RESEARCH ON IMPROVED QUALITY ADJUSTMENT IN THE CPI: THE CASE OF TELEVISIONS

Brent R. Moulton*, Timothy J. LaFleur, and Karin E. Moses**

Bureau of Labor Statistics
U.S. Department of Labor
Washington, D.C. 20212
e-mail: brent.moulton@bea.doc.gov
lafleur_t@bls.gov
moses_k@ bls.gov

September 1998

*Brent R. Moulton is presently Associate Director for National Income, Expenditure, and Wealth Accounts, Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC 20230. When the first draft of this paper was written he was at the Bureau of Labor Statistics.
** Timothy J. LaFleur and Karin E. Moses are Economists, Division of Consumer Prices and Price Indexes, BLS.

We thank Joseph Chelena and Paul Liegey for helpful suggestions. The opinions expressed in this paper are those of the authors and do not represent an official policy of either the Bureau of Labor Statistics or the Bureau of Economic Analysis or the views of other staff at either agency.

In recent articles, reports, and congressional testimony, a number of economists have surveyed or proposed estimates of bias in the U.S. Consumer Price Index (CPI). The report by the Advisory Commission to Study the Consumer Price Index has received the most attention, and its estimate of overall bias was 1.1 percent per year, of which 0.6 percent per year was attributed to unmeasured quality change and new goods.[1] Treatment of quality change and new goods is an issue that the Bureau of Labor Statistics has tried to address in a variety of ways over many years. The BLS has made a number of methodological improvements during recent years and continues to conduct research on these issues (Moulton and Moses, 1997).

The category of consumer electronics has been singled out by many of the recent critiques of the CPI as a leading example of new goods and quality bias. The consumer's surplus from major improvements in quality and the introduction of important new goods, such as have occurred in consumer electronics, may tend to be underestimated by the use of linking and overlap methods by the CPI. This is the conclusion drawn in many studies of computers (e.g., Cole, et al., 1986; Gordon, 1990; Berndt, Griliches, and Rappaport, 1995) and by Gordon (1990) for television sets.

Televisions is a particularly interesting item for analysis of these effects in the CPI. The CPI sample size (more than 300 items) is adequate for hedonic analysis, and the characteristics are well defined and relatively limited in number. Many interesting technological developments have occurred and the market for television sets has changed considerably in recent years. Unit sales of color television sets increased from 19.5 million in 1991 to 24.7 million in 1994, before declining to 21.3 million in 1997. The majority of U.S. households now have two or more color TVs (Consumer Electronics Manufacturers Association, 1996, 1997 & 1998). Figure 1 shows recent price changes of the CPI television component.

Many products have shown dramatic sales growth in recent years. As shown in Table 1, sales of projection TVs grew from 380 thousand units in 1991 to 917 thousand in 1997, while sales of

---

[1] U.S. Senate, Committee on Finance (1996). The members of the Commission were Michael J. Boskin (chairman), Ellen R. Dulberger, Robert J. Gordon, Zvi Griliches, and Dale Jorgenson.

TV/VCR combinations grew from 662 thousand units in 1991 to 2.3 million in 1997. Over half of color TV receivers now come equipped with stereo sound, and other recent developments include liquid crystal displays (LCD), caption decoders for the hearing impaired, widescreen TV, and new standards for high-definition TV (HDTV).

The present paper has two major objectives: first, to conduct a case study that quantifies the possible size of quality bias for the television component of the CPI, and second, to develop hedonic models that might be usable for future quality adjustment of televisions in the index.

The hedonic approach to measuring quality change continues to be controversial. It is well known that hedonic functions do not provide direct estimates of changes of a cost-of-living index, and in some cases may be biased.[2] Triplett (1983), Fixler and Zieschang (1992), and Feenstra (1995) have discussed how the hedonic function might be used to bound or approximate an exact index. These methods require additional information such as current-period quantities, and thus are not estimable directly from the estimated hedonic function. An interesting recent paper by Ioannidis and Silver (1997) applied Feenstra's methods to scanner data on televisions from the United Kingdom, and found that the base-period and current-period weighted indexes resulted in very similar estimates of price change.

Although we acknowledge the ambiguities associated with interpreting hedonic indexes, our own view is similar to that expressed by Griliches (1990). When a model of a sample item is replaced, the statistical agency is forced to make some sort of implicit or explicit quality adjustment. The link and overlap methods that BLS traditionally has relied upon is equivalent to a fairly strong assumption about quality change, i.e., that the quality difference between the disappearing model and the replacement model can be inferred almost entirely from the difference in price. The hedonic function loosens this assumption, basing the quality adjustment upon information drawn from a much larger sample of items. Consequently, hedonic quality adjustment provides an alternative way

[2] In contrast, the methods proposed, e.g., by Berry, Levinsohn, and Pakes (1995) and Hausman (1997) can produce exact consumer welfare and cost-of-living measures provided the assumptions underlying their methods are satisfied and the estimating equations are free of specification error.

of describing the budget constraint faced by consumers and may allow prices to be compared with fewer breaks in the time series. Although we recognize that the hedonic method is not a panacea for quality adjustment and new goods problems, we consider the method to be useful and feasible for handling many quality change problems, especially for durable goods.

In the present paper we will (a) briefly review the quality adjustment methods currently used by the BLS to calculate the CPI, (b) describe hedonic regression specifications for televisions, (c) present results of hedonic regressions, and (d) present simulations of a hedonic-based CPI for televisions for the period 1993-97.

CPI Quality Adjustment Methods

The CPI data collection methods were designed to identify and adjust for quality changes.[3] Each year approximately one-fifth of the CPI samples are reselected through a process known as sample rotation. The BLS selects sample items by probability methods so that the items that are repriced each month are representative of consumer purchases. Each item is then described in detail on a checklist to ensure that the price of exactly the same item is compared as long as that item remains in the sample. The checklist for televisions, shown in Figure 2, allows for detailed description of each item in the sample. Each time that price data are collected, the data collector compares the item to the detailed description to ensure that the characteristics of the item have not changed. If, during the monthly (or bimonthly) price collection, the precise version of the sample item has become permanently unavailable at that outlet, then the data collector selects a similar item as a replacement. This item replacement process is the focus of our analysis in the remainder of this paper.

After an item replacement, a BLS commodity analyst examines the descriptions of the old and new versions of the item to determine which quality adjustment procedure is to be applied.

[3] New products may be linked into the sample through the regular rotation of samples that currently occurs at 5-year intervals, or they may enter through the sample replacement procedures described below (see Armknecht, Lane, and Stewart (1997)).

These methods were developed to be applied in an environment in which 80,000 sample prices are collected and processed each month, of which roughly 4 percent represent item replacements. These item replacements are much more important than may be suggested by the 4 percent monthly attrition rate, however. Approximately 30 percent of all sample items that are scheduled to remain in the sample for the full year (i.e., not scheduled for a regular sample rotation) need to be replaced some time during the year. Detailed explanations of the various methods used by BLS for quality adjustment of item replacements are available elsewhere, so here we will give a heuristic description.[4]

1. *Comparable items*. In some cases, the commodity analyst examines the differences in between the two specifications and determines that the change did not result in a significant change in the quality of the item, so that the prices of the old version and the new version can be directly compared. Let $P_{t-1,i}^{1}$ denote the price in the previous period ($t-1$) of the old version (denoted by superscript 1) of quote *i* and P_{ti}^{2} denote the price in the current period (*t*) of its new version (2). As shown in Figure 3, this method counts the entire price difference, $P_{ti}^{2} / P_{t-1,i}^{1}$, as part of inflation, i.e., no quality difference is attributed to the new version of the item. These comparable replacements would typically consist of pairs of versions that differ by minor changes in styling or other minor differences in characteristics that do not reflect quality differences.[5]

2. *Overlap method*. The second method is used when prices of the old version and the new version are both available during an overlap period so that the difference in price level between versions can be used as an estimate of the quality difference. As shown in Figure 4, the pure price change (or "price effect") prior to period *t* is measured by the price change of the old version, and the price change after period *t* is measured by the price change of the new version. The availability of an

[4] Recent papers that describe the methods currently used for quality adjustment in detail are Armknecht, Lane, and Stewart (1997) and Reinsdorf, Liegey, and Stewart (1996).

[5] The terminology used to describe the various methods of handling item substitutions is not standardized. We follow the terminology used by Armknecht and Weyback (1989). The advisory commission (U.S. Senate, 1996) and Triplett (1971) use different terminology: "direct comparison" instead of "comparable," "linking" instead of "overlap method, " and "deletion" instead of "link method;" the Advisory Commission report omits the relatively new "class-mean imputation" method.

overlap-period price is relatively uncommon for item replacements, but an aggregate version of the overlap method is used when an entire CPI component sample is replaced during sample rotation. Both the old and new samples are collected during an overlap period *t*, and the old sample is used to measure the price change from t - 1 to t while the new sample is used to measure the price change from t to t + 1.

3. *Link method*. When items disappear, it is typically not detected until the item is no longer available at the sample outlet, so prices of the old and new versions are not available concurrently. Consequently another method must be used to estimate the portion of the price difference that is attributable to inflation and the portion that is attributable to quality change. The link method first calculates the rate of inflation for the stratum during that month by omitting the item from the calculation of price change. For example, say that the inflation rate based on the other goods was 2 percent, but that the replacement version, when it appeared, cost 5 percent more than the earlier version. As illustrated in Figure 5, the link method effectively assumes that of the 5 percent, 2/5 was due to the overall rise in the price of goods, and the other 3/5 was due to a quality improvement. Notice that the estimated quality change is essentially a residual in this calculation.

4. *Class-mean imputation method*. A related method is *class-mean imputation,* which was introduced to the CPI new cars index in 1989, and to other items in 1992 (Armknecht, Lane, and Stewart, 1997; Reinsdorf, Liegey, and Stewart, 1996). Like the link method, this method also imputes a price change and treats the quality change as a residual. In this method, however, the price change is imputed from a set of similar items that are classified as comparable replacements or that are directly quality adjusted. This method is based on the assumption that the inflation occurring when a new model of an item replaces an earlier model is different from the inflation occurring when the model doesn't change.

5. *Direct quality adjustment*. These methods are applied when information is available for directly estimating the dollar value of the change in quality. Sometimes (especially in the cases of new and used cars and motor fuel) these come from information provided by manufacturers of the product on the cost of the quality improvement. In other cases the hedonic method is used to estimate

the price-quality relationship from regressions of price on characteristics of the goods. The coefficients of these regressions are then used to infer the value of changes in characteristics of the goods in the sample. The CPI has used hedonic methods since 1988 for calculating the effects of depreciation and other housing characteristics on rent, since 1991 for quality changes in apparel, and since 1998 for personal computers. The BLS has recently announced that, beginning in 1999, hedonic quality adjustments also will be applied to televisions. Figure 6 exhibits a direct quality adjustment, in which an adjustment is made to the period $t-1$ price of the old item for the estimated value of the quality improvement embedded in the new item.

Hedonic Models

The application of hedonics used in this paper is based on specifications that permit coefficients of characteristics to vary over time. Chow (1967) applied this type of hedonic specification (for an overview of empirical hedonic research, see Berndt, 1991). A very similar type of specification has also been used extensively in labor economics where it is known as the Oaxaca (1973) decomposition.

Because the specifications are all in semi-logarithmic form, let *y* = ln(price). The regression model is

(1) $$y_{it} = x_{it}\beta_t + u_{it} .$$

and the estimated regression is

(2) $$y_{it} = x_{it}\hat{\beta}_t + \hat{u}_{it} .$$

For a particular item *i* in period *t*, the predicted ln(price) given characteristics x_{it} is

(3) $$\hat{y}_{it} = x_{it}\hat{\beta}_t ,$$

and if ordinary least squares is used to estimate β_t, then

$$\sum_i \hat{y}_{it} = \sum_i y_{it} \,.$$

The multiplicative quality adjustment applied to a replacement where characteristics in period *s* to differ from the characteristics in period *t* is the change in the predicted price attributable to the change in characteristics:

(4) $$QA_{i,s,t} = (x_{is} - x_{it})\hat{\beta}_t \,.$$

In its application of hedonics, the BLS applies the period t regression estimates to replacement-item quality adjustments for a period of time (usually about a year in the case of apparel, three or four months in the case of computer equipment). Then the regressions are re-estimated and the latest coefficients are applied to subsequent item replacements.

An alternative, direct measure of the price change is derived as follows. Assume that the aggregation formula of the price index comparing periods *s* and *t*, $I_{s,t}$, is a geometric mean. Then, if there are no changes in characteristics the index is

(5) $$I_{s,t} = \exp(\sum_i y_{is} - \sum_i y_{it}) \,.$$

If, however, characteristics of item *i* change, then the quality-adjusted log price change for item *i* is

(6) $$y_{is} - y_{it} - QA_{i,s,t} = y_{is} - x_{is}\hat{\beta}_t - (y_{it} - x_{it}\hat{\beta}_t) \,.$$

Summing this expression then exponentiating gives the quality-adjusted index, which simplifies to:

(7) $$I_{s,t} = \exp[\sum_i x_{is}(\hat{\beta}_s - \hat{\beta}_t)].$$

This index focuses on the "Paasche perspective," that is, the characteristics associated with the period *s* (by "Paasche perspective," we are referring only to the reference period; as was stated earlier, the index aggregation formula is a geometric mean). An analogous derivation would produce the "Laspeyres perspective," with characteristics from period *t*. If the index formula is based on a geometric mean, if the weights of the items are the same, and if all sample replacements receive the same quality adjustments, then the BLS matched model approach and the Paasche perspective reduced approach of (7) should result in the same answer. In practice, though, a potential source of difference between the two approaches arises because the BLS does not adjust for adjust for quality differences when samples rotate. This difference in procedures will cause the two approaches to result in different quality-adjusted indexes.

Hedonic Regression Specification

The data used in this analysis were drawn from the CPI television sample, with characteristics data drawn from specifications on the CPI checklist. To examine possible changes in coefficients over time, regressions were run over five time periods. Because television price quotes are collected monthly in some cities and bimonthly in others, the regression data sets are defined as prices and specifications collected July and August of 1993 through July and August of 1997.

The following types of televisions were excluded from the regression samples because their characteristics were relatively rare within the CPI sample: black and white sets, sets with screen size smaller than 9 inches, and TV/VCR combinations. Also a few high-end televisions were excluded (for example, if only one sample quote was available from the brand). These sample exclusions were fewer than 5 percent of all quotes.

The dependent variable is the logarithm of price. Although a theoretical case can be made for using a linear functional form for some of the characteristics (for example, inclusion of a universal remote), the semi-log form provided better fit and more plausible coefficient estimates for most variables, particularly the brand effects.

Brand names are important in this market—a set with the same screen size and other observable characteristics with a premium brand name, such as Sony, may sell for as much as 50 percent more than similar television from a less prestigious brand. It is possible that this premium may represent, at least in part, the effects of unmeasured characteristics, and if we add additional characteristics to the regression the effects of brand may be reduced. Following previous hedonic studies of televisions and computers we have included indicator variables for brands. We experimented with including an indicator variable for each brand (the method used by Ioannidis and Silver), but based on preliminary results and informed judgment about brand quality we collapsed the brands into 3 groups, plus Sony (Group # 1: Emerson, General Electric, Goldstar, Samsung, and Sanyo; Group # 3: Hitachi, Mitsubishi, Panasonic, and Proscan; and Group # 2: all others, except Sony). Collapsing these cells is equivalent to a set of parameter restrictions—i.e., the restriction that all brands within a group have the same coefficient. An F test failed to reject the implied parameter restrictions.

Several variables that appear on the checklist were either difficult to use (coded as free text) or appear to be recorded incompletely or, in some cases, inaccurately.[6] With further work it may be possible to correct some of these problems, by examining textual information in the CPI data and possibly contacting industry representatives. With respect to coefficients with the "wrong" sign or

[6] For example, the database shows several models having specification "J1"—high-definition television—even though this new technology was not yet available for sale during this period. Another example is the specification for specification "BB99," horizontal resolution, which we considered using, but face the problem that it is not reported for about one fourth of the observations.

statistically insignificant coefficients, we faced the usual decisions. In testing possible specifications with the 1995 and 1997 data, the estimated coefficient for the stereo sound indicator variable was negative, though statistically insignificant. We chose to drop this variable from the model after checking that none of the other estimated coefficients were substantially affected by the exclusion. (An alternative approach would have been to retain the variables, then decline to use its coefficient in making quality adjustments.)

The variables used as explanatory characteristics in the regression are: screen size, screen size squared, wide screen, liquid-crystal display, projection, surround sound, console, picture-in-picture (1 tuner), picture-in-picture (2 tuners), number of video inputs, brand group # 1, brand group # 3, Sony, universal/learning remote, and free delivery. All of these are indicator variables except screen size, its square, and the number of video inputs.

Results

Table 2 gives the means for the variables used in the regressions. Some of the characteristics that changed in the CPI sample between 1993 and 1997 include surround sound, which was included in 17.7 percent of the sample in 1993 and 24.8 percent of the sample in 1997, projection, increasing from 7.9 to 11.7 percent, and picture-in-picture with two tuners, increasing from 2.7 percent to 7.3 percent of the sample. Not all changes in sample mean characteristics were quality improvements, however. The percentage of console models dropped from 15.3 percent to 12.3 percent, and the percentage of sets which include free delivery dropped from 7.3 percent to 5.8 percent.

The regression results are shown in Table 3. The fit of the models is comparable to regressions reported by Ioannidis and Silver, with $\overline{R}^2$ greater than 0.91 for all five regressions. Some changes in the coefficients have occurred over time. Perhaps the most noticeable change in a coefficient is the coefficient for projection display, which has gone from a small, statistically insignificant value in 1993, –0.017, to a large, statistically significant value in 1997, –0.160. The marginal price of screen size also has fallen: differentiating the estimated quadratic between log of price and screen size and evaluating it for a 25-inch television, the marginal proportionate price of an additional inch of screen size was 0.0604 in 1993, and had dropped to 0.0561 in 1997.

To apply the estimated hedonic function in Table 3 to calculate alternative quality adjustments for the CPI requires calculating an adjustment for each item replacement during the period. As shown in Table 4, each month about 15 percent of the models in the sample become permanently unavailable and must be replaced. Thus, a typical television set remains in the sample for less than a year. Thus, improvements to measuring price change during this linking process might be expected to have a significant impact on the index.

Table 5 shows (a) the change of the published CPI for televisions at yearly stages from August 1993 to August 1997, (b) the change of hedonic indexes calculated using formula (7) with each of the five possible base periods, (c) a chained "Laspeyres perspective" index that evaluates the price change using the most recent year's mean characteristics, and (d) a "Fisher/Törnqvist" type index that takes a geometric mean of the price change using the previous year's and current year's vector of mean characteristics.

We also calculated revised indexes using quality adjustments on an item-by-item basis, such as would be done if hedonic quality adjustment were adopted for use by the BLS for the television component of the CPI. We used hedonic based quality adjustments in place of the linking and comparable adjustments that are currently used by the BLS. From August of 1993 to August of 1997, there were over four hundred quality adjusted price comparisons. The resulting simulated index change was 1.4% less than the actual CPI for Televisions.

Table 6 shows the monthly effects of our quality adjustments. The monthly effects are small and not all of our quality adjustments were for improvements in quality at the time of item replacement.

It is interesting to notice that our cumulative effect in simulating the CPI quality adjustment procedure, as shown in Table 6, is much less than results in Table 5 might suggest they would be. We hypothesize that the differences between these results may be caused by the fact that Table 5 calculations include comparisons of prices for items that entered the sample as part of a sample rotation. During sample rotations prices are compared using the overlap method and would therefore be excluded from our simulations in Table 6, though the quality differences would affect the estimate of quality change shown in Table 5. The differences suggest that much of quality change for televisions is not of a type captured by the routine replacements that occur because of sample attrition. Replacement items are selected to be close to the item that is no longer available, and, unlike computers, televisions with older vintages of characteristics apparently do not become wholly unavailable. Thus, even if the market is moving toward larger screen sizes and better quality picture and sound, the smaller screen sizes and older characteristics are still available.

To more fully capture the move toward higher quality characteristics, we suggest a couple of options. On the one hand, a method might be developed for applying quality adjustments to rotating samples, if that is when most of the items with new or different characteristics are entering the sample. Alternatively, if the BLS has information that the quality mix of the sample is no longer representative of the mix now purchased by consumers, it might require data collectors to replace out-of-date items with items that are more representative of the current level of quality, and adjust for the quality change by using the hedonic approach to calculate the quality adjustment.

References

Armknecht, Paul A., Walter F. Lane, and Kenneth J. Stewart (1997), "New Products and the U.S. CPI," in Timothy F. Bresnahan and Robert J. Gordon, eds., *The Economics of New Goods*, University of Chicago Press, Chicago.

Armknecht, Paul A., and Donald Weyback (1989), "Adjustments for Quality Change in the U.S. Consumer Price Index," *Journal of Official Statistics* 5, no. 2, 107-123.

Berndt, Ernst R. (1991), *The Practice of Econometrics: Classic and Contemporary*, Addison-Wesley, Reading, MA.

Berndt, Ernst R., Zvi Griliches, and Neal J. Rappaport (1995), "Econometric Estimates of Price Indexes for Personal Computers in the 1990's," *Journal of Econometrics* 68, 243-268.

Berry, Steven, James Levinsohn, and Ariel Pakes (1995), "Automobile Prices in Market Equilibrium," *Econometrica* 63, no. 4, 841-890.

Chow, Gregory C. (1967), "Technological Change and the Demand for Computers," *American Economic Review* 57, no. 5, 1117-1130.

Cole, Roseanne, Y. C. Chen, Joan A. Barquin-Stolleman, Ellen Dulberger, Nurhan Helvacian, and James H. Hodge (1986), "Quality Adjusted Price Indexes for Computer Processors and Selected Peripheral Equipment," *Survey of Current Business* 66, no. 1 (January), 41-50.

Consumer Electronics Manufacturers Association (1996), *The Year in Consumer Electronics 95*, Consumer Electronics Manufacturers Association, Arlington, VA.

——— (1997), *The Year in Consumer Electronics 96*, Consumer Electronics Manufacturers Association, Arlington, VA.

Feenstra, Robert C. (1995), "Exact Hedonic Price Indexes," *Review of Economics and Statistics* 77, no. 4, 634-653.

Fixler, Dennis, and Kimberly D. Zieschang (1992), "Incorporating Ancillary Measures of Process and Quality Change into a Superlative Productivity Index," *Journal of Productivity Analysis* 2, no. 2, 245-267.

Gordon, Robert J. (1990), *The Measurement of Durable Goods Prices*, University of Chicago Press, Chicago.

Griliches, Zvi (1990), "Hedonic Price Indexes and the Measurement of Capital and Productivity: Some Historical Reflections," in Ernst R. Berndt and Jack E. Triplett, eds., Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth, University of Chicago Press, Chicago.

Hausman, Jerry (1997), "Cellular Phones, New Products, and the CPI," unpublished paper, Massachusetts Institute of Technology (February).

Ioannidis, Christos, and Mick Silver (1997), "Chained, Exact, Hedonic Price Changes: Estimates from Micro Data," unpublished paper presented at meeting of International Working Group on Price Indices, Voorburg, Netherlands, April 16-18.

Moulton, Brent R., and Karin E. Moses (1997), "Addressing the Quality Change Issue in the Consumer Price Index," forthcoming in *Brookings Papers on Economic Activity 1997:1*.

Oaxaca, Richard (1973), "Male-Female Wage Differentials in Urban Labor Markets," International Economic Review 14 (October): 693-709.

Reinsdorf, Marshall B., Paul Liegey, and Kenneth Stewart (1996), "New Ways of Handling Quality Change in the U.S. Consumer Price Index," Bureau of Labor Statistics working paper no. 276.

Shapiro, Matthew D., and David W. Wilcox (1997), "Alternative Strategies for Aggregating Prices in the CPI," Federal Reserve Bank of St. Louis *Review,* vol. 79, 113-125.

Triplett, Jack E. (1971), "Quality Bias in Price Indexes and New Methods of Quality Measurement," in Zvi Griliches, ed., *Price Indexes and Quality Change: Studies in New Methods of Measurement,* Harvard University Press, Cambridge.

——— (1983), "Concepts of Quality in Input and Output Price Measures: A Resolution of the User Value-Resource Cost Debate," in Murray F. Foss, ed., *The U.S. National Income and Product Accounts: Selected Topics*, University of Chicago Press, Chicago.

U.S. Senate, Committee on Finance (1996), "Final Report of the Advisory Commission to Study the Consumer Price Index," S. Prt. 104-72, December 1996, Washington: U.S. Government Printing Office.

Table 1. Television Sales to Dealers in Units and Factory Sales in Dollars, 1991 to 1996.

	Color TV receivers		Color receivers w/stereo		TV/VCR combinations		Projection TV	
	Units[a]	Dollars[b]	Units[a]	Dollars[b]	U[a]nits	Dollars[b]	Units[a]	Dollars[b]
1991	19,474	5,979	7,377	3,209	662	265	380	683
1992	21,056	6,591	8,534	3,729	936	375	404	714
1993	23,005	7,316	9,767	4,288	1,629	599	465	841
1994	24,715	7,225	10,438	4,452	2,017	710	636	1,117
1995	23,231	6,798	10,579	4,435	2,205	723	820	1,417
1996	22,384	6,492	11,189	4,517	2,199	697	887	1,426
1997	21,294	6,036	11,096	4,230	2,311	684	917	1,362

[a] Thousands
[b] Millions
Source: Consumer Electronics Manufacturers Association (1996, 1997 & 1998).

Table 2. Means of variable used in hedonic regressions.

Variable	Aug-1993	Aug-1994	Aug-1995	Aug-1996	Aug-1997
ln (Price)	6.275	6.208	6.220	6.211	6.170
screen size	24.810	24.520	25.415	25.923	25.523
$(\text{screen size})^2$	695.255	691.942	738.432	760.342	747.840
wide screen	0.063	0.088	0.072	0.055	0.076
liquid crystal display	0.021	0.000	0.013	0.017	0.023
projection	0.079	0.086	0.115	0.107	0.117
surround sound	0.177	0.246	0.271	0.247	0.248
console	0.153	0.103	0.132	0.094	0.123
picture-in-picture (1 tuner)	0.252	0.193	0.263	0.239	0.238
picture-in-picture (2 tuners)	0.027	0.053	0.094	0.112	0.073
video inputs	1.391	1.383	1.365	1.425	1.370
brand group # 1[a]	0.072	0.072	0.106	0.080	0.095
brand group # 3[b]	0.157	0.147	0.168	0.174	0.161
Sony	0.110	0.190	0.140	0.157	0.116
universal/learning remote	0.470	0.413	0.434	0.472	0.432
free delivery	0.073	0.081	0.049	0.046	0.058
N	293	263	320	287	274

[a]Includes Emerson, General Electric, Goldstar, Samsung, and Sanyo.

[b]Includes Hitachi, Mitsubishi, Panasonic, and Proscan.

Table 3. Hedonic regression parameter estimates and standard errors.

	Aug-1993		Aug-1994		Aug-1995		Aug-1996		Aug-1997	
Variable	Coef. Est.	Std. Err.	Coef. Est.	Std. Err.	Coef. Est.	Std. Err.	Coef. Est.	Std. Err.	Coef. Est.	Std. Err.
intercept	4.466	0.098	4.526	0.094	4.473	0.095	4.597	0.102	4.508	0.105
screen size	0.0651	0.0071	0.0591	0.006934	0.0566	0.007	0.04714	0.007537	0.048	0.0078
(screen size)2	-9.50E-05	1.20E-04	-4.06E-05	1.23E-04	3.70E-05	1.30E-04	2.08E-04	1.39E-04	1.59E-04	1.32E-04
wide screen	-0.021	0.068	0.091	0.100	0.005	0.064	-0.071	0.074	-0.067	0.071
liquid-crystal display	0.174	0.085	0.128	0.091	0.006	0.089	0.039	0.078	0.048	0.073
projection	-0.017	0.068	-0.053	0.092	-0.038	0.078	-0.130	0.089	-0.160	0.093
surround sound	0.054	0.036	0.067	0.039	0.014	0.033	0.019	0.036	0.026	0.038
console	0.228	0.036	0.276	0.047	0.331	0.041	0.329	0.046	0.352	0.049
picture-in-picture (1 tuner)	0.215	0.037	0.153	0.043	0.135	0.035	0.058	0.040	0.038	0.041
picture-in-picture (2 tuners)	0.254	0.067	0.355	0.075	0.326	0.052	0.375	0.055	0.263	0.053
video inputs	0.058	0.019	0.053	0.022	0.047	0.021	0.047	0.019	0.052	0.022
brand group # 1a	-0.141	0.050	-0.151	0.049	-0.128	0.039	-0.258	0.046	-0.244	0.057
brand group # 3b	0.143	0.040	0.260	0.045	0.278	0.035	0.246	0.037	0.271	0.038
Sony	0.231	0.043	0.256	0.042	0.243	0.038	0.191	0.040	0.331	0.044
universal/learning remote	0.049	0.031	0.016	0.035	0.089	0.030	0.094	0.032	0.086	0.036
free delivery	0.167	0.043	0.123	0.065	0.067	0.061	0.099	0.071	0.204	0.088
$\bar{R}^2$	0.9234		0.9136		0.9248		0.9212		0.9154	
standard error	0.203		0.21683		0.2108		0.21493		0.23126	
N	293		263		320		287		274	

[a]Includes Emerson, General Electric, Goldstar, Samsung, and Sanyo.

[b]Includes Hitachi, Mitsubishi, Panasonic, and Proscan

Table 4. Number of price quotes, total replacements, and comparable replacements by year.

Year	Total priced	Total replacements	Comparable replacements
1993	1,966	324	178
		(16.5%)	(54.9%)
1994	2,081	334	182
		(16.1%)	(54.5%)
1995	2,132	322	181
		(15.1%)	(56.2%)
1996	2,204	328	202
		(14.9%)	(61.6%)
1997	2,170	306	191
		(14.1%)	(62.4%)

Table 5. Alternative price indexes for televisions

Type of index	Aug-1993	Aug-1994	Aug-1995	Aug-1996	Aug-1997
Published CPI (rebased to Aug 1993=100)	100.0	98.2	95.6	90.9	86.8
Hedonic index - 1993 characteristics	100.0	94.7	90.1	86.9	81.1
Hedonic index - 1994 characteristics	100.0	95.8	90.2	87.2	82.1
Hedonic index - 1995 characteristics	100.0	95.5	90.3	86.6	80.1
Hedonic index - 1996 characteristics	100.0	95.3	90.3	87.1	80.5
Hedonic index - 1997 characteristics	100.0	96.2	90.8	87.7	81.3
Hedonic index – chained[a]	100.0	94.7	89.1	85.4	79.0
Hedonic index - combined characteristics, chained[b]	100.0	95.2	89.9	86.4	79.6

[a]The price changes are calculated using the preceding period's characteristics: i.e., 1993-94 uses 1993 mean characteristics, and 1995-96 uses 1995 mean characteristics.

[b]The price changes are calculated as the geometric mean of the price changes from using the preceding period's characteristics and the current period's characteristics: i.e., Aug-1994 is the geometric mean of the index changes using 1993 mean characteristics and 1994 mean characteristics, and Aug-1996 is the geometric mean of the index changes using 1995 mean characteristics and 1996 mean characteristics.

Table 6. Simulated CPI for Televisions versus simulated quality adjusted CPI for Televisions.

	1993											
	jan	**feb**	**mar**	**apr**	**may**	**jun**	**jul**	**aug**	**sep**	**oct**	**nov**	**dec**
Simulated CPI								100.000	99.051	99.885	100.348	99.781
Simulated Quality adjusted CPI								100.000	99.243	100.261	100.899	100.297
Difference in 1 month price change									-0.002	-0.002	-0.002	0.000
	1994											
Simulated CPI	99.931	100.256	101.066	100.909	100.066	99.568	97.601	98.078	99.151	98.565	98.373	98.285
Simulated Quality adjusted CPI	100.458	100.740	101.595	101.894	100.875	100.626	98.487	98.724	100.045	99.122	98.682	98.870
Difference in 1 month price change	0.000	0.000	0.000	-0.005	0.002	-0.003	0.002	0.002	-0.002	0.003	0.002	-0.003
	1995											
Simulated CPI	98.587	99.209	98.666	98.389	97.994	97.128	96.566	95.576	95.210	94.070	93.902	94.237
Simulated Quality adjusted CPI	99.288	99.902	99.253	99.170	99.077	98.297	98.077	96.877	96.382	95.297	94.973	95.702
Difference in 1 month price change	-0.001	0.000	0.001	-0.002	-0.003	-0.001	-0.004	0.002	0.001	-0.001	0.002	-0.004
	1996											
Simulated CPI	93.293	93.717	93.754	93.154	92.387	92.326	91.911	90.848	89.809	89.432	88.867	89.340
Simulated Quality adjusted CPI	94.603	95.031	94.860	94.188	93.555	93.470	93.169	91.637	90.384	89.818	89.171	89.112
Difference in 1 month price change	0.001	0.000	0.002	0.001	-0.002	0.000	-0.001	0.005	0.002	0.002	0.001	0.006
	1997											
Simulated CPI	89.609	89.625	89.394	88.339	88.348	88.118	87.300	86.827				
Simulated Quality adjusted CPI	89.681	89.343	89.541	88.118	88.250	87.910	87.099	86.448				
Difference in 1 month price change	-0.003	0.004	-0.005	0.004	-0.001	0.001	0.000	0.002	**0.014**			

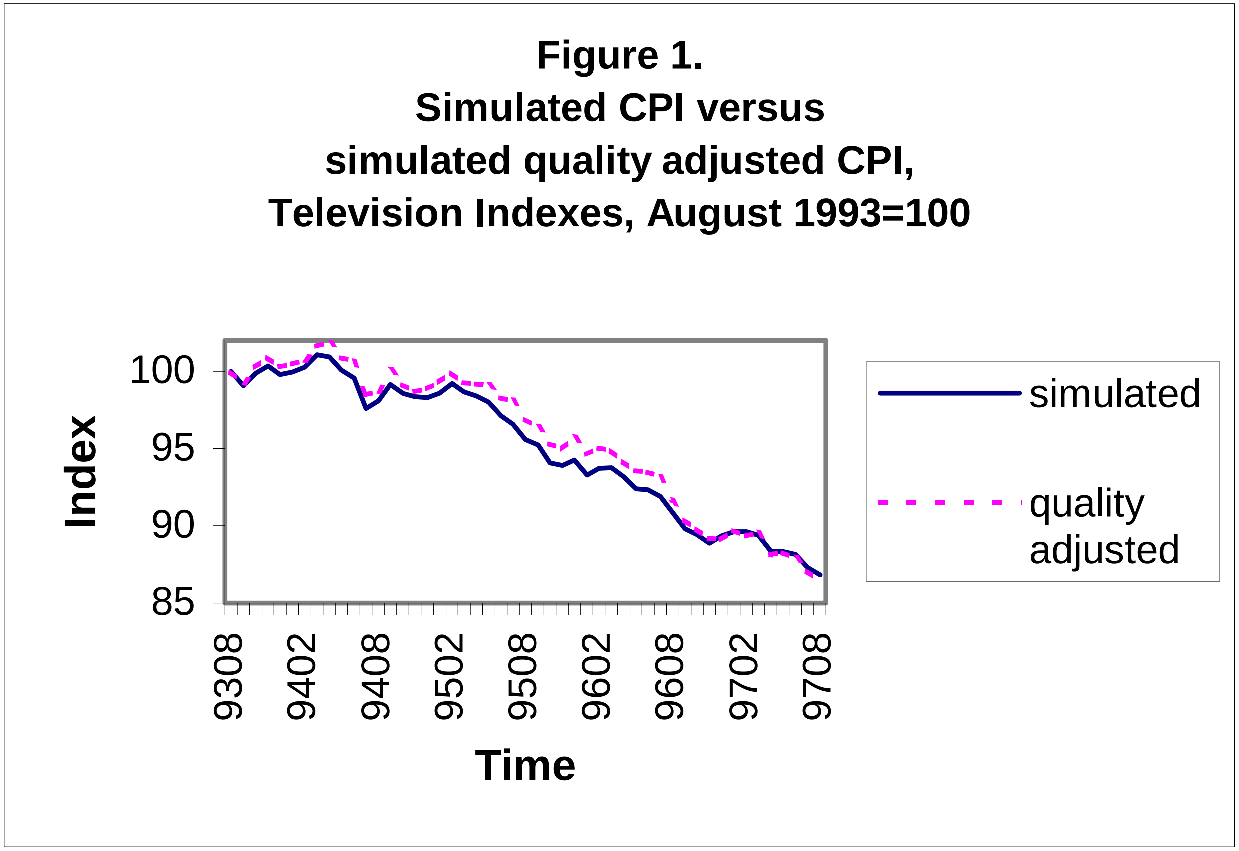
Figure 1.
Simulated CPI versus
simulated quality adjusted CPI,
Television Indexes, August 1993=100
Index
100
95
90
85
9308
9402
9408
9502
9508
9602
9608
9702
9708
Time
simulated
quality adjusted

Figure 2, page 1.

BUREAU OF LABOR STATISTICS **U.S. DEPARTMENT OF LABOR**

CONSUMER PRICE INDEX - ELI CHECKLIST

collection period: _ _ _ _ outlet number: _ _ _ _ _ _ _ _ quote code: _ _ _ arranging code: _ _ _ _

ELI No./ title **RA011 TELEVISIONS** cluster code **01**

item availability: 1-AVAILABLE 2-ELI NOT SOLD 3-INIT INCOMPLETE

purpose of checklist: 1-INIT 2-INIT COMPL 3-SPEC CORR 4-SUB 5-REINIT 6-CHECK REV

CURRENT PERIOD | **SALES TAX**

price _ _ _ _ _ _ . _ _ _ | included: YES NO

type of price: REG SALE |

YEAR-ROUND | in-season: JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

respondent: location:

field message:

PICTURE TYPE
- A1 Color
- A2 Black and white

DISPLAY TYPE
- D1 Cathode Ray Tube (CRT)
- D2 Liquid Crystal Display (LCD)
- D3 Projection

SCREEN SIZE - DIAGONAL MEASURE
- B1 Under 2.5 inches
- B2 2.5 TO 5 inches
- B3 5 inch
- B4 9 inch
- B5 13 inch
- B6 19 inch
- B7 20 inch
- B8 25 inch
- B9 26 inch
- B10 27 inch
- B11 29 inch
- B12 30 inch
- B13 31 inch
- B14 32 inch
- B15 35 inch
- B16 40 inch
- B17 45 inch
- B18 46 inch
- B19 50 inch
- B20 51 inch
- B21 52 inch
- B22 60 inch
- B99 Other, ______________________ Inches

AUDIO FEATURES
- E1 Monaural
- E2 Stereo (MTS)

STEREO FEATURES
- F1 Dolby Pro-Logic/Dolby 3 Surround Sound
- F2 Dolby Surround Sound
- F3 Matrix Surround Sound
- F4 Carver Sonic Holography
- F5 Hughes' Sound Retrieval System (SRS)
- F99 Other Audio System/Surround Sound, Type ______________________________
- G1 Subwoofer
- H99 Extended Bass System, Name ______________________________

STYLE
- I1 Portable or Table Model (CRT OR LCD)
- I2 Console (CRT OR LCD)
- I3 Two Unit Systems, Front Projection
- I4 One Unit System, Front Projection
- I5 One Unit System, Rear Projection
- I99 Other Style or Projection System,

ASPECT RATIO (Width:Height)
- C1 Conventional (4:3)
- C2 Widescreen (16:9)
- C99 Other, ______________________________

SPECIFY ADDITIONAL INFORMATION ON RA011 PAGES 2 AND 3 OF 6

ZZ99

Figure 2, page 2.

ELI RA011-01 TELEVISIONS - CONTINUED

MAJOR FEATURES

J1 High Definition Television (HDTV)
J2 Improved Definition Television (IDTV)
K1 Black and White Picture-in-Picture (PIP) -- one tuner
K2 Black and White Picture-in-Picture (PIP) -- two tuners
K3 Color Picture-in-Picture (PIP) -- one tuner
K4 Color Picture-in-Picture (PIP) -- two tuners
L1 Channel Preview
M1 Instant Replay
N1 Fuzzy Logic (Part of TV not Remote Control)

MONITOR CAPABILITY

P99 Number of Video Inputs, ________________________
Q99 Number of Video Outputs, ________________________
R99 Number of Audio Inputs, ________________________
S99 Number of Audio Outputs, ________________________
T99 Number of RF Inputs, ________________________
U99 Number of S-Video Inputs, ________________________
V1 RGB Input

BRAND

W1 Curtis Mathes
W2 Emerson
W3 General Electric
W4 Goldstar
W5 Hitachi
W6 JVC
W7 Magnavox
W8 Memorex
W9 Mitsubishi (MGA)
W10 Panasonic
W11 Philips
W12 Pioneer
W13 Prism
W14 Quasar
W15 RCA
W16 Samsung
W17 Sanyo
W18 Sears
W19 Sharp
W20 Sony
W21 Sylvania
W22 Tatung
W23 Toshiba
W24 Zenith
W99 Other, ____________________________

MODEL NUMBER

X99 Manufacturer's Model Number, ____________________________

COLOR SYSTEM NAME (Color Television Only)

AA99 Color System Name, ____________________________
AB99 Color System Name, ____________________________

REMOTE CONTROL

AC71 Remote Control Not Available
AC72 Remote Control Standard
AC73 Remote Control Optional and Not Incl.
AC79 Remote Control Optional and Included, Amount, (include in reported price) ______________// $__________________
AD1 Second Remote Control Standard

REMOTE CONTROL TYPE

(remote standard or included in price)

AE1 Standard (works TV only)
AE2 Unified (works TV & VCR of same brand)
AE3 Universal (works TV & VCR of many brands)
AE4 Learning (learns codes of other brands)
AE5 Combined Universal/Learning Remote

POWER

AF1 AC (house current)
AG1 DC (battery)

DELIVERY

AH71 Delivered or Not Delivered, No Extra Charge For Delivery
AH72 Not Delivered, Extra Charge for Delivery
AH73 No Delivery Available
AH79 Delivered, Extra Delivery Charge, Amount, (include in reported price)

______________// $__________________

CHANNEL SELECTION

AI1 Manual (one or two knobs)
AI2 Electronic
AJ1 Not Cable Ready
AJ2 Cable Ready

ADDITIONAL EQUIPMENT

AK1 Built-In VHS Video Cassette Recorder
AK2 Built-In 8MM Video Cassette Recorder
AL1 Built-In Compact Disc Player
AM1 Built-In Radio
AN1 Built-In Tape Deck
AP1 External Speaker(s)
AQ1 Stand Included in Price of Set
AR99 Other Equipment, ____________________________
AS99 Other Equipment, ____________________________
AT99 Other Equipment, ____________________________

Figure 2, page 3.

SPECIFY ADDITIONAL INFORMATION ON RA011 PAGE 3 OF 6

BLS 3400B (Rev. February 1995) RA011 page 2 of 6
Revised January 1996

ELI RA011-01 TELEVISIONS - CONTINUED

OTHER FEATURES

AU1 On-screen Menus
AV1 Sleep Timer
AW1 Time/Channel Block
AX99 Other feature, ______________________________
AY99 Other feature, ______________________________
BA99 Other feature, ______________________________

TECHNICAL SPECIFICATIONS

BB99 Horizontal Resolution, ______________________________ lines
BC99 Amplifier Power, __________________________ watts per channel
BD99 Peak Power Consumption, ______________________________ watts

ADDITIONAL CHARGES

Description Amount (Include in Reported Price)
BE99 ____________________________ BF79 _________________________// $______________
BG99 ____________________________ BH79 _________________________// $______________

OTHER PRICE FACTORS

BI99 ___________________________________
BJ99 ___________________________________
BK99 ___________________________________

**** OTHER CLARIFYING INFORMATION**

BL99 ___________________________________
BM99 ___________________________________
BN99 ___________________________________

PRICING

CA79 Offering Price, Amount
___________________________// $___________________
CB89 All Other Charges (AC79 + AH79 + BF79 + BH79)
___________________________// $___________________
CC89 Subtotal (CA79 + CB89)
___________________________// $___________________
CD79 Estimated dealer concession,
___________________________// $___________________
CE89 REPORTED PRICE (CC89 - CD79)
___________________________// $___________________

BLS 3400B (Rev. February 1995) RA011 page 3 of 6
Revised January 1996

Figure 3

Comparable Substitute

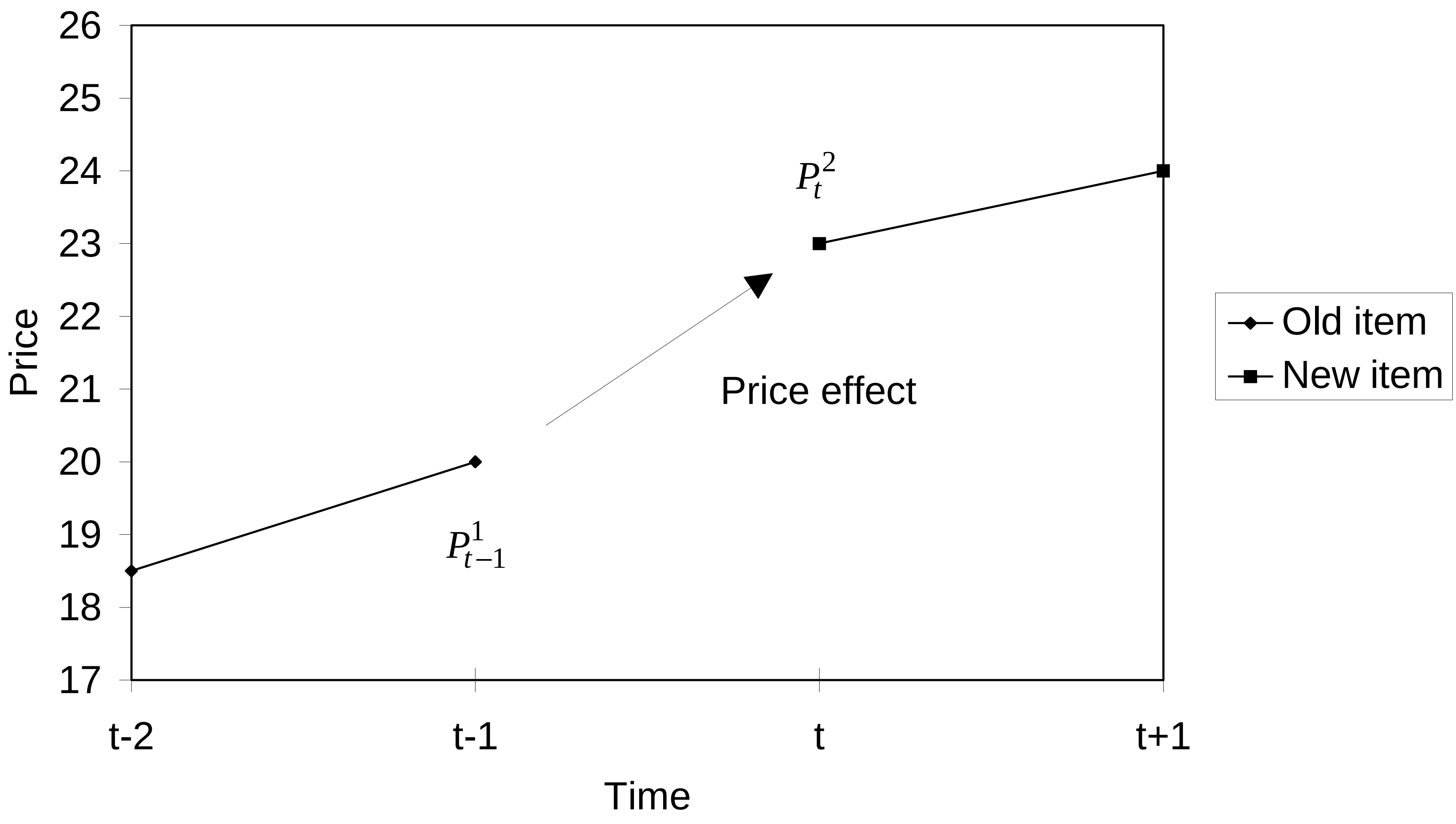

Figure 4

Overlap Method

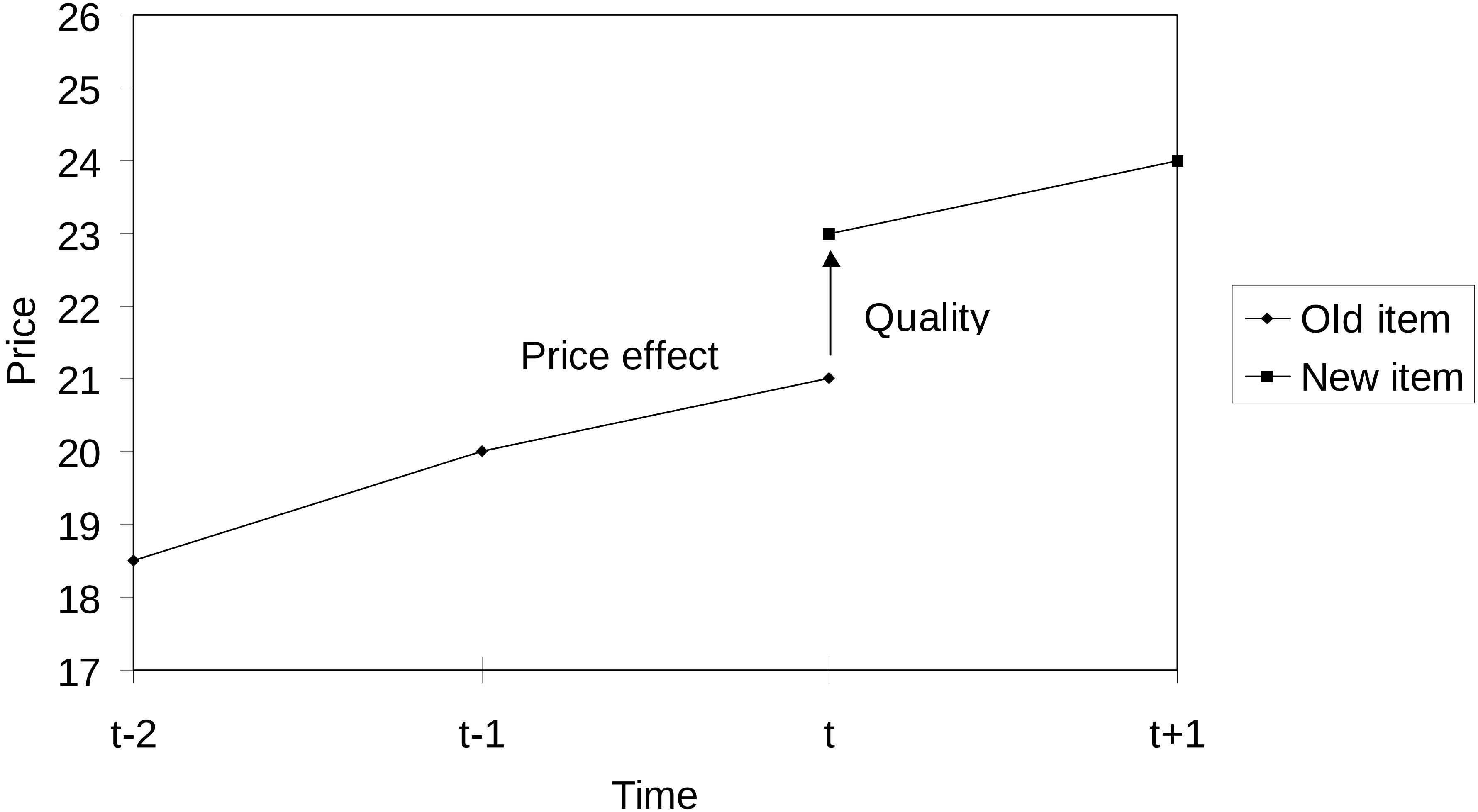

Figure 5

Link Method and Class-Mean Imputation

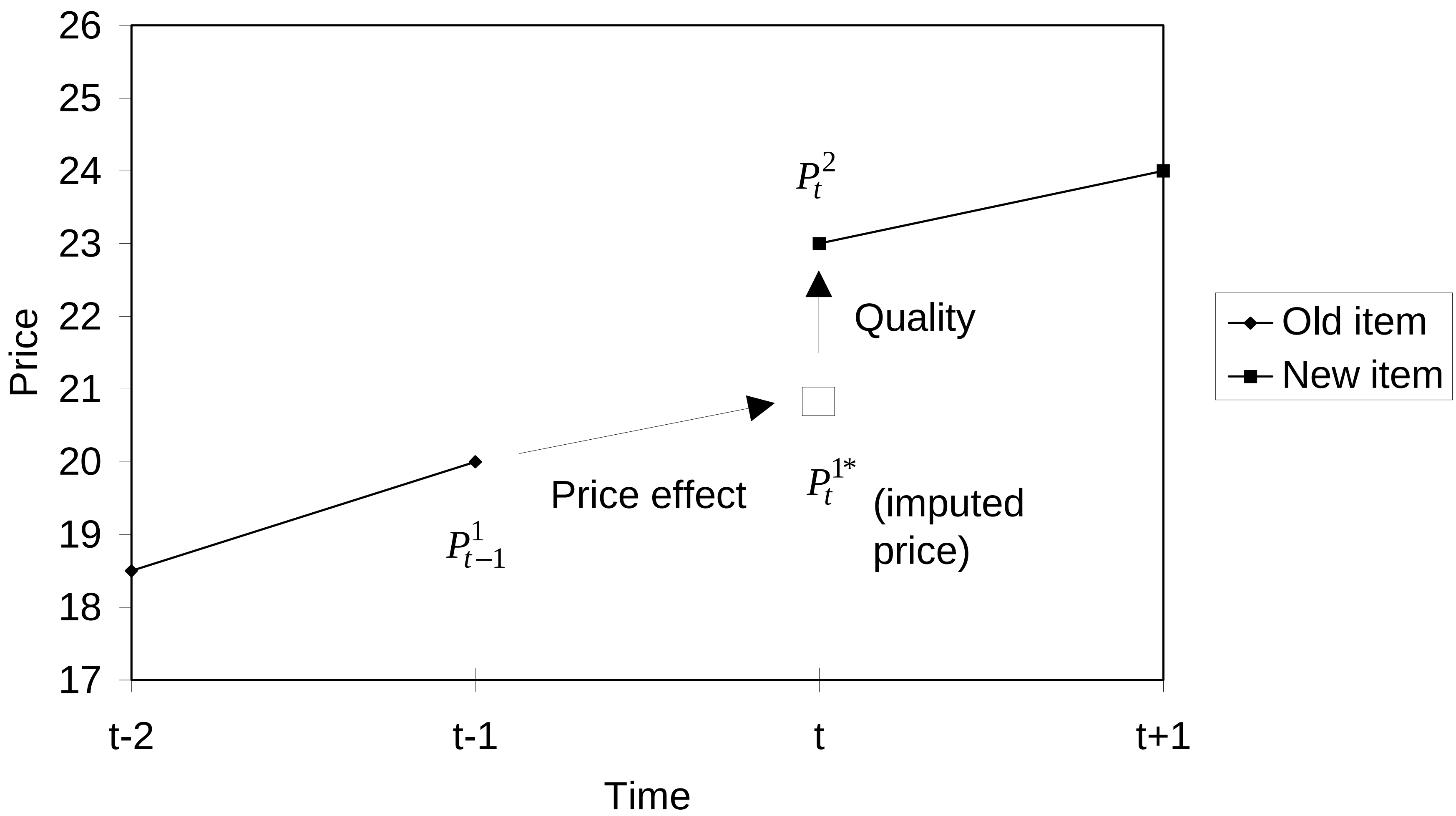

Figure 6

Direct Quality Adjustment