Price measurement in the United States: a decade after the Boskin Report

Since the 1996 Boskin Report, BLS has made some important changes to improve the Consumer Price Index (CPI), such as the implementation of the geometric means formula to calculate basic indexes and the creation of alternative indexes to serve various user needs

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The report by the U.S. Advisory Commission to Study the Consumer Price Index (known more commonly as the Boskin Report), issued on December 4, 1996, addressed the broad conceptual question of whether a cost-of-living index (COLI) should be the measurement objective of a price index and focused attention on three key problems inherent in the calculation of consumer price indexes: consumer substitution, quality change, and new goods. These issues received further attention in the 2002 report produced by an 11-member panel convened by the Committee on National Statistics entitled *At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes* (known as the CNSTAT Report).[1] Subsequent to the Boskin Report, the Bureau of Labor Statistics (BLS) reaffirmed its cost-of-living conceptual framework and, building on prior research, introduced methodological changes that have addressed the substitution, quality, and new-goods issues. These include the following: 1) the introduction of the geometric means formula to account for lower-level substitution, 2) the introduction of the Chained Consumer Price Index for All Urban Consumers (C-CPI-U) to provide an index that accounts for upper-level substitution, 3) expansion of the use of hedonic models to improve the measurement of quality change, and 4) the institution of procedures to introduce new goods into the index more quickly by more frequent updates to the item samples. This article details these methodological changes and provides some estimate of their quantitative impact.

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Conceptual basis of the CPI

Decisions about particular CPI issues are rooted in the fundamental conceptual goals of the CPI. BLS remains committed to using a cost-of-living index (COLI) as its theoretical goal for the CPI. The updated (online) version of the *BLS Handbook of Methods* asserts the following:

> As it pertains to the CPI, the COLI for the current month is based on the answer to the following question: *"What is the cost, at this month's market prices, of achieving the standard of living actually attained in the base period?"* This cost is a hypothetical expenditure—the lowest expenditure level necessary at this month's prices to achieve the base period's living standard. The ratio of this hypothetical cost to the actual cost of the base-period consumption basket in the base period is the COLI. Unfortunately, because the cost of achieving a living standard cannot be observed directly, in operational terms a COLI can only be approximated. Although the CPI cannot be said to equal a cost-of-living index, the concept of the COLI provides the CPI's measurement objective and the standard by which we define any bias in the CPI. BLS long has said that it operates within a cost-of-living framework in producing the CPI. That framework has guided, and will continue to guide, operational decisions about the construction of the index.[2]

This approach is explicitly endorsed by the

Boskin Report and supported by the CNSTAT report.[3] Indeed, this framework dates to the 1961 report by the Stigler Committee of the National Bureau of Economic Research, which was an important predecessor to the Boskin Report.[4] This choice arises from the way the CPI is used in practice. In the United States, the CPI is used extensively both by government and private entities to make cost-of-living adjustments, which argues for a COLI framework. Such a framework necessarily involves complications, because measuring a concept as broad as the cost of living in a dynamic economy and using only price data is theoretically and operationally difficult, but the cost-of-goods index (COGI) concept would have difficulties of its own and lead to an index that is possibly unsuitable for the way it is used.[5] A cost-of-goods index would perhaps yield different decisions about quality adjustments, substitution, and other CPI issues. The CNSTAT panel mentioned, however, that "for many (perhaps even most) purposes, the distinctions (between the COLI and COGI approaches) are less important than they might seem."

While the Boskin Report generated a great deal of attention, it is best understood as one chapter in a long history of evaluation of the conceptual foundations and methodologies of the CPI and price indexes in general, a history chronicled in a 2005 article by Marshall Reinsdorf and Jack E. Triplett.[6] This history includes both the development of price index theory and occasional reviews of the CPI, specifically.

Bias in the CPI

The Boskin Report asserted an upward bias in the CPI of 1.1 percent, arising mostly from biases related to substitution, new goods, and quality change. This estimate was consistent with widespread perception and with most other estimates at the time.[7] Table 1 summarizes the state of estimates on CPI bias up through the Boskin Report.[8] While there have been substantial changes in CPI methodology since, other recent studies and comments indicate a wide belief that an upward bias still exists. In an update to their report, the members of the Boskin commission estimated the bias at 0.8 percent as of 1999. In a careful analysis in the *Journal of Economic Literature*, David E. Lebow and Jeremy D. Rudd estimate the upward bias at 0.9 percent, with most of the bias coming from new goods and quality change.[9]

On the other hand, some argue that the CPI understates inflation, partly as a result of recent changes to address quality and substitution issues. Charles R. Hulten, for example, argues that the quality change bias may be negative, possibly so much so that it more than offsets the positive biases.[10] Outside of the academic community, there is some perception that the CPI understates inflation, a view that has been articulated by some members of the finance community. Additionally, Robert Gordon, one of the members of the Boskin commission, presented two papers (one with coauthor Todd vanGoethem) at conferences in 2004 that suggested a historical downward bias in the CPI due to the treatment of rent and apparel.[11]

Substitution bias

Substitution bias arises in a fixed-weight CPI if consumers change their purchasing behavior in response to relative price changes. Operationally, this substitution bias can be divided into upper-level substitution bias and lower-level substitution bias. This distinction between upper- and lower-level bias corresponds to the two-stage process involved in calculating the CPI. The CPI is broken down into 211 item categories and 38 areas, which are cities or groups of cities where prices are collected. This classification forms a matrix

Table 1. Pre-Boskin Report estimates of bias in the U.S. Consumer Price Index

Author(s)	Point Estimate	Interval Estimate
Advisory Commission to Study the CPI (interim report, 1995)	1.0	0.7–2.0
Michael Boskin (1995)	1.5	1.0–2.0
Congressional Budget Office (1995)	–	.2–0.8
Michael R. Darby (1995)	1.5	.5–2.5
W. Erwin Diewert (1995)	–	.7–1.3
Robert J. Gordon (1995)	1.7	–
Alan Greenspan (1995)	–	.5–1.5
Zvi Griliches (1995)	1.0	.4–1.6
Dale W. Jorgenson (1995)	1.0	.5–1.5
Jim Klumpner (1996)	–	.3–0.5
Lebow, Roberts, and Stockton (1994)	–	.4–1.5
Ariel Pakes (1995)	0.8	–
Shapiro and Wilcox (1996)	1.1	.7–1.6
Wynne and Sigalla (1994)	less than 1.0	–

NOTE: This table is adopted from Brent R. Moulton, "Bias in the Consumer Price Index: What Is the Evidence?" ***Journal of Economic Perspectives***, Fall 1996. Dashes indicate the estimate was not produced in that study.

of 8,018 cells. Basic indexes are calculated for each cell; this is the first stage of calculation, and substitution within each of these 8,018 cells is characterized as lower-level substitution. The basic indexes are then aggregated into composite indexes, culminating with the aggregate of all basic indexes, the All Items index. Substitution among the 8,018 different cells must be addressed differently and is termed upper-level substitution. Substituting between Swiss and cheddar cheese by consumers in a CPI area would be an example of lower-level substitution, because these items would be in the same cell. Beef and chicken, on the other hand, are in different cells, so substituting between them would be an example of upper-level substitution.

Until 1999, the CPI was a modified Laspeyres index and used a modified Laspeyres or "Lowe" formula for both creating the basic indexes and aggregating to upper-level indexes. This formula effectively assumes zero substitution, as the initial quantities used in the formula are assumed to stay fixed after their introduction until the next expenditure weight update. That is, the modified Laspeyres formula assumes an elasticity of substitution of zero. It is well known that a Laspeyres index is an upper bound to a cost of living index. To the extent that consumers can and do change their purchasing behavior in response to relative price changes, a Laspeyres formula will result in an upward bias in the index and overstate the cost of living.[12]

The Boskin Report estimated biases for both upper- and lower-level substitution: 0.15 percent per year for upper-level bias and 0.25 percent per year for lower-level bias, which resulted in a total bias of 0.4 percent. Substitution bias had been a concern in the CPI and other price indexes even before the Boskin Report,[13] and BLS has addressed both upper-level and lower-level bias in the index in the years since the report.

In 1999, the CPI converted to a geometric means formula for item strata within which substitution is realistic, about 61 percent of the index.[14] The strata that remained Laspeyres are mostly from housing and medical care; excluding rent and owners' equivalent rent, only one-seventh of the weight in the CPI still uses a Laspeyres formula to calculate basic indexes. The geometric means formula effectively assumes constant relative expenditure on a given item, rather than constant quantity; as the relative price increases, the assumed quantity proportionally decreases. This formula thus implicitly assumes a unitary elasticity of substitution. This geometric means formula is used in averaging of prices to create basic indexes, but not in the aggregation of those indexes; hence, it addresses only lower-level bias.[15]

In 2002, the CPI started producing an additional index, the Chained Consumer Price Index for All Urban Consumers (C-CPI-U).[16] This index uses a Tornqvist formula and expenditure data from both the base and current period in the upper-level aggregation to calculate the indexes. Thus, the final version of the C-CPI-U is based on actual consumer behavior, rather than on assumptions about substitution behavior. However, since expenditure data are available only with a time lag, a geometric means formula is used to estimate the indexes initially and then the figures are revised when the final expenditure data are available. Note that the C-CPI-U is a distinct index from the standard CPI-U, rather than a change to CPI-U methodology. However, the C-CPI-U provides an approximation of the quantitative impact of upper-level substitution. The effect on the CPI of the change to the geometric mean formula and the difference between the CPI-U and the C-CPI-U can be used as measures of the effects of lower- and upper-level substitution, respectively. Table 2 summarizes those effects.[17]

The far right columns show estimates of the effects of lower-level substitution, upper-level substitution, and total substitution. The lower-level substitution estimate is derived by comparing the standard CPI-U, which now uses a geometric means formula to calculate most basic indexes, with the CPI-U-XL, an experimental index that has retained a Laspeyres formula at both levels of aggregation.[18] The upper-level substitution estimate is the difference between the CPI-U and the C-CPI-U. All data are from December 1999 through December 2004.

Table 2 also shows differences broken down by major group and for special categories. Many of the results are intuitive. For example, apparel, a group of goods among which substitution is relatively easy for consumers, has a large lower-level effect. Because substitution may be difficult in housing and medical care, both have many strata that are still Laspeyres and thus the lower-level effects are small. Commodities have a larger effect than services. For lower-level bias, many of these results correspond closely to earlier BLS estimates. Before the change to geometric means was instituted—indeed before the Boskin Report was issued—BLS created an experimental measure called the CPI-U-XG to study the effects of a possible change to geometric means. The difference between the CPI-U and the CPI-U-XG averaged 0.27 percent per year from December 1994 to December 1996.[19]

However, caution must be used in interpreting these numbers as definitive measures of lower-level substitution. The estimated effect of lower-level substitution (and, hence, total substitution) shown in Table 2 is slightly overstated, due to a formula bias inherent in the experimental CPI-U-XL. As background, in 1995 and 1996, BLS introduced seasoned samples into the CPI to eliminate a functional form bias.[20] With the adoption of the geometric means formula for most components of the CPI in 1999, seasoning of most samples became unnecessary and was discontinued for items using the geometric means formula. However, the discontinuation of seasoned samples means that the experimental index, the CPI-U-XL, is upwardly biased. The effect of this bias differs

Table 2. Estimate of lower-level and upper-level substitution

[Annualized percent changes, December 1999 to December 2004[1]]

Item	CPI–U–XL	CPI–U	C–CPI–U	Lower	Upper	Total
All items	2.77	2.49	2.09	0.28	0.40	0.68
CPI major groups:						
Food and beverages	2.9	2.6	2.3	.3	.3	.6
Housing	3.0	3.0	2.8	.0	.2	.2
Apparel	–.3	–1.8	–2.2	1.5	.4	1.9
Transportation	2.4	2.1	1.8	.3	.3	.6
Medical care	4.5	4.4	4.3	.1	.1	.2
Recreation	1.8	1.2	.7	.6	.5	1.1
Education and communication	2.5	1.9	.0	.6	1.9	2.5
Education	6.5	6.3	6.5	.2	–.2	.0
Communication	–1.4	–2.3	–4.8	.9	2.5	3.4
Other goods and services	3.5	3.2	2.8	.3	.4	.7
Special aggregates:						
Food	2.9	2.6	2.3	.3	.3	.6
Energy	6.8	6.5	6.1	.3	.4	.7
All items less food and energy	2.4	2.1	1.7	.3	.4	.7
Commodities and services:						
Commodities	1.8	1.3	.6	.5	.7	1.2
Services	3.5	3.3	3.2	.2	.1	.3

[1] Data for the 2004 C–CPI–U are based on interim indexes.

by item category, but at the All Items level, the CPI-U-XL is perhaps 0.1 percent higher per year than its target measure, a Laspeyres CPI. Said another way, the lower-level (and total) substitution effect columns shown in the table contain both a substitution effect and a functional form effect, with the functional form effect being about 0.1 percent per year at the All Items level.

Moreover, while the geometric means formula corrects for the lower-level substitution bias, recent BLS research suggests that this estimate introduces a detectable upward bias in small samples. The bias occurs because a geometric mean of sample of price changes will overestimate, on average, the geometric mean of all price changes in the population. As the sample increases, the upward bias is reduced. BLS research has indicated that finite samples in CPI basic cells could yield an upward bias in the estimator of 0.1 percentage point or more per year.[21] In fact, this small sample bias could decrease the estimate of the upper-level substitution bias shown previously.[22]

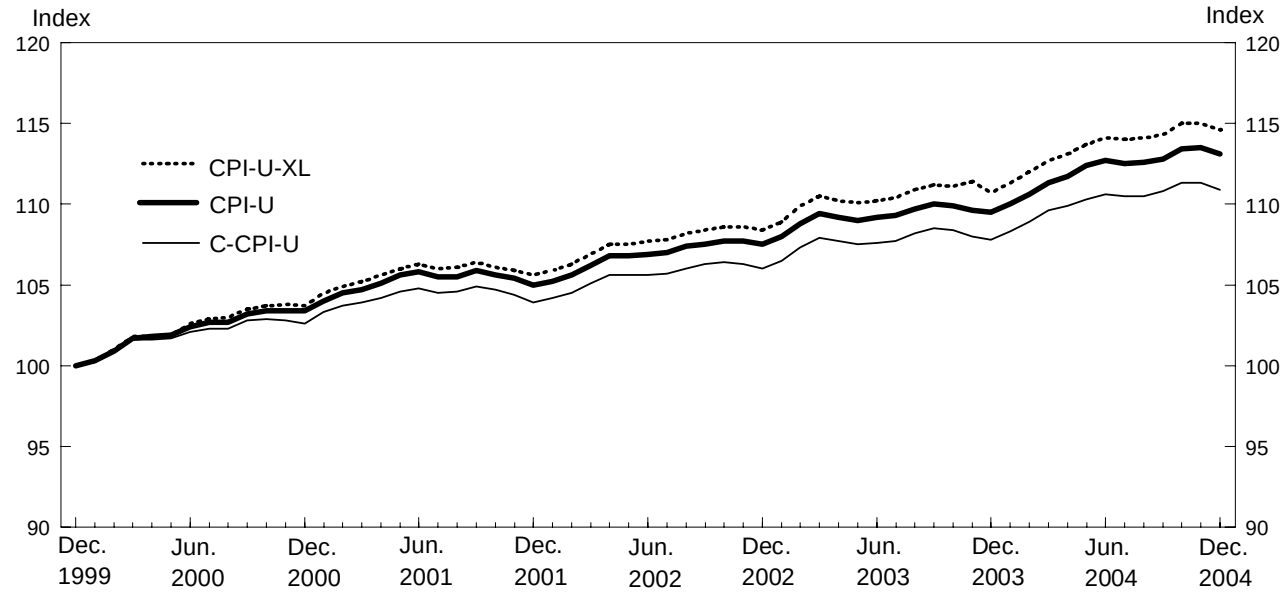
Upper-level bias, as measured by the difference between the CPI-U and C-CPI-U, at first appears to be larger than expected, but these figures should be interpreted cautiously as well. BLS simulations before the C-CPI-U was first published resulted in an initial estimate of 0.15 percent, later revised to 0.22 percent. As seen previously, the average annual difference from 1999 to 2004 has been 0.4 percent. Chart 1 provides a graphic representation of the CPI-U, C-CPI-U, and C-CPI-XL from December 1999 to December 2004. But it also is useful to examine the actual data for each year, as shown in table 3. From the table, for example, it is evident that the high upper-level figure is largely the result of the anomalously high 0.80-percent effect in 2000.[23] The size of this effect was a result of unusually large price dispersion and the weights for the CPI-U being relatively old at that time.[24] From 2001 to 2004, the effect is fairly consistent and more modest, about 0.3 percent.

It should again be emphasized that while the geometric means formula used to address lower-level substitution is in the standard CPI-U, upper-level substitution bias is not addressed in the current CPI-U, but only in the C-CPI-U. Thus, if one believes that conceptually a COLI should account for upper-level substitution, then the C-CPI-U may represent a preferable measure.

New goods and quality change bias

Perhaps the most fundamental problem in creating a price index is that the market basket available to consumers constantly changes, and a price index must have methods in place to account for these changes. In the CPI, new goods can enter the CPI sample in one of three ways. First, during repricing, if a sampled item is no longer available in the sampled outlet, the data collector "substitutes" to the most comparable item still remaining in that outlet and begins pricing it. This is typically what is referred to as the "quality change" issue. Second, new goods can also enter the CPI sample through sample rotation. Finally, there are some new goods that do not fit neatly into the existing CPI structure (for example, cell phones before 1998).[25] These goods are introduced into the CPI only during a revision of the item structure. Therefore, the CPI must deal both with making quality adjustments to items discontinued in the CPI sample and incorporating new items into the index as quickly as feasible.

Chart 1. Consumer Price Index measures, 1999–2005



NOTE: December 1999 = 100. CPI-U-XL = experimental index; uses Laspeyres at both levels. CPI-U = official index; uses geometric means for averaging most prices and uses a Laspeyres framework for averaging indexes across items and areas. C-CPI-U = official index, but differs from the CPI-U in that it addresses consumer substitution across items and areas.

Table 3. All items percent changes, CPI-U-XL, CPI-U, C-CPI-U, 2000–2004

Year	CPI–U–XL	CPI–U	C–CPI–U	Lower	Upper	Total
2000	3.70	3.40	2.60	.30	.80	1.10
2001	1.83	1.55	1.27	.28	.28	.56
2002	2.65	2.38	2.02	.27	.36	.63
2003	2.12	1.86	1.69	.26	.17	.43
2004	3.52	3.29	2.88[1]	.23	.41	.64

[1] Data for the 2004 C-CPI-U are based on interim indexes.

Because the CPI seeks to approximate a COLI, conceptually the goal is for the CPI to be a constant-quality index. Thus, when the quality of goods and services in the market basket changes, it is inevitable that the CPI must make some estimate of the quantitative value of such changes. This has been, and surely will continue to be, a source of disagreement and controversy in the CPI, because consumers have widely varying preferences and, consequently, disagreement over the valuation of changes in goods and services is to be expected. Arguments about a quality bias in the CPI have come from both sides and with different levels of sophistication. It is widely perceived, or perhaps was widely perceived, that much quality change goes undetected, resulting in an upward bias in the CPI. The Boskin Report, while noting BLS efforts to account for quality change, asserted an upward bias of 0.6 percent, larger than the upper- and lower-level substitution bias combined. Indeed the report went through a category-by-category analysis of quality bias, although some of its estimates seemed to be conjectural. Robert Gordon conceded that this estimate might have been too high by one-tenth of 1 percent.[26] In addition, David E. Lebow and Jeremy D. Rudd assert a smaller upward bias of 0.3 percent, about half of that coming from the medical care category.[27]

More recently, some have argued that there may actually be a downward quality change bias. Hulten, for example, estimates a downward bias of 0.71 percent to 0.97 percent per year due to what he terms "link bias" and "quality cost bias."[28] Link bias refers to a potential downward bias that could occur if manufacturers time real price increases to coincide with the

introduction of new models or redesigned products. Quality cost bias is the bias that would result if the assumption of cost elasticity of 1, implicit in CPI quality adjustment procedures, does not hold. Bart Hobijn also argues for at least the possibility of a downward bias.[29] Comments by Bill Gross are indicative of a somewhat widespread belief that new BLS methods have a downward bias.[30] BLS has maintained that the evidence on quality bias and its direction are much less clear than for substitution bias.[31]

It is certainly true that the CPI—and indeed virtually any price index—faces difficulties both conceptually and operationally in dealing with quality change, and economists of different persuasions have disagreed, and will continue to disagree, on the merits of different approaches. However, it should be emphasized that any price index must somehow deal with quality change, so the problem amounts to a choice among different methods. The CPI has several methods it uses to address quality change under different circumstances, and shifts from one method to another for several types of goods, while conceptually important, seem to have very minor quantitative impact on the All Items index.

Operationally, the CPI deals with quality change in several different ways. For any given item being priced, the CPI economic assistant in the field must determine if the item has changed in any way—that is, if it has been replaced with a new version. If the original and new versions are essentially the same, a commodity expert may deem them directly comparable and use the price comparison as if no quality change had occurred. If the versions are substantially different, then some sort of quality adjustment procedures must be used. These procedures can be categorized either as imputation or as direct quality adjustment.

There are two distinct methods of imputation in the CPI. *Cell-relative imputation*, sometimes called "linking," imputes the price change for the noncomparable versions by the price change of all the other similar items in the same geographic area. Thus, the price change for that quote is estimated as being the same percentage change as the price change for the cell for that item stratum and index area. *Class-mean imputation* is used when price change is closely associated with the introduction of new lines or models, such as in the new vehicles category. With class-mean imputation, the price change is estimated from the other observations going through replacement at the same time that they were either quality adjusted directly or judged directly comparable.[32]

Quality adjustment and hedonics

Direct quality adjustment refers to the analyst making an estimate of the quantitative value of a quality change. This is done either based on manufacturer cost data or on estimates of the value to consumers of particular features of the good in question. Often these values are estimated with hedonic models, a technique referred to simply as hedonics. Hedonics is widely considered the most promising technique for direct quality adjustment,[33] and the CPI employs it for an increasing number of categories of goods. In practice, the hedonic approach gives BLS analysts another tool to consider when confronted with the problem of quality change. Table 4 summarizes the implementation of hedonic methods in the CPI. The hedonics in the housing categories are small adjustments based on the aging of the housing units sampled. The remaining hedonic adjustments are for categories that together make up a fairly modest portion of the total weight in the CPI—about 3 percent.

It is clear that hedonics has become an important tool for dealing with quality change in certain categories, increasing the ability to make direct quality adjustments. In 1999, for VCR's and DVD players, imputation was used 267 times and direct quality adjustment only once. In 2001, after a hedonic model was developed for this category, imputation was used 92 times and direct quality adjustment 260 times. In major appliances, imputation was used 80 times in 1999, with no direct quality adjustment; in 2001, imputation was used 40 times, while 80 quotes were directly quality adjusted.

While hedonics is an important technique for particular categories, it is important to emphasize that it is used for only a small part of the total index. Moreover, research from the CPI-U Research Series (CPI-U-RS) shows that its impact on indexes often has been modest and of uncertain direction. The CPI-U-RS was created to provide a methodologically consistent index; to this end estimates were made of the quantitative index of methodological changes in the CPI since 1978.[34] These included changes to quality adjustment procedures. The estimates in the research series are taken from simulations described in the research for each item category for which hedonics was implemented.

In table 5, a negative sign indicates that the change to hedonic adjustment has caused the index to rise more slowly (or decline more rapidly) than it would have if previous quality adjustment procedures had been used. The inconsistency of the effect is exemplified by the fact that the impacts for washers and dryers have the opposite sign. While the switch to hedonic adjustment had a significant effect on several of the individual item categories, it is important to note that the net effect on the All Items index was negligible. This is because the direction of these effects varied and the items in question had such a small weight. (The total relative importance of items for which hedonics have been implemented since 1998 is less than 1 percent.) Indeed, the net effect of hedonics from 1999 onward (which excludes personal computers, but includes televisions and all later categories) on the All Items index is estimated to be less than 1-hundredth of 1 percent per year, specifically +0.005 percent.

Table 4. Hedonics in the CPI by date of introduction

Date	Item	Weight[1]
February 1988[2]	Rent	6.133
	Owners' equivalent rent	23.158
January 1991	Apparel[3]	2.160
January 1998	Computers[4]	.192
January 1999	Televisions	.132
January 2000	Audio equipment (12 items)	.104
	Video cameras[5]	.043
April 2000	VCR's and DVD players[5]	.043
July 2000	Refrigerators, freezers, and microwave ovens[6]	.165
	College textbooks	.217
October 2000	Washers and dryers[6]	.165
Total		32.304
Total excluding housing		3.013
Total excluding housing and apparel		.853

[1] "Weight" represents the relative importance of components in the Consumer Price Indexes: U.S. city average, December 2004; available on the Internet at ftp://ftp.bls.gov/pub/special.requests/cpi/cpiri_2004.txt.

[2] Age-bias adjustments were introduced in 1988, and structural change adjustments were introduced in 1989.

[3] The figure for apparel represents the total relative importance of the portions of the apparel category for which hedonic adjustment is used.

[4] Computer quality adjustment is now done using an attribute pricing approach that uses specific manufacturer's cost information to estimate values for features of the good.

[5] Video cameras, VCR's, and DVD players make up approximately 84 percent of the CPI sample for the stratum video products other than televisions. The relative importance given here is for the entire stratum.

[6] Refrigerators, home freezers, microwave ovens, washers, and dryers make up approximately 75 percent of the major appliances stratum.The relative importance given here is for the entire stratum.

This contrasts sharply with the perception that the recent increased use of hedonics has had a substantial downward effect on the index.

To the extent that hedonic methods were used prior to 1998, they tended to make the CPI slightly *higher*. The CPI implemented hedonic methods for many apparel categories in 1991. Apparel is different from technology goods, in that changes in quality are not as likely to be consistently positive. The estimated net affect on apparel of using hedonic adjustment is positive; the hedonic methods make the relevant apparel indexes higher by an estimated +0.39 percent per year, compared with previous methods. In 1988, the CPI implemented a hedonic approach to quality adjust housing for the aging of the housing stock. This adjustment is estimated to have an effect of +0.31 percent per year on the affected indexes.[35]

Note that these figures are estimates of the effect of switching to hedonic methods from other quality adjustment procedures. An internal BLS study looked at the effects of hedonics compared with completely omitting any quotes where there was a quality change for the video and audio equipment categories (basically a matched model approach).[36] This study used data from December 2002 to February 2005. (See table 6.) As would be expected, this produces quantitative differences more substantial than the previous methods, but only for televisions and computers is the effect relatively large. Table 6 also illustrates the differences due to quality adjustments for women's dresses and computers. As suggested earlier, the quality adjustment used for women's dresses causes the index to rise (or fall less rapidly). Quality adjustments for computers, however, have the same effect on the index as for televisions—these adjustments cause the index to fall more rapidly.

In the past few years, BLS has moved away from using hedonics to value the quality changes resulting from substitutions in computers. From January 1998 to September 2003, the CPI program used hedonic regressions, developed in a cooperative effort with the other price programs, as a basis to determine appropriate quality adjustment amounts for personal computers. Due to the rapid and constant change in PC configurations, the CPI began to move towards an approach that uses attribute values available on the Internet as a basis for determining the appropriate quality adjustment amounts for personal computers. By September 2003, a process of attribute cost adjustment was fully implemented. The attribute cost adjustment process has a database of 250 to 300 variables/items that are updated monthly. This alternative method for quality adjustments allows for more adjustments to be calculated, because many of the items that change in a PC are not specifically covered in a hedonic model.

A recent BLS study compared the quality adjustments arising from the current attribute method with those that would arise

Table 5. Estimated impact of hedonic quality adjustment versus previous method for CPI categories in which hedonics has been introduced since 1998

Item	Yearly effect (in percent)
Computers	–3.81[1]
Televisions	–.11
Audio equipment	1.52
VCR's	1.89
Camcorders	.15
Refrigerators	.02
Washers	–.78
Dryers	.06
Microwaves	–.17
College textbooks	–2.53

[1] This effect was for the expenditure category Information Processing Equipment, of which computers was a portion. The effect on computers alone was about –6.5 percent.

Table 6. Annualized percentages with and without quality adjustment

Item	Annualized percent change	Annualized percent change without substitution[1]	Difference
Video and audio products (Dec. 2002 – Feb. 2005)	0.46	0.68	–0.22
Televisions	–12.86	–10.92	–1.94
Video products other than televisions	–13.52	–13.43	–.10
Audio products	–6.66	-6.26	–.41
Women's dresses (Dec. 2002 – Feb. 2005)	–3.83	–3.99	+.16
Computers and peripheral equipment (Mar. 2004 – Sep. 2004)	–9.78	–6.60	–3.18

[1] Because the phrase "without substitution" is vague, the following briefly describes the actual procedures used in this simulation: for video and audio products, the simulation removed quality adjustments and imputed the price change for those quotes, while directly compared substitutions were left alone. For women's dresses, the simulation removed quality adjustments and either directly compared or imputed the price change for those quotes, while the directly compared substitutions were left alone. For personal computers, the simulation removed all substitutions regardless of whether actual quality change was present.

from the hedonic method.[37] This study compared 6 months of adjustments (April 2004 to September 2004). Compared with the original hedonic method, the new attribute method results in a slightly larger decline in the index (an annualized rate of –9.78 percent, compared with –8.58 percent for the hedonic method).

Updating the market basket

Along with quality adjustment of goods in the sample, there is the issue of goods entering the economy that are not in the sample. Given the COLI concept, it is crucial that the CPI get new goods into the sample quickly, in order to have a market basket that accurately reflects consumer purchases. Additionally, it allows the CPI to capture some of the consumer surplus when new goods enter the economy and decline steadily in price, as sometimes happens with new technology goods; failure to capture this surplus has been seen as a possible source of upward bias in the CPI.

Although BLS has chosen not to attempt to reflect consumer surplus in the index explicitly—consistent with the recommendation of the CNSTAT panel—the CPI program has taken several steps in recent years to keep the market basket up to date. Since 2002, updated expenditure weights based upon consumer expenditure surveys have been introduced every 2 years (as opposed to roughly every 10 years in the past). Moreover, the lag time from survey to implementation is shorter, and the survey is completed in a shorter time. The result is that weights used in the CPI reflect much more recent consumer behavior than in years past. This probably results in a smaller increase in the index; for 2004, the increase in the index was 0.06 percent lower than it would have been had the old weights been in place. This figure is consistent with estimates of the impact of past revisions, which have usually, though not always, indicated that the weight update tends to cause a slightly lower rate of growth in the index.

Additionally, the CPI has changed its sample and outlet rotation procedures. In 1998, the CPI went from rotating 20 percent of the outlet sample each year to 25 percent, so that the entire sample is rotated every 4 years instead of every 5 years. Moreover, some items in selected categories that tend to change rapidly are rotated every 2 years. Thus, the market basket of the CPI is considerably more up to date than it used to be, particularly in terms of high-tech goods. For example, the new procedures have resulted in greater representation in the sample for technology items like flat panel televisions and digital video recorders.

One final recommendation of the Boskin Report was for BLS to improve its mechanism for bringing in outside information, research, and expertise. In 2000, the Federal Economic Statistics Advisory Committee (FESAC) was created.This group meets periodically with BLS representatives and provides a nexus between BLS and the academic research community. FESAC has allowed the CPI to exchange ideas with the academic and research community more efficiently, acting as a tool for the CPI both to transmit its latest research and methodology to the academic sector and to receive new research relevant to the CPI.

THE BOSKIN REPORT FOCUSED ATTENTION ON THE CPI and some particular sources of possible bias in the index, but improving the CPI is an ongoing process. Since the 1996 report, there have been important changes to improve the index. The implementation of the geometric means formula to calculate basic indexes addressed lower-level substitution bias, and the creation of the C-CPI-U provides a measure that accounts for upper-level substitution. While the case for quality change bias is much less clear cut, the expanded use of hedonic models to adjust directly for changes in quality has given BLS analysts another sophisticated option with which to address this issue. However, compared with the new methods used to address consumer substitution, and in contrast to widespread perception, these changes have not had an important quantitative effect on the All Items index. More frequent weight updates and sample rotation mean that the

market basket used in calculating the CPI is more up to date and reflective of current consumer behavior than it ever has been. The CPI will continue to evaluate and improve its methodologies in order to produce the most accurate index possible. □

Notes

[1] Charles L. Schultze and Christopher Mackie, eds., *At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes*, Panel on Conceptual, Measurement, and Other Statistical Issues in Developing Cost-of-Living Indexes (Washington, National Academy Press, 2002).

[2] "Chapter 17, The Consumer Price Index," *BLS Handbook of Methods*, updated online version (Bureau of Labor Statistics, April 10, 2006), pp. 2–3; available on the Internet at **http://www.bls.gov/opub/hom/pdf/homch17.pdf**. For more information on the historical context of the COLI approach used in the CPI, see John S. Greenlees, "A Bureau of Labor Statistics Perspective on Bias in the Consumer Price Index," Federal Reserve Bank of St. Louis *Review*, May 1997, pp. 175–78.

[3] For a detailed discussion of the conceptual foundations of price indexes, see Schultze and Mackie, eds., *At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes*, pp. 43–73. The CNSTAT report approves of a COLI approach, but does not explicitly recommend it to the exclusion of other approaches.

[4] For a detailed history of the Consumer Price Index, see Marshall Reinsdorf and Jack E. Triplett, "A Review of Reviews: Ninety Years of Professional Thinking About the Consumer Price Index." Paper presented at the CRIW Conference on Price Index Concepts and Measurement, Vancouver, Canada, June 28–29, 2004.

[5] For a discussion of the COLI and COGI debate, see Reinsdorf and Triplett, "A Review of Reviews," pp. 34–41.

[6] *Ibid.*

[7] See Brent R. Moulton, "Bias in the Consumer Price Index: What is the Evidence?" *Journal of Economic Perspectives*, Fall 1996.

[8] The table is adopted from Moulton; *ibid*.

[9] David E. Lebow and Jeremy D. Rudd, "Measurement Error in the Consumer Price Index: Where Do We Stand?" *Journal of Economic Literature*, March 2003, 159–201.

[10] Charles R. Hulten, "Quality Change in the CPI," Federal Reserve Bank of St. Louis *Review*, May 2001, pp. 87–111.

[11] See Robert Gordon, "Apparel Prices 1914–93 and the Hulten/Bruegel Paradox." Paper presented at CRIW Conference on Price Index Concepts and Measurement, Vancouver, Canada, 2004; and Robert Gordon and Todd vanGoethem, "A Century of Housing Shelter Prices: Is There a Downward Bias in the CPI?" NBER Working Paper No. 11776 (National Bureau of Economic Research, November 2005).

[12] Technically, the CPI is a Lowe price index, not a Laspeyres index. For more on this distinction, see Bert M. Balk and W. Erwin Diewert, "The Lowe Consumer Price Index and its Substitution Bias," Discussion Paper 04–07 (Department of Economics, University of British Columbia), July 2004. In general, the modified Laspeyres or Lowe index does not have the property of being an upper bound to a cost-of-living index. This follows because the comparisons of intermediate values of a Laspeyres index subsequent to the base period do not have this property.

[13] See Ana M. Aizcorbe and Patrick C. Jackman, "The Commodity Substitution Effect in CPI Data, 1982–1991: Anatomy of a Price Change," *Monthly Labor Review*, December 1993, pp. 25–33.

[14] See "Chapter 17, The Consumer Price Index," *BLS Handbook of Methods*, for item categories that use the Laspeyres formula.

[15] Reinsdorf and Triplett suggest other reasons beyond substitution to use the geometric mean estimator.

[16] For a detailed discussion of this index, see Robert Cage, John S. Greenlees, and Patrick Jackman, "Introducing the Chained Consumer Price Index." Paper presented at Seventh Meeting of the International Working Group on Price Indices, Paris, France, May 2003.

[17] Unlike the CPI-U and CPI-U-XL, major group and other subaggregate C-CPI-U indexes are not independent. For example, the Food and Beverage C-CPI-U index reflects average price change among food and beverage items, but because relative price change for items in other major groups (Housing, Transportation, for example) may affect the level of expenditure on food items, the Food and Beverage C-CPI-U index is conditional upon price change in other major groups. Moreover, C-CPI-U indexes are not precisely consistent in aggregation, although in practice they are very close. That is, an expenditure weighted average of the subindexes may not yield the exact estimate of All Items price change as the official All Items index. Additionally, the difference between the C-CPI-U and published CPI-U is being used as a measure of upper-level substitution even though the published CPI-U is technically a Lowe index. Thus, while this table does give an idea of the relative magnitude of the substitution effects, it should be interpreted with caution for the major groups and other subaggregates. Note, however, that BLS research on upper-level substitution bias, which had preceded the development of the C-CPI-U and had been provided to the Boskin Commission, was based on the comparison of a true Laspeyres index with Fisher and Tornqvist superlative indexes.

[18] The CPI-U-XL is an unofficial index that uses a Laspeyres formula to average the prices within basic item area cells, as well as aggregating those indexes.

[19] Data from which this figure is derived are available on the BLS website at **http://www.bls.gov/cpi/cpigmatab.htm**.

[20] See Ken Stewart, "Improving Sample Rotation Procedures," *CPI Detailed Report*, October 1994, pp.7–8; and "Extending the Improvements in CPI Sample Rotation Procedures and Improving the Procedures for Substitute Items," *CPI Detailed Report*, March, 1996, pp.4–5.

[21] See Robert McClelland and Marshall Reinsdorf, "Small Sample Bias in Geometric Mean and Seasoned CPI Component Indexes," Bureau of Labor Statistics Working Paper 324, August 1999; and Ralph Bradley, "Analytical Bias Reduction for Small Samples in the US Consumer Price Index," BLS unpublished manuscript, September 3, 2004.

[22] See Bradley, "Analytical Bias Reduction for Small Samples in the US Consumer Price Index."

[23] Robert Cage and coauthors estimate that the size of the differenceis only 0.6 percent if the biennial weights are used in the construction of the CPI-U. In addition, this large difference is also apparent in the difference between the PCE chain-weight and fixed-weight indexes for 2000.

[24] Weights for the final version of the C-CPI-U are from contemporaneous expenditure data and so the CPI-U weights are always, in a sense, older than those of the C-CPI-U. However, since the CPI-U weights are updated every 2 years, the time gap between the weights of the two indexes varies over time.

[25] For more on these discussions, see Schultze and Mackie, eds., *At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes*, p. 31.

[26] See Robert Gordon, "Apparel Prices 1914–93 and the Hulten/Bruegel Paradox."

[27] David E. Lebow and Jeremy D. Rudd, "Measurement Error in the

Consumer Price Index: Where Do We Stand?" *Journal of Economic Literature*, March 2003, pp. 159–201.

[28] Hulten, "Quality Change in the CPI."

[29] Bart Hobijn, "On Both Sides of the Quality Bias in Price Indexes," Staff Report 157 (Federal Reserve Bank of New York, 2002); on the Internet at **http://ideas.repec.org/p/fip/fednsr/157.html#provider**.

[30] Bill Gross, "Haute Con Job," *Investment Outlook* (PIMCO Bonds, October 2004).

[31] This is made especially clear in Brent R. Moulton, "Bias in the Consumer Price Index: What is the Evidence?"; and in John S. Greenlees, "A Bureau of Labor Statistics Perspective on Bias in the Consumer Price Index."

[32] This discussion follows that in the *BLS Handbook of Methods*.

[33] See, Schultze and Mackie, eds., *At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes*, p. 122.

[34] Kenneth J. Stewart and Stephen B. Reed, "Consumer Price Index Using Current Methods," *Monthly Labor Review*, June 1999, pp. 29–38.

[35] In the past 3 years, the average adjustment has fallen to 0.26 percent per year.

[36] David S. Johnson and Craig Brown, Internal BLS memorandum, April 2005.

[37] David S. Johnson and Joe Chelena, Internal BLS memorandum, February 2005.