 to 100. Each of the remaining characteristics is represented by a binary dummy variable. Control variables for city size, region, and type of business were included to capture the effects of price variations across urban areas and sectors of the country and business pricing practices. Results pertaining to the coefficients' magnitude, direction, and significance for women's coats and jackets and for women's suits are reported in tables 6.1 and 6.2, respectively. These tables are arranged by quality characteristic, as described in the CPI data collection documents; they show the characteristics included in the base model and parameter estimates for the statistically significant price-influencing characteristics.

Determination of the best set of characteristics to explain price for each stratum is naturally limited to physical attributes. This is a serious limitation with apparel because of the influence that fashion has on price. This subjective measure *fashion* is difficult to capture quantitatively since it relies strictly on (industry) opinion. To some extent, nonetheless, fashion can be captured peripherally with such characteristic categories as type, design, brand/label, and closure found in tables 6.1 and 6.2. Other characteristic categories such as lining and fiber are more obvious candidates for inclusion in the regression models since their existence is so fundamental to the price of an apparel item. All these characteristics can be physically observed and tested to see the degree of influence, if any, they exert on price. The parameter estimates calculated in each of the full linear regression models presented in tables 6.1 and 6.2 are of considerable theoretical importance since their inclusion in the models makes logical sense and conforms with a priori expectations.

Several tools were utilized to corroborate the determination of the best set of characteristics in terms of explanatory power and acceptable collinearity levels. Forward stepwise regressions were used to examine the relative importance and significance of both continuous and dummy variables. In these stepwise regressions, as each variable was added to the model, existing variables remained statistically significant. Also, the relations between the variables were analyzed using a correlation matrix to help guard against multicollinearity in the regression models. Finally, price-determining characteristics were examined for frequency in the sample to ensure against the inclusion of variables for which there were few observations and that had no direct influence on price.

Within a characteristic category, specific characteristics contributed differently to price depending on factors such as durability, comfort, general market supply, etc. The importance of a characteristic is indicated by the magnitude of its coefficient relative to the coefficients for the other characteristics in the category. For instance, inspection of tables 6.1 and 6.2 will reveal that luxurious fibers such as cashmere and silk were found to influence price more than ordinary fibers such as wool and cotton. Other results pertaining to table 6.1 indicate that coat and jacket characteristics such as trenchcoat, all weather, and heavyweight styles are more price determining than lightweight, shirt

**Table 6.1 Women's Coats and Jackets—Regression Model**

| Characteristic | Parameter Estimate | *t*-Statistic |
|---|---|---|
| Intercept | 3.7487 | 45.383 |
| Type: | | |
| All-weather | 0.3945 | 7.118 |
| Raincoat | 0.2344 | 3.332 |
| Heavyweight | 0.2858 | 5.311 |
| Lightweight | base | |
| Closure: | | |
| Single-breasted | −0.1902 | −3.961 |
| Double-breasted | base | |
| Design: | | |
| Shirt jacket | −0.1546 | −2.588 |
| Windbreaker | −0.5099 | −8.043 |
| Balmacaan | 0.2036 | 3.787 |
| Parka | base | |
| Trenchcoat | 0.3709 | 6.166 |
| Fiber: | | |
| Cashmere | 0.0214 | 6.069 |
| Wool | 0.0078 | 10.680 |
| Cotton | 0.0023 | 3.925 |
| Manmade | base | |
| Leather | 0.0127 | 10.101 |
| Lining: | | |
| With | 0.3103 | 5.662 |
| Without | base | |
| Control: | | |
| Full-service family | 0.1417 | 2.353 |
| Discount department | −0.4569 | −7.451 |
| Full-service/ready to wear | base | |
| Northeast | 0.0963 | 2.114 |
| South | 0.0886 | 2.117 |
| West | base | |
| A-size city | 0.1539 | 4.106 |
| B-size city | base | |
| D-size city | −0.1347 | −2.213 |
| $R^2 = .60, N = 904$ | | |

*Note:* All variables except those for fiber content are dummy (0, 1) variables. Since the dependent variable is the logarithm of price, the parameter estimates for each characteristic can be interpreted as the percentage change in price associated with the presence of the particular characteristic. For the fiber specifications, the variables are continuous, with values from 0 to 100. The parameter estimates can be interpreted as the percentage change in price associated with a 1 percent change in the content of a particular fiber.

**Table 6.2 Women's Suits—Regression Model**

| Characteristic | Parameter Estimate | *t*-Statistic |
|---|---|---|
| Intercept | 3.9224 | 23.768 |
| Fiber: | | |
| Silk | 0.0062 | 2.847 |
| Wool | 0.0023 | 3.610 |
| Cotton | −0.0036 | −2.269 |
| Polyester | −0.0057 | −7.836 |
| Rayon/nylon | base | |
| Brand/label: | | |
| Store/private | base | |
| National/regional | 0.1575 | 3.233 |
| Exclusive brand | 0.7286 | 6.006 |
| Composition: | | |
| Jacket or coat | 0.3056 | −2.076 |
| Shirt or pants | base | |
| Lining: | | |
| With | 0.7231 | 11.006 |
| Without | base | |
| Control: | | |
| Discount/ready to wear | −0.2523 | −2.213 |
| Full-service/ready to wear | base | |
| A-size city | 0.0855 | 1.931 |
| B-size city | base | |
| | $R^2 = .58, N = 430$ | |

*Note:* All variables except those for fiber content are dummy (0, 1) variables. Since the dependent variable is the logarithm of price, the parameter estimates for each characteristic can be interpreted as the percentage change in price associated with the presence of the particular characteristic. For the fiber specifications, the variables are continuous, with values from 0 to 100. The parameter estimates can be interpreted as the percentage change in price associated with a 1 percent change in the content of a particular fiber.

jacket, and windbreaker styles. These results also are to be expected; they make sense when considering the durability and comfort, especially in cold, wet weather, that these characteristics provide. The closure characteristic group is more influenced by fashion than other groups. The closure characteristics for women's coats and jackets indicate that single-breasted construction detracts from price, indicating that, while double-breasted construction may not cost more to manufacture, it is a feature that fashion-oriented consumers prefer to single-breasted construction.

The regression model in table 6.2 reveals that the presence of an exclusive brand contributes more to price than a national/regional brand. This result is realistic when considering that the price of a London Fog–brand coat (national/regional) will inevitably be less than the price of a Gucci-brand coat (exclusive) if other characteristics are the same. The presence of a lining,

which lends durability and comfort, in commodities in both strata is—as expected—a positive price-determining characteristic. Finally, the signs of the coefficients were found to be reasonable for both strata. For example, the parameter estimates for discount stores are negative, while those for full-service stores are positive.

The parameter estimates in tables 6.1 and 6.2 measure the value added to the item by the presence of a particular quality characteristic. For the continuous variables, the parameter estimate represents the percentage contribution to the price of the item of a 1 percentage point increase in the content of a particular fiber. For the dummy variables, the parameter estimate represents the percentage contribution to the price of the item of the presence of a particular characteristic.

To calculate the quality-adjusted price, the parameter estimates were used in the following manner. Assume that a woman's coat without lining containing 20 percent wool and 80 percent polyester (a base variable) was no longer available for pricing and was replaced in the sample by a coat with lining containing 40 percent wool and 60 percent polyester, ceteris paribus. In this example, the value of a lining and 20 percent wool would be added to the price of the old item so that constant-quality prices could be compared. Since in this example polyester is considered to be a base variable (i.e., it neither adds to nor subtracts from the value of the coat), the value of 20 percent polyester is not subtracted from the price of the old item.

### 6.1.3 Determination of Eligible Substitution Data

Data for a full year—from November 1988 to October 1989—were used for both strata. Product specifications, arranged by collection period and apparel stratum, were analyzed. Substitutions eligible for price adjustment based on quality differences were determined by the following criteria:[8]

1. All pertinent characteristics were reported for both items.
2. The characteristics for an item were not contradictory.
3. Parameter estimates existed for all characteristics that varied between the discontinued item and its replacement.[9]

8. I gratefully acknowledge the contribution of Melinda K. McAllister during this phase of the study. She devoted numerous hours deciphering thousands of characteristics. Her efforts culminated in abridged listings that highlighted the degree of relevant characteristic variation for all substitutions evaluated in this study. These abridged characteristic listings greatly simplified determination of substitutions eligible for quality adjustment.

9. An exception to this criterion existed for characteristics considered to be "base" variables. Theoretically, base variables neither add to nor subtract from the value of the item; i.e., they represent the quality level to which others are compared. These base variables are explicitly excluded from hedonic regression models and not represented by parameter estimates as are price-determining variables. Only those pertinent characteristics that were significantly correlated with price and varied between the substitute items were used in the adjustment process.

Substitutions that met the three criteria were eligible for adjustment. Table 6.3 shows the number of ineligible and eligible substitutions by collection period for each stratum, with the eligible substitutions in two groupings. The first group contains replacement items that possess identical price-determining characteristics. This group is labeled COMPARE. The second group contains replacement items that differ in one or more of the price-determining characteristics. This group is labeled ADJUST.

Table 6.4 shows the breakdown of ineligible substitutions in terms of the three criteria. These criteria were applied sequentially in the order shown above in the text. The third criterion—lack of parameter estimates—was by far the major reason for substitutions being declared ineligible for price adjustment.

### 6.1.4 Adjusting Apparel Prices for Quality Differences

The COMPARE group simply required direct price comparison between items. Theoretically, the types of substitutions found in this group should have been deemed comparable when they were originally reviewed for use in the CPI since the major price-contributing characteristics were identical for both items. However, in practice, price change is monitored, and, if the price change generated by two items with comparable characteristics exceeds established thresholds, it may be edited from index calculations and replaced by an imputed price change as discussed above for substitutions with items of differ-

**Table 6.3 Breakdown of Substitutions**

| | Women's Coats and Jackets | | | Women's Suits | | |
|---|---|---|---|---|---|---|
| Month | Ineligible | Compare | Adjust | Ineligible | Compare | Adjust |
| Nov. 1988 | 30 | 5 | 16 | 7 | 0 | 4 |
| Dec. 1988 | 19 | 1 | 11 | 2 | 3 | 0 |
| Jan. 1989 | 6 | 0 | 6 | 4 | 1 | 0 |
| Feb. 1989 | 19 | 3 | 11 | 6 | 4 | 6 |
| Mar. 1989 | 32 | 10 | 34 | 13 | 5 | 11 |
| Apr. 1989 | 30 | 7 | 20 | 12 | 2 | 12 |
| May 1989 | 10 | 1 | 6 | 4 | 2 | 7 |
| June 1989 | 3 | 1 | 8 | 1 | 2 | 1 |
| July 1989 | 2 | 1 | 2 | 1 | 0 | 5 |
| Aug. 1989 | 18 | 5 | 8 | 6 | 1 | 1 |
| Sep. 1989 | 29 | 11 | 27 | 10 | 3 | 12 |
| Oct. 1989 | 39 | 15 | 24 | 13 | 3 | 9 |
| Total | 237 | 60 | 173 | 79 | 26 | 68 |

*Note:* Ineligible substitutions did not meet the criteria listed in the methodology section of the text. Eligible substitutions in which the replacement items possess identical price-determining characteristics are accounted for in the COMPARE column; those in which the replacement item differs in one or more price-determining characteristics are accounted for in the ADJUST column.

**Table 6.4** **Percentage of Substitutions Ineligible for Price Adjustment, by Criteria**

| | Pertinent Characteristics Not Reported | Contradictory Characteristics | Parameter Estimates Unavailable | Other | Total |
|---|---|---|---|---|---|
| Women's coats and jackets | 14.5 | 1.5 | 32.6 | 1.8 | 50.4 |
| Women's suits | 3.5 | 1.2 | 41.0 | 0 | 45.7 |

*Note:* The three criteria were applied sequentially in the order shown in the text in sec. 6.1.3. A substitution determined ineligible under the first or second criterion was not evaluated under the remaining criteria.

ent quality. This type of price editing results mainly from BLS concerns that the checklist may fail to capture some aspects of the quality of the item priced. BLS is thus applying a "reasonableness" check based on the price differential. Product substitution of this nature is prevalent for apparel commodities owing to the difficulties encountered when trying to define and quantify notions of fashions and style. The COMPARE group accounted for approximately 26 percent of all substitutions eligible for adjustment in both strata.

Calculating price change for substitutions in the ADJUST group required an assessment of the quality difference between the old and the new items using the hedonic parameter estimates. The characteristics for both items were compared, and, when a major or tier 1 difference occurred, the price of the discontinued item was adjusted on the basis of the difference in characteristics. This adjusted price was then used in index recalculation.

For example, assume that the discontinued item was an exclusive brand suit while the replacement item was a national/regional brand suit and that all other characteristics of the two items were the same. The discontinued item's price would be adjusted by subtracting the "exclusive brand" quality effect and adding the "national/regional brand" quality effect. A numeric example is presented in table 6.5.[10]

10. As noted at the beginning of this section, the natural logarithm of price was used to calculate the parameter estimates in this study. Therefore, an antilogarithmic conversion of these estimates was necessary so that "same scale" price changes could be observed between the discontinued and the replacement items. In particular, the price of the old item was adjusted such that

$$P_{(\text{old, adjusted})} = P_{(\text{old})} \times e^{x}.$$

In the text example, $x$ represents the national/regional brand value less the exclusive brand value and is computed by subtracting the parameter estimate for the exclusive brand quality, the discontinued item, from the parameter estimate for the national/regional brand quality, the replacement item. The resulting adjusted price for the discontinued item can be compared with the replacement item's price to produce a (theoretically) constant-quality price change that can be used for index calculation. The choice of the exponential function for parameter estimate conversion follows from the relation

$$x = e^{\ln(x)}.$$

The exponent, $x$, as indicated in the example above, represents the aggregate value of all varying replacement item characteristics, as represented by the sum of their parameter estimates, minus

**Table 6.5** **Derivation of Estimated Price Change from Observed Prices for Exclusive and National/Regional Brands of Women's Suits**

| | |
|---|---|
| Observed Prices ($): | |
| Discontinued exclusive brand in period 1 | 262.50 |
| Substitute national/regional brand in period 2 | 157.50 |
| Parameter estimates (table 6.2): | |
| Exclusive brand characteristic | 0.7286 |
| National/regional brand characteristic | 0.1575 |
| Difference | −0.5711 |
| Price in period 1 adjusted for quality difference ($), (262.50) * $e^{-.5711}$ | 148.29 |
| Estimated constant-quality price change (%), [(157.50/148.29) − 1.0] * 100 | 6.2 |

### 6.1.5 Recalculating Apparel Indexes with the Adjusted Data

For each apparel stratum, four indexes were developed. The first index, labeled PUBLISHED, reproduces the not seasonally adjusted CPI-U (the urban population CPI). The second, labeled COMPARE, includes the substitutions described above in which a direct price comparison without any quality adjustment was possible. The third, labeled ADJUST, includes the substitutions in which the hedonic parameter estimates were used to develop a quality adjustment. The fourth, labeled COMPARE/ADJUST, includes both types of substitutions.

To compute the indexes for each group, COMPARE, ADJUST, and COMPARE/ADJUST, the adjusted prices were entered into a Statistical Analysis System (SAS) program simulating an actual CPI estimation. Indexes were computed for each group by collection period and stratum. Aggregated price change was then calculated for each stratum, reflecting the quality-adjusted data. The aggregate price change is the ratio of the weighted sum of prices in the current period to the weighted sum of prices in the previous period for a specific item stratum within a market basket (index area). Generally speaking, the weight for each price quote is the estimate of the average expenditure for the stratum in a retail outlet as determined from the Consumer Expenditure Survey (CEX) and Point of Purchase Survey (POPS). Price changes for the U.S. city level, such as those examined in this study, are obtained by summing price changes over all index areas using aggregation weights derived from the CEX.[11]

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the aggregate value of all counterpart discontinued item characteristics, as represented by the sum of their parameter estimates. In general, as this difference in aggregate parameter values becomes larger, the difference between the logarithmic quality-adjusted price and the "true" quality-adjusted price becomes much larger. Failing to account for this antilogarithmic conversion will result in distorted price change results between the discontinued and the replacement items. I am grateful to Marshall B. Reinsdorf for bringing this matter to my attention.

11. The SAS program that simulates index computation was devised by Kenneth J. Stewart. Without this program, it would have been virtually impossible to observe and measure the effect of the constant-quality price changes. Stewart's advice and comments throughout the development of this paper are also greatly appreciated. Additional information on the estimation of expenditure and population weights are provided in BLS (1988, chap. 19).

Given recalculated price changes, new index numbers were computed. For each stratum and group, the published CPI index number recorded one collection period prior to the start of the study period was used as a beginning point. Since the study period began in November 1988, the published index number for October 1988 was multiplied by the stratum-level price change recalculated for November 1988. The resulting index number, rounded off to three decimal places, was then recorded as the recalculated index number for November 1988. This recalculated index number was then multiplied by the new price change calculated for December 1988 to obtain the recalculated index number for December. This process continued for each month of the study period. The results are presented in table 6.6 and figure 6.1 for women's coats and jackets and table 6.7 and figure 6.2 for women's suits.

## 6.2 Empirical Findings

The results presented in this section measure both the effect of replacing edited price changes with observed price changes for substitute items with the

**Table 6.6** **Indexes for Women's Coats and Jackets**

| Month | Published | Compare | Adjust | Compare/ Adjust |
|---|---|---|---|---|
| Oct. 1988 | 110.337 | . . . | . . . | . . . |
| Nov. 1988 | 108.650 | 108.666 | 107.065 | 107.082 |
| | (−1.5) | (−1.5) | (−3.0) | (−3.0) |
| Dec. 1988 | 104.546 | 104.614 | 102.491 | 102.560 |
| | (−3.8) | (−3.7) | (−4.3) | (−4.2) |
| Jan. 1989 | 100.219 | 100.285 | 98.262 | 98.328 |
| | (−4.1) | (−4.1) | (−4.1) | (−4.1) |
| Feb. 1989 | 104.554 | 104.604 | 102.893 | 102.948 |
| | (+4.3) | (+4.3) | (+4.7) | (+4.7) |
| Mar. 1989 | 112.780 | 111.358 | 110.512 | 110.831 |
| | (+7.9) | (+6.5) | (+7.4) | (+7.7) |
| Apr. 1989 | 114.409 | 114.316 | 110.947 | 112.462 |
| | (+1.4) | (+2.7) | (+.4) | (+1.5) |
| May 1989 | 110.067 | 109.898 | 105.869 | 107.235 |
| | (−3.8) | (−3.9) | (−4.6) | (−4.6) |
| June 1989 | 106.439 | 105.579 | 101.479 | 102.110 |
| | (−3.3) | (−3.9) | (−4.1) | (−4.8) |
| July 1989 | 102.053 | 101.983 | 100.252 | 101.604 |
| | (−4.1) | (−3.4) | (−1.2) | (−0.5) |
| Aug. 1989 | 104.197 | 105.347 | 104.258 | 106.603 |
| | (+2.1) | (+3.3) | (+4.0) | (+4.9) |
| Sept. 1989 | 112.726 | 113.879 | 114.894 | 117.453 |
| | (+8.2) | (+8.1) | (+10.2) | (+10.2) |
| Oct. 1989 | 116.205 | 117.389 | 117.587 | 120.473 |
| | (+3.1) | (+3.1) | (+2.3) | (+2.6) |

*Note:* The indexes correspond to the not seasonally adjusted CPI-U. Percentage change is given in parentheses.

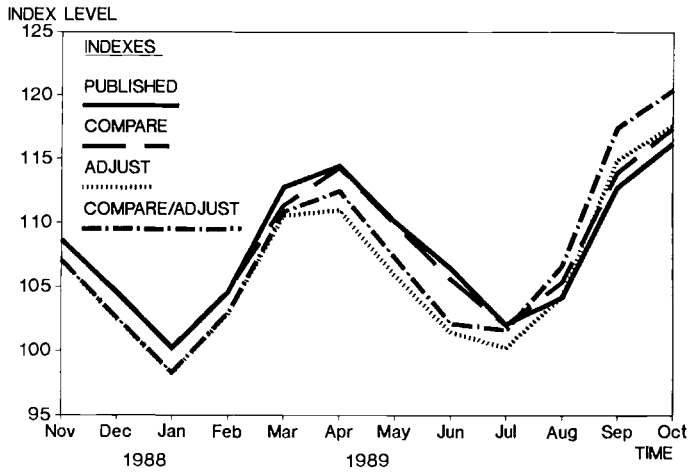


**Fig. 6.1 Women's coats and jackets**

**Table 6.7 Indexes for Women's Suits**

| Month | Published | Compare | Adjust | Compare/ Adjust |
|---|---|---|---|---|
| Oct. 1988 | 126.035 | . . . | . . . | . . . |
| Nov. 1988 | 122.467 | 122.467 | 122.332 | 122.332 |
| | (−2.8) | (−2.8) | (−2.9) | (−2.9) |
| Dec. 1988 | 120.133 | 122.995 | 120.000 | 122.859 |
| | (−1.9) | (+0.4) | (−1.9) | (+0.4) |
| Jan. 1989 | 116.075 | 119.454 | 115.947 | 119.322 |
| | (−3.4) | (−2.9) | (−3.4) | (−2.9) |
| Feb. 1989 | 117.258 | 121.832 | 114.950 | 119.455 |
| | (+1.0) | (+2.0) | (−0.9) | (+0.1) |
| Mar. 1989 | 139.524 | 146.914 | 135.572 | 142.795 |
| | (+19.0) | (+20.6) | (+17.9) | (+19.5) |
| Apr. 1989 | 135.962 | 143.299 | 131.780 | 138.933 |
| | (−2.6) | (−2.5) | (−2.8) | (−2.7) |
| May 1989 | 128.061 | 135.271 | 124.753 | 131.789 |
| | (−5.8) | (−5.6) | (−5.3) | (−5.1) |
| June 1989 | 119.991 | 126.453 | 116.834 | 123.138 |
| | (−6.3) | (−6.5) | (−6.3) | (−6.6) |
| July 1989 | 114.157 | 120.305 | 109.552 | 115.463 |
| | (−4.9) | (−4.9) | (−6.2) | (−6.2) |
| Aug. 1989 | 121.180 | 127.646 | 116.423 | 122.647 |
| | (+6.2) | (+6.1) | (+6.3) | (+6.2) |
| Sept. 1989 | 132.411 | 140.791 | 125.510 | 132.692 |
| | (+9.3) | (+10.3) | (+7.8) | (+8.2) |
| Oct. 1989 | 133.937 | 141.782 | 126.415 | 133.061 |
| | (+1.2) | (+0.7) | (+0.7) | (+0.3) |

*Note:* The indexes correspond to the not seasonally adjusted CPI-U. Percentage change is given in parentheses.

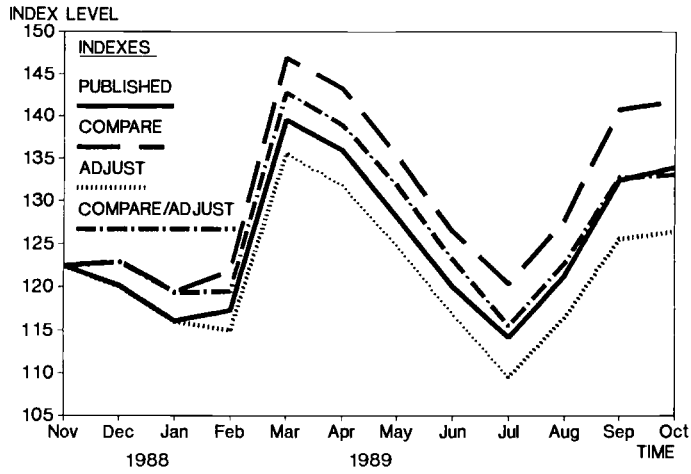


**Fig. 6.2 Women's suits**

same characteristics and the effect of using hedonic regression models to adjust apparel prices for quality differences in substitute items with different price-determining characteristics. Interpretations and conclusions drawn from these empirical findings are limited in scope. More general conclusions concerning the effects of using hedonic models in quality adjustments for all CPI apparel commodities will require further research when more resources can be allocated to the project.

Test indexes replicating the published apparel CPIs located in tables 6.6 and 6.7 indicate that the annual October 1988–October 1989 index change for women's coats and jackets and women's suits are +5.3 and +6.3 percent, respectively. The results for the two strata including the new information gleaned from the hedonic models reveal the differences between the published indexes and those developed for each of the test groups—COMPARE, ADJUST, and COMPARE/ADJUST.

### 6.2.1 COMPARE Group Results

The results of hedonic models permit the development of a consistent set of criteria for making the decision about substitution comparability. For women's coats and jackets, use of these criteria results in the annual price change being +1.1 percentage points greater than that for the published index (COMPARE, +6.4, vs. PUBLISHED, +5.3). In the case of women's suits, this effect is even larger, with the annual price change +6.2 percentage points greater (COMPARE, +12.5, vs. PUBLISHED, +6.3). Thus, uncertainty about quality change versus price change resulted in some price change being excluded from the published index for both strata.

### 6.2.2 ADJUST Group Results

The parameter estimates from the hedonic models are used to make price adjustments based on quality differences when sufficient information on the price-determining quality characteristics of the discontinued and substitute items are available. For women's coats and jackets, this results in the adjusted annual price change being +1.3 percentage points greater than that for the published index (ADJUST, +6.6, vs. PUBLISHED, +5.3). This implies that, over the test period, some price change was treated as quality change and excluded from the published index. For women's suits, the effect of using the parameter estimates from the hedonic model for adjusting price on the basis of quality differences was the reverse. The adjusted annual price change was 6.0 percentage points lower than the published change (ADJUST, +0.3, vs. PUBLISHED, +6.3). This result implies that some quality change was treated as price change and included in the published index.

### 6.2.3 COMPARE/ADJUST Group Results

When the two individual approaches are combined, the effects become interactive because of the method of CPI estimation. This is a result of the imputation procedure used for items that do not have current price information because they are out of season, temporarily out of stock, or discontinued—that is, when a noncomparable substitution occurs. When more items are deemed comparable, as with the COMPARE group, more information is used in index estimation. The new information includes both the new price changes and the new average price change used for imputation. The same holds true when more price changes are used owing to quality adjustments, as in the ADJUST group. When both groups of information are used together, they have an interactive effect on the average price change used for imputation.

In the case of women's coats and jackets, the combined effects result in an annual price change that is +3.9 percentage points above that for the published index (COMPARE/ADJUST, +9.2, vs. PUBLISHED, +5.3). This indicates that a downward bias may exist in the published index owing to price change being treated as quality change and excluded from the (published) index. In the other case, the combined effects for women's suits result in an annual change that is 0.7 percentage points below that for the published index (COMPARE/ADJUST, +5.6, vs. PUBLISHED, +6.3). This indicates that an upward bias may exist in the published index owing to quality change being treated as price change and included in the (published) index.

### 6.2.4 Interpretation of Test Group Results

The most striking difference in the results between the apparel strata is the difference in the direction of the potential bias in the price indexes. In the case of coats and jackets, the difference between published and test indexes indicates a positive quality change. By contrast, the case of women's suits indicates a negative quality change between published and test indexes.

Results of this nature may be directly linked to the complexity of the commodity (or service) under consideration. Women's suits, which are frequently composed of at least two, and sometimes three, components, are difficult to keep constant from discontinued to replacement item because of the great number of characteristics. Consequently, the published index for women's suits may have reflected more quality change than the (published) index for women's coats and jackets because it is more difficult to capture quality factors for the former than the latter. As a result, test indexes may not perform consistently when the degree of quality "creep" varies for published indexes.

Given the description of the apparel market presented earlier (i.e., that manufacturers and retailers pass along any price increase when new items are introduced at the beginning of the fall/winter and spring/summer selling seasons), the test results for women's coats and jackets should be more indicative of what should occur when other commodities are tested.

### 6.2.5 Additional Sources of Explanation for Index Behavior

The different behavior of these test indexes may also be attributable to the following factors.

First, the "success" of test index behavior is greatly determined by the "accuracy" of the implicit characteristic prices. A measure of this accuracy is the explanatory power, $R^2$, of the models. The models presented possess implicit prices explaining approximately 60 percent of the variation in (the natural logarithm of) price. Given the nature of these commodities—that is, the inherent difficulty associated with quantifying fashion—explanatory powers of 60 percent are "reasonable." However, when using these models to determine the dollar value of quality differences between substitute items, it should be recognized that test indexes may not always behave alike. Models for commodities possessing characteristics that, unlike fashion, are easily quantified would display greater explanatory power.

Second, the actual number of substitutions adjusted for quality differences in the samples available for this study may have been inadequate to produce consistent test index behavior. The two primary reasons for exclusion of substitutions in this study, noted in table 6.4 above, were missing characteristics and unavailable parameter estimates for characteristics that varied between items. Lack of parameter estimates was by far the major reason for substitutions being declared ineligible for price adjustment. Unfortunately, little headway has been made in developing parameter estimates for quality factors or characteristics that appear infrequently in the CPI data base. Therefore, quality adjustment of these characteristics is effectively precluded. A method for treating characteristics without parameter estimates must be devised in order to reduce this potential source of substitution ineligibility.

The explanations outlined above are meant to convey possible reasons for differences in behavior of the test indexes. These explanations are plausible owing to their intrinsic links to the quality-adjustment procedure. Continuing

efforts focused on reducing the number of ineligible substitutions will further decrease potential index bias.

### 6.3 Summary

Historically, eliminating potential index bias generated when substitute items of different quality have been selected for use in the CPI has been a difficult task. Nowhere has this bias been more suspect than with apparel commodities whose indexes have reflected minimal price changes or even declining prices over long periods. Revision of data collection procedures and materials has been oriented toward increasing the likelihood that a comparable item will be chosen by the CPI data collection staff as a replacement for the discontinued item. However, in situations when selection of a noncomparable item is unavoidable, action must be taken so that constant quality price change is captured.

This paper has outlined the empirical results of applying an important tool to provide better estimates of price change. Adjustment of substitute items of different quality using parameter estimates developed for apparel commodity characteristics from hedonic regression techniques has been demonstrated. Greater emphasis must be placed on developing models that explain those factors that influence the prices of goods and services. Also, continued enhancement of collection documents and review procedures is needed to minimize the possibility of missing important data on quality characteristics. Pursuit of these broad goals will lead to a more adequate separation of price and quality change when items are replaced with substitutes of different quality.

### 6.4 Postscript

Since January 1991, BLS has employed about twenty hedonic regression models to assist with the production of published consumer price indexes for apparel commodities in the manner described in this article. Further research to examine the consistency of index performance among these different commodities could be conducted by removing the hedonic price adjustment effect from the CPI data. At least a twelve-month period should be analyzed in order to include both spring/summer and fall/winter selling seasons. Research of this depth, which would require more resources than were available for this study, would provide more conclusive evidence.

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