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An Application of the Hedonic Approach to Clothing Items in the Consumer Price Index (CPI): A Pilot Study Using Checklists

By Terri Markle

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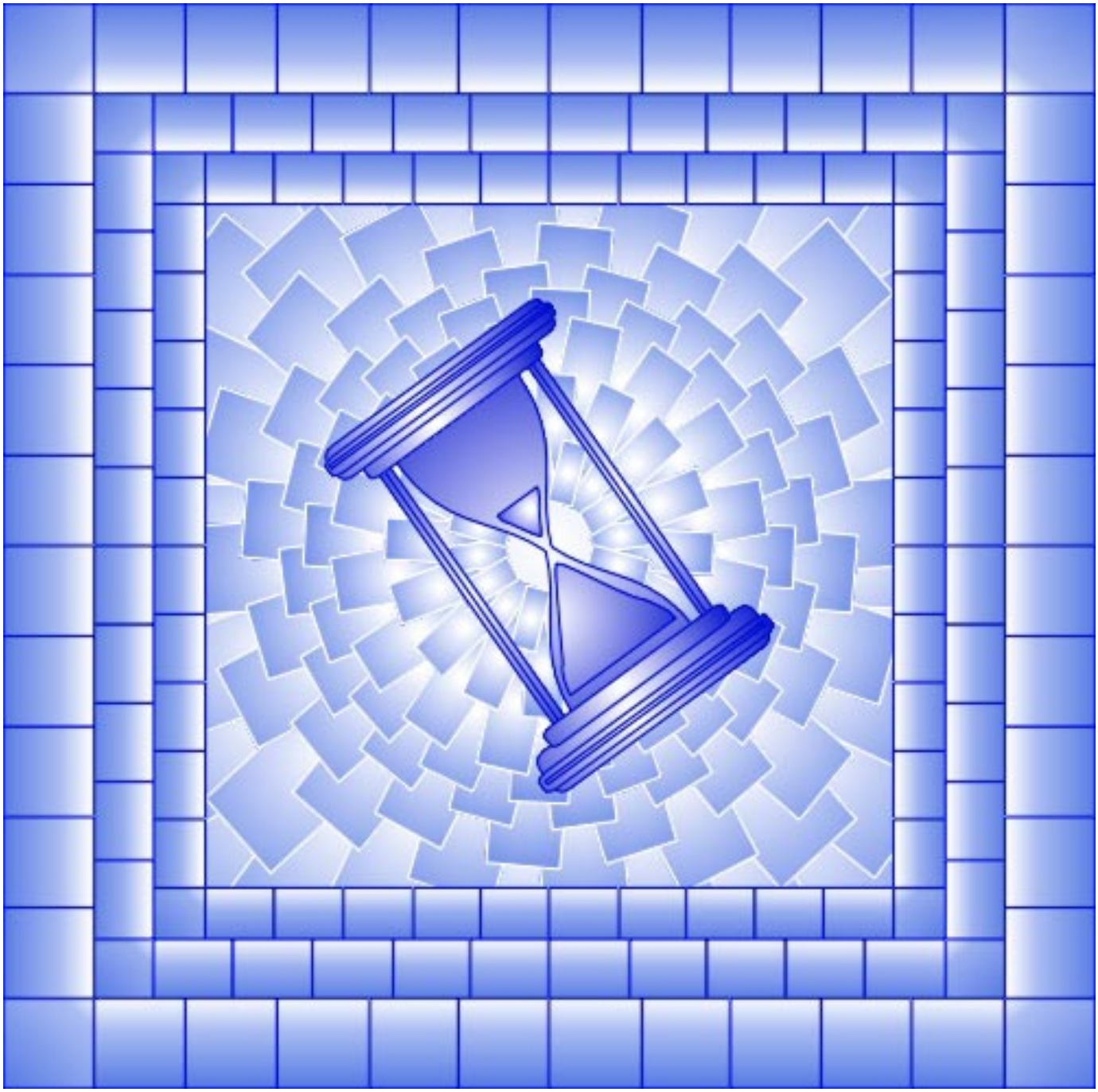

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Abstract

This paper is the second in a series reporting on the current progress of a study whose purpose is to explore the feasibility of using the hedonic approach for making quality adjustments to the Clothing component of the Consumer Price Index (CPI). In this phase of the study, two preliminary checklists were developed for obtaining prices and quality characteristics for Men's Dress Shirts and Men's Sports Jackets. These checklists were then used for data collection in the field on expanded CPI samples for the two items. To date, the resulting database for Men's Dress Shirts has been used to derive a hedonic model. The main conclusions that can be made at this point are: 1) checklists represent a certain improvement over the current method of reporting and should be developed for all clothing items in the CPI; 2) if the hedonic approach to quality adjustment in clothing is to be formally adopted then the CPI samples will have to be augmented, at least periodically to permit estimation; and 3) more experience is needed with the hedonic approach in research mode, using clothing items with more complexity, before we can say whether the hedonic approach should be formally adopted as an alternative to our current method of quality adjustment for clothing items.

Preface

Prices Division first started publishing the Analytical Series in December 1996 as a means to convey conceptual and applied research undertaken by its staff, and at times, by other persons from within or outside Statistics Canada on the subject of price indexes.

All papers are reviewed by a panel of experts from within Statistics Canada or outside the agency. Views expressed in the papers are those of the authors and do not necessarily reflect those of Prices Division or Statistics Canada.

The purpose of the series is to disseminate knowledge and stimulate discussion. Questions and comments on any aspect of the papers are welcome and can be forwarded to either the Director, Louis Marc Ducharme (Internet email: ducharl@statcan.ca; telephone (613) 951-0688), or the Chief of Quality Assurance, Robin Lowe (Internet email: lowerob@statcan.ca; telephone (613) 951-9495), Prices Division, Statistics Canada, Ottawa, Ontario, K1A 0T6.

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1. Introduction[1]

The measurement of quality change in clothing items priced in the Canadian CPI as they are substituted over time has always proved to be a major challenge. Because of the extremely high frequency of quality adjustments in clothing relative to other commodities, a study was initiated recently to explore ways of improving on the techniques currently used. This paper is the second in a series reporting on the progress of this effort. The focus is on a description of a pilot study launched to experiment with the use of checklists to find out how well they work in the field, in terms of facilitating the data gathering process from the perception of the field representatives, and whether the information collected has improved enough over that which was used in the first phase of the study to permit reasonably robust hedonic models to be estimated.

Both the U.S. and Sweden use checklists when substituting clothing items priced in their respective CPIs. Moreover, both countries have adopted the hedonic approach for quality adjustment in the production of their clothing price indexes, and are satisfied that this method represents an improvement over previous methods. The basic strategy used in this study was to learn from their experiences and procedures, and adapt and apply them to the Canadian CPI. The rationale was that after carrying out such an exercise we would be in a better position to decide whether to formally adopt this approach.

The organization of this paper is as follows. Section 2 describes the impetus for the current phase, beginning with a brief background on how clothing items are initially selected for pricing in the CPI, and substituted once they vanish from the marketplace. The main considerations in the development of the two experimental checklists for Men's Dress Shirts and Men's Sports Jackets are given in Section 3. Since the most extensive work to date has been done in connection with Men's Dress Shirts, Sections 4 through 6 will focus on this item alone. Section 4 outlines the criteria used to augment the sample for the purpose of this study. Section 5 comments on the quality of the information obtained through the use of checklists. Two alternative hedonic models for Men's Dress Shirts are presented in Section 6. Section 7 concludes the paper.

2. Impetus for a Checklist Pilot Study

New and replacement items are selected for pricing in the CPI according to a predetermined set of specifications (see Appendix A, which includes the specification for pricing Men's Dress Shirts). The current practice is to complete a special form called a Quality Price Change Report (QPCR) each time a selection is made. This form requires that specific information be recorded about the new selection, as indicated in the section entitled "Special

[1] *The author would like to acknowledge the many contributions and the enthusiastic support of fellow project team members, Ted Baldwin, Lyne Bolduc, Michelle Soucy, and Marion Workman. Mark Illing performed all of the data capture with absolute precision, assisted with several aspects of the analysis, and contributed to Appendices D and E. Excellent comments and suggestions on an earlier draft of this paper were received from Charles Bérubé, Louis Marc Ducharme, Mark Illing, Gail Logan, Robin Lowe, and Alan White. The author assumes full responsibility for all remaining errors.*

Instructions" at the bottom of the pricing specifications. When a substitution occurs (which implies that the item is being selected as a replacement item) the field representatives must also provide their assessment of the quality difference between the two items. Currently, in the overwhelming majority of cases, these assessments are the basis for quality adjustments in clothing. For many reasons, this approach is not deemed to be very precise.

In the first phase of this study an attempt was made to use the hedonic approach for quality adjustment in relation to Men's Dress Shirts by constructing a database of prices and characteristics using the information supplied on the QPCRs. Several problems with the reliability and completeness of the data were encountered, which was probably the main reason that no acceptable hedonic models could be generated. Another major problem was several important quality characteristics lacked the necessary diversity to be able to determine their influence on price.

In the second phase of the study, the goal was again to explore the feasibility of using the hedonic approach. This time, however, a concerted effort was made to overcome the two main problems experienced in the first phase. Checklists were used to improve the reliability and completeness of the data, rather than QPCRs. In order to deal with the problem of limited diversity in the values of certain characteristics, the usual CPI samples were augmented.

3. Specification of Checklists

The main intent of the checklist was to collect a comprehensive set of information on a predetermined set of quality characteristics. In specifying the design of the checklist, a conscious effort was made to: 1) remove any possible ambiguities in the information we were striving to obtain (e.g. workmanship, grade); 2) eliminate any requirement for subjective judgements (e.g. weight of a garment); and 3) bring some consistency to the terminology being used (e.g. fabric weave).

Removing ambiguities often meant taking vague concepts and identifying their observable elements. One such concept appearing in the CPI pricing specifications for Men's Dress Shirts is "workmanship". This was considered ambiguous in the sense that it was not clear that all price collectors were examining the same set of attributes when assessing the level of workmanship of a shirt. Even if they were, it was not clear that they all had the same notion of what constituted "very good workmanship" as opposed to "good workmanship". The solution in this case was to come up with a list of the most important observable features relating either positively or negatively to workmanship (e.g. close straight stitches, matching patterns, loose threads or buttons) and have the field representative check off all those that apply.

An example of a variable required by the CPI pricing specifications that involved subjectivity was the weight of the garment in relation to Men's Sports Jackets. The interviewers are required to describe this attribute as either "light", "medium", or "heavy", or some combination thereof. In fact, no weight ranges have ever been specified to determine which category applies

and, furthermore, no garment is ever actually weighed. On reflection, therefore, we did not see the value of requesting this information on the checklist.

As far as the terminology is concerned, we found many characteristics were described on the QPCRs with inconsistent terminology, making it very difficult to interpret or classify the data values. For example, numerous descriptions were given on QPCRs for fabric weave in relation to Men's Dress Shirts when in fact only three possibilities exist (Broadcloth, Oxford cloth, and Dobby). In order to avoid this problem, the checklist questions were posed in such a way as to exhaust all possible responses, and overcome the difficulties presented by open-ended questions whenever possible. The actual checklist for Men's Dress Shirts used in this pilot study is shown in Appendix B.

4. Criteria for Augmenting the Sample

Currently, the regular CPI sample consists of one price quote in each of 116 outlets for Men's Dress Shirts. Therefore, if we attempted to estimate a hedonic model using the CPI sample we would be restricted to a total sample size of 116 observations. Based on the lack of diversity in characteristic values observed in the first phase of this study for Men's Dress Shirts, using the 73 observations available at that time, a decision was made to augment the sample for the purpose of this pilot study. A truly representative sample would include observations for a wide spectrum of garments with varied characteristics. Ideally, the sample should contain most of the popular varieties in the same proportions as they are found in the population. The cost of doing this on a monthly basis for all clothing items in the CPI would be prohibitive. However, for the sake of this study a decision was made to augment the sample as a one-time effort for the March 1997 pricing month. A tripling of the sample size was decided upon. Specific selection criteria were devised with the goal of acquiring adequate representation of the item, and in so doing overcome any biases held by the field representatives (e.g. away from imports, or towards varieties that take up the most floor space) in making their selections.

A preferred way of obtaining a representative sample would be to select the sample scientifically using, for example, a probability-proportional-to-size procedure (PPS), such as that used at the Bureau of Labor Statistics (BLS) in the United States. With such a procedure, the probability of a given article being selected is proportional to the value of sales revenue it generates. However, we did not have at our disposal such information. So, we had to try to find a practical and economical way to approximate this method that could be easily understood by the field representatives.

The first practical constraint for making the additional 232 selections was that two additional items would have to be selected in each of the 116 outlets where pricing of Men's Dress Shirts is currently carried out. In other words, a total of three selections would be required from each outlet. The selection criteria specified that the most representative, or popular, shirt should be selected for each of three broad quality levels (within the range of quality available in the store): high, medium, and low. Therefore, before making the additional two selections, the field

representative had to first determine which level of quality best described the original CPI selection. If, for example, the CPI selection was of decidedly low quality, then the two additional selections would have to be of medium and high quality.

It is worth emphasizing that the quality levels low, medium, and high, were intended to be determined at the outlet level, and indeed, the low level in one type of outlet could actually represent higher quality than the high level in another outlet. The idea here was that once in an outlet, the interviewer would first try to gain some appreciation of the range of quality of the dress shirts carried, then select one shirt from either extreme and one from the middle of the quality range. In some outlets, certain selections could not be made as some of the interviewers perceived the total range of quality offered to be too narrow to be able to identify three selections, each representing a distinct level of quality. Hence, the total number of checklists completed in this study was 334.

5. Assessment of Characteristic Information

For the most part, the information obtained using checklists appeared to be complete and accurate. Because the checklists are experimental, the general approach taken was to request information on every conceivable quality characteristic. However, in retrospect, many of the characteristics were considered to be marginal in terms of their influence on price, which means that several questions could be removed if these checklists are to be used routinely by field representatives.

In the first phase of this study, missing data for some of the presumably important price-determining variables was a problem. While there is no such problem with missing data as a result of using checklists, there is still some doubt as to the precision of certain characteristic values. The best example here is the thread count of a shirt. While values were always recorded by the field representatives, this variable is almost certainly associated with some degree of measurement error.

A second problem in the first phase of the study was the lack of diversity in values for some important characteristics. Country of origin was one such example. Due to the augmentation of the sample, however, this seems to have been corrected. In fact, the country of origin was very significant in the hedonic models estimated, which will be seen in the next section.

Part of the review of the characteristics data involved a comparison of identical shirts that were inspected by different field representatives to check reporting consistency. We assumed that two shirts were identical if they were produced by the same manufacturer, and had identical brand descriptions and style numbers. Although we could not be completely sure in some cases that this definition was sufficient to uniquely define a shirt, it provided a reasonable guide for conducting such an analysis. Of the 32 groupings of identical shirts, there were only six groupings for which two or more interviewers reported identical thread counts. Discrepancies were as high as 72 threads (per 2.5 cm^2), but averaged 24. Reporting on cuff construction was

not consistent within identical groupings: combinations of "fused-interlined" and "fused-not-interlined" were frequent. Locations reported for single needle tailoring also varied frequently within identical groupings: different combinations of sleeve, shoulder, side, and armhole often appeared. Aside from these three characteristics, there appeared to be a high degree of consistency among field representatives for reporting characteristics. There were only two groupings in which discrepancies were found involving the percentage fibre content, which could be attributed to the fact that our definition of identical shirts did not apply in all cases.

6. Models for Men's Dress Shirts

The underlying model being estimated is the semi-log model, which is specified by (1).

$$\ln(P) = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + e \qquad \textbf{(1)}$$

where the dependent variable, P, is the regular pre-tax price of a shirt (before discounting) expressed in natural logarithms, β_i measures the percentage change in price caused by a unit change in the i^{th} quality characteristic x_i (of which there are k), and β_0 is the value of the base model of the item excluding the additional quality characteristics.

The semi-log specification for the hedonic model was supported by an analysis of the distribution of the dependent variable in our sample, namely the regular price of a shirt. The sample distribution most closely approximated the normal distribution after a log transformation. However, there are practical reasons that may be even more important for preferring this specification over the linear version, which has to do with the interpretation of the parameters, β_i's, as percentage changes in price, rather than as absolute dollar values.

In terms of the model specification, our methodology resembles that of the BLS, where those variables relating to fibre content are represented as continuous variables and all remaining variables are represented as dummies. In addition, we follow the BLS in terms of the type of characteristics we include: we put the emphasis on physical characteristics. Statistics Sweden, on the other hand, includes only dummy variables in their hedonic models and does not give quite as much emphasis to physical characteristics. Both the BLS and Statistics Sweden use the semi-log specification.

A table describing all characteristics considered for inclusion in the model for Men's Dress Shirts can be found in Appendix C. In the first column of this table is the characteristic name and a rank ranging from one to three assigned by our senior commodity officer responsible for clothing. The rank is indicative of the perceived relative importance of a characteristic in terms of its determination on price. Assigning these rankings was an attempt at specifying an *a priori* model. Also included in this first column are the SAS variables defined in this study, all of which are dummy variables except for fibre content. The second column reports frequencies

for each SAS variable. A description of each variable is given in the third column, giving reference to the appropriate box number on the checklist from which the information was derived. Potential problems concerning each characteristic are offered in the final column of the table.

It was clear in the first phase of this study that specifying appropriate classifications was critical to creating meaningful groups of dummy variables. The importance of this, however, cannot be stressed enough. In spite of the fact that the data obtained through the use of checklists are far superior to the data used in the last phase in terms of completeness, accuracy, and diversity of characteristic values, the resulting hedonic models are still very sensitive to the way the characteristic values are assigned to the various dummy variables. In the case of brands, for example, this time we distinguished between only two groups, "national/regional" brands and "store" brands. More diversity here that might refine or improve the model would be to differentiate between different levels of prestige within "national/regional" brands, say, "exclusive national/regional" and "average national/regional" brands. A similar breakdown could be done with the "store" brands category.

Once all of the characteristic values were transformed appropriately into variables that could be used for modeling, a considerable amount of time was spent becoming familiar with the data set. Through examination of the correlation matrix, it was revealed which variables were the most highly correlated with price, and also provided some indication of potential problems with multicollinearity. Analysis of the raw observations in the sample also highlighted why certain variables may be problematic if included in the model. This type of analysis helped to sharpen the *a priori* expectations that had been specified by our senior clothing commodity officer, which are shown as rankings in the first column of the table in Appendix C.

After becoming familiar with the data, various techniques were used to choose the most suitable model.[2] One of these techniques was to generate the entire universe of possible models using all combinations of the variables in the data set. It was then possible to review only those models that were feasible by specifying various criteria including a minimum R^2 value and correctly signed parameters. This helped to identify and eliminate many variables that were problematic, since certain variables never entered the model with the correct sign. Once the number of variables was reduced to a manageable size, the stepwise variable selection technique was used to gain further insight as to the "best" possible specification. Two alternative models were ultimately chosen.

[2] *These techniques were made available through the RSQUARE and STEPWISE procedures in SAS.*

Table 1. Model I

Dependent Variable: Logarithm of Regular Price

Variable	Parameter Estimate	Standard Error	T Statistic for H_0:β=0
Constant	2.650675	0.04898231	54.115
Cotton (%)	0.010589	0.00068007	15.570
National/Regional Brand	0.316923	0.03048043	10.398
"High" Outlet	0.345076	0.04576748	7.540
"Low" Outlet	-0.396536	0.03732431	-10.624
"High" Country of Origin	0.528084	0.06633471	7.961
"Low" Country of Origin	-0.133625	0.03482042	-3.838
Woven Stripes	0.175009	0.03916695	4.468
Superior Thread Count	0.091960	0.03582145	2.567
More Than 7 Buttons	0.221023	0.05891602	3.751
Buttoned Sleeve Placket	0.194620	0.02954553	6.587
Flawed	-0.193066	0.08388617	-2.302
Wrinklefree Cotton	0.259897	0.08737793	2.974
R^2=0.8895; **Adj R^2**=0.8854; **Prob>F**=0.0001; **n**=334			

Table 2. Model II

Dependent Variable: Logarithm of Regular Price

Variable	Parameter Estimate	Standard Error	T Statistic for H_0:β=0
Constant	2.653789	0.04952752	53.582
Cotton (%)	0.010553	0.00069151	15.260
National/Regional Brand	0.317567	0.03104303	10.230
"High" Outlet	0.340558	0.04661028	7.307
"Low" Outlet	-0.414379	0.03747968	-11.056
"High" Country of Origin	0.546942	0.06738853	8.116
"Low" Country of Origin	-0.130779	0.03534820	-3.700
Woven Stripes	0.174511	0.03978956	4.386
Superior Thread Count	0.106292	0.03630372	2.928
More Than 7 Buttons	0.217135	0.05999198	3.619
Buttoned Sleeve Placket	0.196751	0.03010447	6.536
R^2=0.8846; **Adj R^2**=0.8810; **Prob>F**=0.0001**; n**=334			

The two models presented in Tables 1 and 2 are very similar. Their coverage of the important characteristics is quite broad. Six of the seven characteristics with a number one ranking are included: fibre content, brand, outlet, country of origin, colour (i.e. woven stripes), and thread count. Furthermore, all parameters are appropriately signed with reasonable magnitudes, and all are highly significant. The first ten variables are identical, with very similar parameters. The R^2 values of both models are very high. In addition, there was no problem of multicollinearity detected in either case. The key difference between them is the inclusion of "flawed" and "wrinklefree" in the first model.

One thing that was apparent was that the parameter estimates of the first ten variables were hardly affected by the inclusion of two additional variables in the first model. Considering that the intended use of the model is to make specific quality adjustments, it would appear, from a practical standpoint, that the more variables included in the model the better. There is some cause for concern however with the first model. From Appendix C we notice that "flaws" were only reported nine times, which is close to the bare minimum for inclusion of a variable in the model. The wrinklefree attribute also had a very low frequency of eight, which again is the bare minimum. In addition, it was not explicitly asked for on the checklist. This could mean that the observed frequency of the wrinklefree attribute in the sample may be artificially low.

In order to gauge the nature of the quality adjustments that each of the above models would produce, some experimentation with hypothetical examples of shirt substitutions were carried out. In general, the method of adjustment used in the production of the CPI involves the estimation of a previous month's price net of quality change, which is referred to as a "back price". The method by which the parameters of the hedonic model are used to calculate this back price is given in Appendix D.

Four detailed examples of adjustments are given in Appendix E. Only the highlights will be mentioned here. The first example is a very extreme case, included for illustration purposes only. It involves a substitution where the original item is of very low quality and the replacement item is of extremely high quality. It also involves a substitution across outlets which is never done in the CPI. The adjustment procedure takes the observed price of the replacement item in the current month ($235.00) and estimates the "back price" of that shirt. This is done by inflating (or deflating) the price of the original item by a factor representing the quality improvement (deterioration) between the original and the replacement item. The pure price change can then be calculated through a comparison of the replacement item's price and its back price, which turns out to be a decrease of 30.5 (an increase of 5.1) per cent using the adjustment suggested by Model I (Model II). The second example considers a less extreme case, where only four quality characteristics differed, wrinklefree being one of them. In this case, most of the observed price difference between the replacement item and the original was due to quality change. However, the two models led to rather different conclusions about the pure price change: the first (second) model produced a pure price decrease of 4.2 (26.0) per cent. The third and fourth examples are much more typical of the substitutions made in the CPI. In both cases, the observed price of the original and the replacement items are essentially the same. Also, "flaws" and "wrinklefree" do not enter into the adjustments. In the third example, the replacement item is of lesser quality due to the change in the country of origin, but of higher quality due to the buttoned sleeve placket.

The net effect is a quality improvement, which leads to a pure price decrease. Similar values for this pure price change are produced in the case of both models. In the fourth example, the only characteristic that differs due to substitution is a 20 per cent decrease in cotton fibre content. This is clearly a quality decrease. The two models produce almost identical quality adjustment, which yields a correspondingly similar pure price increase.

7. Conclusion

One conclusion that can be made on the basis of this phase of the study is that checklists represent a certain improvement over the current method of reporting. This statement is true from the perspective of the field representatives as well as the commodity officers, whose responsibility it is to review all documentation submitted by the field representatives. From the perspective of the field representatives, they find the forms easier to fill out and less ambiguous than the QPCRs. From the point of view of the commodity officers, the task of reviewing the documentation was greatly facilitated by the use of checklists. Checklists did not undermine the quality, scope, or detail of reporting, which might have been one potential drawback. Hence, even though there is much room for improvement, the recommendation here is that checklists should be developed and used in the field for all clothing items in the CPI. The adoption of checklists would also have the implication that an automated system be developed to routinely capture all information being collected on checklists.

Even if the hedonic approach to quality adjustment in clothing is not formally adopted, checklists should replace the current method of reporting. The exercise alone of developing checklists requires a lot of valuable research by CPI staff that might not be done otherwise due to tight production deadlines.

A second conclusion is that if the hedonic approach to quality adjustment in clothing is to be formally adopted then the CPI samples will have to be augmented, at least periodically, to permit estimation. This conclusion is apparent when we compare the model for Men's Dress Shirts from this phase of the study with that of the previous phase. In the last phase, the diversity of characteristic values was severely limited in certain important cases, such as for country of origin, mainly due to the small sample size.

Finally, it is evident from this pilot study that more experience is needed with the hedonic approach in research mode, using clothing items with more complexity, before we can say whether the hedonic approach is superior to our current method of quality adjustment. Men's Dress Shirts are probably one of the least complex items in the Clothing component of the CPI in the sense that the set of the quality characteristics associated with shirts is relatively limited. Men's Sports Jackets or Ladies Dresses, for example, will present more complicated modeling issues.

Appendix A: CPI Pricing Specifications, Men's Dress Shirts

Amendment Notice No. 646, March 1995
Specification No. 332701 - Men's Dress Shirt

Description:

Dress shirt. Size range 14-17 regular or shaped fit. Sleeve length 33, 34, and 35. Broadcloth, 65% polyester, 35% cotton fibre (soft hand). Thread count approx. 128 × 72 per 2.5 cm^2. Long sleeves. Single cuffs. Full colour range.

Standard Quantity: 1.00

Unit of Measure: EA

Alternate Unit(s) of Measure: CH

Frequency: Monthly.

QPCR Required: A ***SI***: N ***SX***: Y ***GST***: Y

Quality Requirement(s):

Good workmanship. Safety stitched seams. Placket front (may be interlined). Fused collar with stays. Interlined single one button cuffs. Cuffed breast pocket. Double yoke. Six button front. Placket sleeves.

Acceptable Added Value Feature(s):

Patented Mark collar with boomerang stays. Fused cuffs. Two button cuffs. Double cuffs. Seven button front. Dobby weave (tone on tone). Felled seams. 100% cotton.

Acceptable Decreased Value Feature(s):

Lower thread count. Breast pocket not cuffed. Cuffs not interlined. Single yoke. One sleeve length. Limited colour range. Turned back front. Breast pocket turned back and merrowed (possibly not merrowed). Sleeve without placket.

Unacceptable Deviation(s):

Woven stripes, or two seam sleeve construction.

Special Instruction(s):

The item description in Section 8 of the QPCR-A must include: fabric type and grade; colour range; fit; and construction detail. Fabric selected, style and construction must be priced with the highest degree of consistency. When a substitution involves a brand change, a "Comments on Specifications" form requesting H.O. approval must be submitted with the new selection.

Illustrative Manufacturers/Brands:

Arrow, B.V.D., Cluett-Peabody, Mach II, Arrow Mark I, Forsyth, Pierre Cardin, Hathaway

Appendix B: Checklist for Men's Dress Shirt

Men's Dress Shirt	**Specification No.: 332701**
1. Type of selection: ◊ a) Selection used in the CPI ◊ b) Selection for checklist pilot project only	2. Which of the three selection criterion applies (see instructions)? ◊ a) High quality ◊ b) Medium quality ◊ c) Low quality
3. City: a) code: _____ b) name: _____	4. Outlet: a) code: _____ b) name: _____
5. Manufacturer name: _____	
6. CA number: _____	7. Regular price: _____
8. Brand: _____	9. Sale price: _____
10. Style number: _____	11. Country of origin: _____
12. Neck size range: ◊ a) Inches: _____ to _____ ◊ b) Other, please specify (e.g. S,M,L): _____	13. Fit: ◊ a) Regular ◊ b) Tapered ◊ c) Other, please specify: _____
14. Colour: ◊ a) Solid ◊ b) Striped, printed ◊ c) Striped, woven (yarn-dyed)	15. Body fibre: ◊ a) Cotton, _____ % ◊ b) Polyester, _____ % ◊ c) Other, please specify: _____ %
16. Number of colours available: _____	17. Thread count: _____×_____
18. Fabric/Weave: ◊ a) Broadcloth ◊ b) Oxford cloth ◊ c) Dobby	19. Opening style: ◊ a) Placket ◊ b) Turned back, with interfacing ◊ c) Turned back, no interfacing
20. Number of buttons on front opening: ___	21. Yoke: ◊ a) Double

	◊ b) Single

Appendix B: Checklist for Men's Dress Shirt (concluded)

22. Breast pocket: ◊ a) Cuffed ◊ b) Turned back, merrowed ◊ c) Turned back, not merrowed	23. Collar stays: ◊ a) Regular stays ◊ b) Boomerang stays ◊ c) No stays
24. Button-down collar: ◊ a) Yes ◊ b) No	25. Fused collar: ◊ a) Yes ◊ b) No
26. Sleeve length range (inches): _____ to _____	27. Sleeve pleats (at cuff): ◊ a) Yes ◊ b) No
28. Sleeve opening: ◊ a) Placket, with button ◊ b) Placket, without button ◊ c) No placket	29. Cuff style: ◊ a) Single, one button ◊ b) Single, two button (adjustable) ◊ c) Double (French style) ◊ d) Other, please specify: _____
30. Cuff construction*****: ◊ a) Not interlined ◊ b) Interlined ◊ c) Fused	31. Seams: ◊ a) Safety stitched ◊ b) Felled ◊ c) Other, please specify: _____
32. Construction: matching pattern? ◊ a) Yes ◊ b) No ◊ c) No pattern to match	33. Single needle tailoring*****: ◊ a) Sleeve seams ◊ b) Shoulder seams ◊ c) Side seams
34. Details/Features*****: ◊ a) Pearlized buttons ◊ b) Extra buttons, specify number: ____	35. Workmanship*****: ◊ a) Flaws in the seams due to: uneven stitches, skipped stitches, crooked stitching ◊ b) Loose threads or buttons
36. Other price factors: _____ _____ _____	
37. How long did it take you to complete this checklist? _____	

***** Indicates that more than one box can be checked off.

Appendix C: Characteristics Considered for Inclusion in the Hedonic Model for Men's Dress Shirts

Characteristic Name (Rank): SAS Variable Name(s)	Number of Occurrences in Sample	Description (Checklist Box No.)	Potential Problems
Fibre content (1): **COTTON** **POLYEST (base)**	 334 334	The only continuous variables in the model, representing the percentage fibre content. Their values range from 0 to 100. (15)	Different qualities of cotton are not evident from a measurement of percentage fibre content.
Country (1): **ORIG_HI** **ORIG_MED (base)** **ORIG_LO**	 15 235 84	If the country of origin was Austria, Germany, Italy, Sweden, Switzerland, or the U.K. then ORIG_HI was assigned a value of 1. If the country of origin was Canada, Czechoslovakia, Hong Kong, Korea, Singapore, Macau, or Portugal then ORIG_MED was assigned a value of 1. Otherwise, ORIG_LO was assigned a value of 1. (11)	Sensitive to classification.
Outlet (1): **OUTL_HI** **OUTL_MED (base)** **OUTL_LO**	 64 199 71	All outlets in which shirts are priced for the CPI were classified into three groups: high, medium, and low. Correspondingly, the variables OUTL_HI, OUTL_MED, and OUTL_LO were defined. (4)	Sensitive to classification.
Brand (1): **NATRG_BR** **STORE_BR (base)**	 128 206	All shirt brands found in the CPI sample were classified into two groups: national/regional brands and store brands. Correspondingly, the variables NATRG_BR and STORE_BR were defined. (8)	Sensitive to classification.
Colour (1): **STRIPE_W** **STRIPE_P (base)** **SOLID (base)**	 49 17 268	If the shirt had woven (printed) stripes then STRIPE_W (STRIPE_P) was assigned a value of 1. Otherwise, SOLID was assigned a value of 1. (14)	SOLID showed up in the models at a later stage of the stepwise variable selection process, but its parameter estimate was insignificant.

Appendix C: Characteristics Considered for Inclusion in the Hedonic Model for Men's Dress Shirts (continued)

Characteristic Name (Rank): SAS Variable Name(s)	Number of Occurrences in Sample	Description (Checklist Box No.)	Potential Problems
Thread Count (1): **THRD_SUP** **THRD_REG (base)** **THRD_INF (base)**	 62 150 122	If the thread count exceeded 200 then THRD_SUP was assigned a value of 1. If the thread count was less than 180 then THRD_INF was assigned a value of 1. Otherwise, THRD_REG was assigned a value of 1. (17)	Thread count is prone to measurement error. This could explain why THRD_INF showed up in the models at a later stage of the stepwise variable selection process, but its parameter estimate was insignificant.
Fabric/Weave (1): **OXFORD** **BROADCLO (base)**	 83 251	If Oxford cloth or Dobby was indicated then OXFORD was assigned a value of 1. Otherwise, if Broadcloth was indicated then BROADCLO was assigned a value of 1. (18)	The sample data did not support the *a priori* assumption that Oxford cloth commanded a premium. In fact, the correlation coefficient between OXFORD and price (in logs) was not significantly different from zero.
Front Opening (2): **PLACKET** **NO_PLACK (base)**	 284 50	If the shirt had a placket on the front opening then PLACKET was assigned a value of 1. Otherwise, NO_PLAK was assigned a value of 1. (19)	The sample data did not support the *a priori* assumption that the presence of a placket commanded a premium. In fact, it seemed to suggest that the opposite was true: PLACKET was negatively, and significantly, correlated with price (in logs).
Sleeve Opening (2): **SLB_PLAK** **SLNBPLAK (base)** **NO_PLAK (base)**	 151 168 15	If the sleeve opening had a placket with a button then SLB_PLAK was assigned a value of 1. If no button was present then SLNBPLAK was assigned a value of 1. Otherwise, NO_PLAK was assigned a value of 1. (28)	NO_PLAK showed up in the models at a later stage of the stepwise variable selection process, but its parameter estimate was insignificant. This could be due to the very low frequency of shirts falling into that category.

Appendix C: Characteristics Considered for Inclusion in the Hedonic Model for Men's Dress Shirts (continued)

Characteristic Name (Rank): SAS Variable Name(s)	Number of Occurrences in Sample	Description (Checklist Box No.)	Potential Problems
Sleeve Cuff Style (2): **DBL_CUFF** **NODBLCUF (base)**	 300 34	If the shirt had a double cuff then DBL_CUFF was assigned a value of 1. Otherwise, NODBLCUF was assigned a value of 1. (29)	The sample data did not support the *a priori* assumption that the presence of a double cuff commanded a premium. In fact, it seemed to suggest that the opposite was true: DBL_CUFF was negatively, and significantly, correlated with price (in logs).
Seams (2): **FEL_SEAM** **SAFESEAM (base)**	 225 109	If the shirt had felled seams then FEL_SEAM was assigned a value of 1. Otherwise, SAFESEAM was assigned a value of 1. (31)	Although FEL_SEAM was highly, and significantly, correlated with price (in logs), it was also highly, and significantly, correlated with COTTON. Whenever both variables were included in the model at the same time, as was done in a later stage of the stepwise process, the parameter estimate of FEL_SEAM was insignificant.
Neck Size (3): **SPNECK** **REGNECK (base)**	 159 175	If the neck size was 18 or greater then SPNECK was assigned a value of 1. (12)	The sample data did not support the *a priori* assumption that a special neck size commanded a premium. In fact, the correlation coefficient between SPNECK and price (in logs) was not significantly different from zero.
Fit (3): **SPEC_FIT** **REG_FIT (base)**	 43 291	If the shirt was "relaxed" or "tapered" then SPEC_FIT was assigned a value of 1. Otherwise, REG_FIT was assigned a value of 1. (13)	The sample data did not support the *a priori* assumption that a tapered or relaxed fit commanded a premium. In fact, the correlation coefficient between SPEC_FIT and price (in logs) was not significantly different from zero.

Appendix C: Characteristics Considered for Inclusion in the Hedonic Model for Men's Dress Shirts (continued)

Characteristic Name (Rank): SAS Variable Name(s)	Number of Occurrences in Sample	Description (Checklist Box No.)	Potential Problems
Range of Colours (3): **MORCOLOR** **FEWCOLOR (base)**	 78 256	If the shirt was available in more than three colours the variable MORCOLOR was assigned a value of 1. (16)	The established cut-off of the base variable at three colours is somewhat arbitrary.
No. of Buttons (3): **BUTTONS8** **BUTTONS7 (base)**	 25 309	If the shirt had less than 8 buttons on the front opening then BUTTONS7 was assigned a value of 1. Otherwise, BUTTONS8 was assigned a value of 1. (20)	The established cut-off of the base variable at 7 buttons is somewhat arbitrary.
Yoke (3): **YOKE2** **YOKE1 (base)**	 311 23	If the shirt had a double yoke then YOKE2 was assigned a value of 1. Otherwise, YOKE1 was assigned a value of 1. (21)	There was quite a low frequency of shirts with a single yoke. The correlation coefficient between YOKE2 and price (in logs) was not significantly different from zero.
Breast Pocket (3): **CUF_PKT** **TBM_PKT (base)** **TBNM_PKT**	 158 109 67	If the breast pocket was cuffed then CUF_PKT was assigned a value of 1. If it was turned back and merrowed then TBM_PKT was assigned a value of 1. Otherwise, TBNM_PKT was assigned a value of 1. (22)	CUF_PKT showed up in the models at a later stage of the stepwise variable selection process, but its parameter estimate was insignificant.
Collar Stays (3): **BOOMER** **REGSTAYS (base)**	 35 299	If the collar had Boomerang stays then BOOMER was assigned a value of 1. Otherwise, REGSTAYS was assigned a value of 1. (23)	BOOMER showed up in the models at a later stage of the stepwise variable selection process, but its parameter estimate was insignificant.
Button-down Collar (3): **BUT_DOWN** **NOT_DOWN (base)**	 75 259	If there was a button-down collar then BUT_DOWN was assigned a value of 1. Otherwise, NOT_DOWN was assigned a value of 1. (24)	The sample data did not support the *a priori* assumption that a button-down collar commanded a premium. In fact, the correlation coefficient between BUT_DOWN and price (in logs) was not significantly different from zero.

Appendix C: Characteristics Considered for Inclusion in the Hedonic Model for Men's Dress Shirts (continued)

Characteristic Name (Rank): SAS Variable Name(s)	Number of Occurrences in Sample	Description (Checklist Box No.)	Potential Problems
Fused Collar (3): **FUSEDCOL** **NOFUSCOL (base)**	304 30	If the collar was fused then FUSEDCOL was assigned a value of 1. Otherwise, NOFUSCOL was assigned a value of 1. (25)	The sample data did not support the *a priori* assumption that a fused collar on a shirt commanded a premium. In fact, the correlation coefficient between FUSEDCOL and price (in logs) was not significantly different from zero.
Sleeve Length (3): **SP_SLEEV** **REGSLEEV (base)**	30 304	If the sleeve length was 37 or greater then SP_SLEEV was assigned a value of 1. Otherwise, REGSLEEV was assigned a value of 1. (26)	The sample data did not support the *a priori* assumption that a special sleeve length commanded a premium. In fact, the correlation coefficient between SP_SLEEV and price (in logs) was not significantly different from zero.
Sleeve Pleats (3): **SL_PLEAT** **NSPLEAT (base)**	294 40	If the sleeve had pleats at the cuff then SL_PLEAT was assigned a value of 1. Otherwise, NSPLEAT was assigned a value of 1. (27)	SL_PLEAT showed up in the models at a later stage of the stepwise variable selection process, but its parameter estimate was insignificant.
Pattern (3): **MATCHING** **NO_MATCH (base)**	329 5	If the shirt had a pattern (e.g. stripes) and the pattern was not matched at the seams then NO_MATCH was assigned a value of 1. Otherwise, MATCHING was assigned a value of 1. (32)	Not enough variation was observed in the sample.
Pearlized Buttons (3): **PEARLIZE**	280	If the shirt had pearlized buttons then PEARLIZE was assigned a value of 1. (34a)	The sample data did not support the *a priori* assumption that the presence of pearlized buttons commanded a premium. In fact, the correlation coefficient between PEARLIZE and price (in logs) was not significantly different from zero.

Appendix C: Characteristics Considered for Inclusion in the Hedonic Model for Men's Dress Shirts (concluded)

Characteristic Name (Rank): SAS Variable Name(s)	Number of Occurrences in Sample	Description (Checklist Box No.)	Potential Problems
Extra Buttons (3): **XTRA_BUT**	138	If the shirt had (any number of) extra buttons then XTRA_BUT was assigned a value of 1. (34b)	The sample data did not support the *a priori* assumption that the inclusion of extra buttons commanded a premium. In fact, the correlation coefficient between XTRA_BUT and price (in logs) was not significantly different from zero.
Flaws (3): **NO_FLAWS (base)** **FLAWED**	 325 9	If there were visible flaws on the shirt, due to uneven, skipped, or crooked stitching, then FLAWED was assigned a value of 1. Otherwise, NO_FLAWS was assigned a value of 1. (35a)	Not enough variation was observed in the sample.
Loose Threads (3): **NO_LOOSE (base)** **LOOSETHD**	 308 26	If the shirt had loose threads or buttons that were visible then LOOSETHD was assigned a value of 1. Otherwise, NO_LOOSE was assigned a value of 1. (35b)	LOOSETHD showed up in the models at a later stage of the stepwise variable selection process, but its parameter estimate was insignificant.
Wrinklefree (3): **WRINKLEF**	8	If the wrinklefree feature was present then WRINKLEF was assigned a value of 1. (36)	Not enough variation was observed in the sample. Furthermore, this feature was not mentioned explicitly on the checklist and therefore may have been under-reported.

Appendix D: Deriving the Quality Adjusted Back Price for a Replacement Item

Recalling the original model specification from page 5,

$$\ln(P) = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + e \qquad \textbf{(1)}$$

The Ordinary Least Squares (OLS) regression technique yields the following equation,

$$\ln(P) = b_0 + \sum_{i=1}^{k} b_i x_i \qquad \textbf{(2)}$$

where b_i is the parameter estimate for β_i , and x_i is a variable representing the value of the i^{th} characteristic.

Now, assuming the same model applies in the current period (replacement) and the reference period (original), then the log change in prices from the reference period to the current period attributable to changes in any of the *k* quality characteristics can be derived from (2) as follows,

$$\ln(P^{replacement}) - \ln(P^{original}) = \sum_{i=1}^{k} b_i (x_i^{\ replacement} - x_i^{\ original}) \qquad \textbf{(3)}$$

Taking the natural exponent of both sides of equation 3 yields,

$$\frac{P^{replacement}}{P^{original}} = \prod_{i=1}^{k} e^{b_i (x_i^{replacement} - x_i^{original})} \qquad \textbf{(4)}$$

Since the price of the replacement item could not be observed in the reference period, its "back price" ($\tilde{P}^{replacement}$) must be estimated. This may be done by multiplying the original item's price by the hedonic model's adjustment factor as follows.

$$\tilde{P}^{replacement} = P^{original} \prod_{i=1}^{k} e^{b_i (x_i^{replacement} - x_i^{original})} \qquad \textbf{(5)}$$

Appendix E: Hypothetical Examples of Using the Hedonic Approach for Quality Adjustment

EXAMPLE 1

Replacing the lowest quality of shirt with the highest quality across outlets.

Model I

variable	original	replacement	factor	exponent
cotton (%)	35	100	0.69	1.99
brand	store	national	0.32	1.37
outlet high	no	yes	0.35	1.41
outlet low	yes	no	0.40	1.49
origin high	no	yes	0.53	1.70
origin low	yes	no	0.13	1.14
woven stripes	no	yes	0.18	1.19
thread	standard	superior	0.09	1.10
buttons	7	8	0.22	1.25
buttoned sleeve placket	no	yes	0.19	1.21
flaws	yes	no	0.19	1.21
wrinklefree	no	yes	0.26	1.30
column product				34.60866

Model II

variable	original	replacement	factor	exponent
cotton (%)	35	100	0.69	1.99
brand	store	national	0.32	1.37
outlet high	no	yes	0.34	1.41
outlet low	yes	no	0.41	1.51
origin high	no	yes	0.55	1.73
origin low	yes	no	0.13	1.14
woven stripes	no	yes	0.17	1.19
thread	standard	superior	0.11	1.11
buttons	7	8	0.22	1.24
buttoned sleeve placket	no	yes	0.20	1.22
column product				22.893637

Results

original's price	$9.77
replacement's price	$235.00
adjusted back price	$338.13
pure price change	-30.5%

Results

original's price	$9.77
replacement's price	$235.00
adjusted back price	$223.67
pure price change	5.1%

A real-life comparison

FEATURE VALUE	$9.77
GIORGIO ARMANI	$235.00

Appendix E: Hypothetical Examples of Using the Hedonic Approach for Quality Adjustment (continued)

EXAMPLE 2

Replacing a medium quality shirt with a low quality shirt in the same outlet.

Model I

variable	original	replacement	factor	exponent
cotton (%)	60	35	-0.26	0.77
brand	national	store	-0.32	0.73
outlet high	no	no	0.00	1.00
outlet low	no	no	0.00	1.00
origin high	no	no	0.00	1.00
origin low	no	no	0.00	1.00
woven stripes	no	no	0.00	1.00
thread	standard	standard	0.00	1.00
buttons	7	7	0.00	1.00
buttoned sleeve placket	yes	no	-0.19	0.82
flaws	no	no	0.00	1.00
wrinklefree	yes	no	-0.26	0.77
column product				0.354813

Model II

variable	original	replacement	factor	exponent
cotton (%)	60	35	-0.26	0.77
brand	national	store	-0.32	0.73
outlet high	no	no	0.00	1.00
outlet low	no	no	0.00	1.00
origin high	no	no	0.00	1.00
origin low	no	no	0.00	1.00
woven stripes	no	no	0.00	1.00
thread	standard	standard	0.00	1.00
buttons	7	7	0.00	1.00
buttoned sleeve placket	yes	no	-0.20	0.82
column product				0.4592581

Results

original's price	$50.00
replacement's price	$16.99
adjusted back price	$17.74
pure price change	-4.2%

Results

original's price	$50.00
replacement's price	$16.99
adjusted back price	$22.96
pure price change	-26.0%

A real-life comparison

ARROW	$50.00
PROTOCOL	$16.99

Appendix E: Hypothetical Examples of Using the Hedonic Approach for Quality Adjustment (continued)

EXAMPLE 3

Replacing within the same quality range in the same outlet.

Model I

variable	original	replacement	factor	exponent
cotton (%)	100	100	0.00	1.00
brand	store	store	0.00	1.00
outlet high	no	no	0.00	1.00
outlet low	no	no	0.00	1.00
origin high	no	no	0.00	1.00
origin low	no	yes	-0.13	0.87
woven stripes	no	no	0.00	1.00
thread	standard	standard	0.00	1.00
buttons	7	7	0.00	1.00
buttoned sleeve placket	no	yes	0.19	1.21
flaws	no	no	0.00	1.00
wrinklefree	no	no	0.00	1.00
column product				1.062894

Model II

variable	original	replacement	factor	exponent
cotton (%)	100	100	0.00	1.00
brand	store	store	0.00	1.00
outlet high	no	no	0.00	1.00
outlet low	no	no	0.00	1.00
origin high	no	no	0.00	1.00
origin low	no	yes	-0.13	0.88
woven stripes	no	no	0.00	1.00
thread	standard	standard	0.00	1.00
buttons	7	7	0.00	1.00
buttoned sleeve placket	no	yes	0.20	1.22
column product				1.0681968

Results

original's price	$49.99
replacement's price	$50.00
adjusted back price	$53.13
pure price change	-5.9%

Results

original's price	$49.99
replacement's price	$50.00
adjusted back price	$53.40
pure price change	-6.4%

A real-life comparison

DISTINCTIVE EXECUTIVE WEAR	$49.99
CHARTER COLLECTION	$50.00

Appendix E: Hypothetical Examples of Using the Hedonic Approach for Quality Adjustment (concluded)

EXAMPLE 4

Replacing within the same price range, with only cotton fibre content changing.

Model I

variable	original	replacement	factor	exponent
cotton (%)	100	80	-0.21	0.81
brand	store	store	0.00	1.00
outlet high	no	no	0.00	1.00
outlet low	no	no	0.00	1.00
origin high	no	no	0.00	1.00
origin low	no	no	0.00	1.00
woven stripes	no	no	0.00	1.00
thread	standard	standard	0.00	1.00
buttons	7	7	0.00	1.00
buttoned sleeve placket	yes	yes	0.00	1.00
flaws	no	no	0.00	1.00
wrinklefree	no	no	0.00	1.00
column product				0.809143

Model II

variable	original	replacement	factor	exponent
cotton (%)	100	80	-0.21	0.81
brand	store	store	0.00	1.00
outlet high	no	no	0.00	1.00
outlet low	no	no	0.00	1.00
origin high	no	no	0.00	1.00
origin low	no	no	0.00	1.00
woven stripes	no	no	0.00	1.00
thread	standard	standard	0.00	1.00
buttons	7	7	0.00	1.00
buttoned sleeve placket	yes	yes	0.00	1.00
column product				0.8097255

Results

original's price	$34.99
replacement's price	$34.99
adjusted back price	$28.31
pure price change	23.6%

Results

original's price	$34.99
replacement's price	$34.99
adjusted back price	$28.33
pure price change	23.5%

A real-life comparison

CLUB INTERNATIONAL	$34.99
BOSA	$34.99

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