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Reconsideration of Weighting and Updating Procedures in the US CPI

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I. Introduction

In 2002, the US Bureau of Labor Statistics (BLS) made two important enhancements to the Consumer Price Index (CPI) program. First, it accelerated the frequency of expenditure weight updates in the headline CPI. Second, it introduced a new supplemental CPI employing a superlative formula. This paper provides a retrospective look at those changes and suggests conclusions that can be drawn from the experience thus far.

The headline Consumer Price Index for All Urban Consumers (CPI-U) employs a form of the Lowe, or Modified Laspeyres, index structure. The aggregate US City Average All Items CPI-U is computed as an arithmetic average of lower-level indexes, with weights derived from consumer expenditures during a base period. Prior to 2002, the expenditure base period was updated approximately every 10 years. In December of 1998, however, the BLS announced that future updates would take place every two years, with each update introducing a new two-year base period.¹ Thus, effective with the release of January 2002 data, month-to-month changes in the CPI-U were based on weights drawn from 1999 and 2000 calendar year expenditures. Three subsequent biennial updates have now taken place, and expenditure weights in effect since January 2008 are based on 2005-2006 expenditures.²

The published CPI-U remains subject to the “upper level” consumer substitution bias inherent in the Lowe structure. To address this concern, in 2002 the BLS introduced a new, supplemental index, the Chained CPI for All Urban Consumers or C-CPI-U. The Törnqvist formula used in the aggregation of the final C-CPI-U is designed to be a closer approximation to a cost-of-living index (COLI) than the Lowe formula used in the CPI-U. It uses actual consumer expenditure estimates from both the current and previous months to weight the basic indexes as a means of accounting for consumer substitution between item categories.³

Monthly values of the C-CPI-U are published beginning with data for January 2000 (December 1999=100) and continuing through the current month. Because of unavoidable lags in the collection and processing of expenditure data, however, the C-CPI-U is subject to two annual revisions. The most recent final monthly values, for calendar year 2007, became available in February 2009. It is only in this final version of the index that the superlative Törnqvist formula is used in the aggregation of basic indexes. Preliminary monthly index values have been computed using a weighted geometric mean formula with the weights corresponding to the same base period used in the CPI-U.

The availability of eight calendar years of final C-CPI-U data and seven years of preliminary-to-final revisions, along with expenditure data from four consecutive two-year CPI-U base periods, give us an opportunity to analyze both these BLS methodological changes. Among the issues that could be addressed are: how similar the

¹ See Bureau of Labor Statistics (1999).

² The statements in this paragraph apply also to the CPI for Urban Wage Earners and Clerical Workers (CPI-W). The CPI-U and CPI-W differ only in the sampled consumer populations used to derive their expenditure weights.

³ For more details on the C-CPI-U, see Cage, Greenlees, and Jackman (2003).

long-run movements in the monthly-chained C-CPI-U are to those of an annually-chained Törnqvist index; whether the evidence would support a modification of the geometric mean formula used in the preliminary C-CPI-U; and whether the BLS should consider changing or eliminating the current process of price-updating CPI-U expenditure weights between the base period and the so-called link month in which they are first used in the index.⁴

The issue on which we focus in this paper is whether the BLS can improve upon the current biennial weight update process it uses in the CPI-U. That index remains the headline CPI reported by the media. The CPI-U, and its fellow Lowe index the CPI-W, are also the BLS indexes widely used for government tax and benefit programs and in private-sector contracts, largely because unlike the C-CPI-U they are not subject to revision. Therefore, although the BLS and many economists believe that the C-CPI-U is a closer approximation to a COLI, improvements to the CPI-U are of the utmost importance.

The primary potential alternatives to the current weighting process are updating at an annual or other increased frequency and/or reducing the time span of the expenditure base periods to one year or some other length. The question is whether such changes, by enhancing the timeliness of the CPI-U's expenditure weights, would have the effect of bringing the index's movements closer to those of the C-CPI-U.

We begin with a background discussion in Section II, and follow it in Section III by estimating superlative and cost-of-living indexes for each annual and biennial period from 1999 through 2007, and comparing those index changes to those in the official BLS indexes. We also estimate indexes based on the constant-elasticity-of-substitution (CES) consumer demand model, obtaining in this way a series of simple summary statistics for the extent of consumer substitution behavior implied by our expenditure and price data for those years. Of special interest is whether that substitution behavior is statistically significantly different from the behavioral models implicitly underlying the Lowe and geometric mean formulas.

In Section IV of the paper, we simulate various operationally feasible weight update formulas and compare the resulting indexes to the C-CPI-U. We examine whether the Lowe index moves closer to the superlative if it employs more timely base expenditure weights. We also ask whether using a shorter base period causes any instability or drift in the Lowe index, or whether employing sequential but overlapping base periods has any apparent ill effects. Section V presents our conclusions and recommendations for further research.

II. Background and previous research

The central empirical issue of our paper is the degree to which the Lowe-type weighting processes in the CPI-U index can be enhanced so as to bring the CPI-U's movements closer to those of the superlative-type C-CPI-U, without undesirable sacrifices in volatility or infeasible changes in operational procedures.

⁴ As discussed further below, eliminating the weight-updating process would yield a Young index.

As discussed in the international CPI manual,⁵ a Lowe price index is distinguished from the familiar conceptual Laspeyres index by the separation of the weight reference (or expenditure base) period and price reference (or link) period.⁶ That is, with q_{0k} and s_{0k} indicating the period-0 quantity and expenditure share, respectively, of the k -th item, and p_{tk} denoting its price in period t , the Laspeyres index between period 0 and period t can be written as

$$IX_{t,0} = \frac{\sum_k q_{0k} p_{tk}}{\sum_k q_{0k} p_{0k}} = \sum_k s_{0k} (p_{tk} / p_{0k})$$

Construction of the Lowe index recognizes the operational lag in collecting and compiling expenditure shares, which then necessitates a lag between the expenditure base period b and the price reference period 0 in which those weights are introduced into the index. Writing the Lowe index in share form requires that those shares be “price-updated” to the link period. The price-updated share for the k -th item is given by

$$s_{0,bk}^{Lo} = \frac{s_{bk} p_{0k} / p_{bk}}{\sum_j s_{bj} p_{0j} / p_{bj}}$$

These price-updated shares can be thought of as the shares that would be observed in period 0 if there were no changes in relative quantities purchased between periods b and 0. Using the price-updated shares, the Lowe index between periods 0 and t is

$$\begin{aligned} IX_{t,0,b}^{Lo} &= \sum_k s_{0,bk}^{Lo} p_{tk} / p_{0k} \\ &= \frac{\sum_k q_{bk} p_{tk}}{\sum_k q_{bk} p_{0k}} \end{aligned}$$

Note that the Lowe index can be written as the ratio of two Laspeyres indexes, each with prices and quantities from period b in the denominator. In the same way, the period-to-period changes in a Laspeyres index will have the Lowe form.

As in most countries, the CPI-U is constructed at two levels. Basic indexes for most individual item/area categories (for example, Apples in Chicago) are computed using a weighted geometric mean formula. The basic indexes are then aggregated to form higher-level indexes using a Lowe formula.⁷ As noted earlier, at present the CPI employs the period 2005-2006 as its expenditure base period b and the period December 2007 as its link month 0.

It is well known that in the presence of consumer price-taking and utility-maximizing behavior the Laspeyres index provides an upper bound to the true cost-of-living index. That bounding result does not apply to the Lowe index. Research suggests, however, that

⁵ International Labour Office (2004) paragraphs 1.17-1.23.

⁶ The weight reference and price reference periods should not be confused with the index reference period, at which the index is set to 100.

⁷ The same basic indexes are used in the CPI-U and the C-CPI-U.

under many reasonable conditions a Lowe index will tend to have an upward bias relative to the Laspeyres index and hence also to a target superlative or cost-of-living index.⁸ Consistent with that research, we will show in Section III below that increases in the CPI-U have exceeded those of the superlative C-CPI-U in recent years.

The BLS uses a Continuing Consumer Expenditure (CE) Survey to provide expenditure weights for the CPI. The CE survey is carried out for the BLS by the US Census Bureau. Collection and processing of the annual data consumes the greater part of a year, meaning that expenditure data introduced into the CPI at the beginning of year t can pertain to year $t-2$ at the latest. On the other hand, the quarterly rotating panel design of the CE makes it possible, in principle, to use the final quarter of year $t-2$ as the expenditure base period. Using such a timely but short base period could, of course, have unattractive consequences, especially when the weights are drawn from a household survey rather than national accounts data. As noted in the international CPI manual,⁹

“Some countries prefer to use expenditure weights that are the average rates of expenditure over periods of two or three years in order to reduce “noise” caused by errors of estimation (the expenditure surveys are only samples) or erratic consumer behaviour over short periods of time resulting from events such as booms or recessions, stock market fluctuations, oil shocks, or natural or other disasters.”

Recognized international best practice calls only for revising expenditure weights at least every five years, and more frequently if there is high inflation or evidence of rapid changes in consumption patterns.¹⁰ The 1998 BLS decision to move from a roughly 10-year revision cycle to a two-year cycle reflected caution given the lack of evidence on the potential impacts of employing an even shorter expenditure base period or even more frequent revisions.¹¹ At that time there was also little empirical evidence to demonstrate an impact of the frequency of weight revisions on the rate of growth of the CPI.¹² These are the issues we examine in Section III and IV below.

The importance of the price-updating of expenditure weights increases with the distance between the center of a Lowe index’s weight reference period and its price reference period. This distance is currently two years in the CPI-U; it was 3 ½ years prior to processing enhancements that took effect in 2002. Even at two years, the impact of price-updating can be very noticeable for products with relatively strong price trends.

Television prices, for example, have been decreasing steadily in the United States, in absolute as well as relative terms. During the 2001-2002 expenditure base period, televisions accounted for 0.21 percent of total expenditures. After price updating to December 2003 for the 2004 weight revision, however, their share fell to 0.16 percent. This pattern has been consistent over time: at the last CPI-U weight revision in January 2008, the new CPI relative importance for televisions was 0.17 percent, although their share in the 2005-2006 weight reference period was 0.28 percent.

⁸ See, for example, ILO (2004), paragraphs 15.43-15.45, and Balk and Diewert (2003).

⁹ ILO (2004) paragraph 1.197.

¹⁰ See International Conference of Labor Statisticians (2003), paragraph 26.

¹¹ Bureau of Labor Statistics (1999).

¹² See Greenlees (1998).

Such effects might argue for an alternative, such as the Young index, that does not involve price-updating of weights. The Young formula can be expressed in share form as

$$IX_{t,0,b}^Y = \sum_k s_{bk} P_{tk} / P_{0k}$$

The Young index thus seems to combine two contradictory assumptions. The shares applied to the price reference period are the same as those in the weight reference period, consistent with an assumption of a unitary consumption elasticity and a geometric mean index formula. Like the Laspeyres and Lowe indexes, on the other hand, the Young index can be written as an arithmetic mean of long-term price relatives, which is consistent with a zero consumption elasticity assumption. Although the Young formula also has been criticized for violating desirable axioms for price indexes, it has a potential advantage in that it may yield a closer approximation to a superlative index. It is used in some national CPIs, and two recent studies present empirical comparisons of Young indexes to Lowe, superlative, and other alternative indexes.¹³ It will be one of the indexes we consider in Section IV. The 2003 resolution of the International Conference of Labor Statisticians allows for the option of not price-updating, saying¹⁴:

“Where the weight reference period differs significantly from the price reference period, the weights should be price updated to take account of price changes between the weights reference period and price reference period. Where it is likely that price updated weights are less representative of the consumption pattern in the price reference period this procedure may be omitted.”

Hansen (2006, p. 8) sets forth this position clearly. He argues that the preferred choice between a Lowe and Young index is the one that most closely approximates an ideal index, by employing weights that are the best estimates of the expenditure shares between the current and price-reference periods—that is, between periods 0 and t in the equations above:

“Whether the original or the price-updated expenditure weights are the best estimates of the average expenditure shares depends on the households’ response to change in the relative prices. ... If the households are most likely to hold fixed expenditure shares, i.e. the price elasticity of demand is around one, the Young index is the best estimate. If the households hold fixed quantities, indicating zero price elasticity of demand, the Lowe index is the best estimate.”

The final formulas that we will discuss here are based on the constant-elasticity-of-substitution or CES formula. In the consumer price index context, if preferences take the CES form the resulting cost-of-living index is often referred to as the Lloyd-Moulton index,¹⁵ and in share form it is given by:

$$IX_{t,0}^{LM} = \left[\sum_k s_{0k} (P_{tk} / P_{0k})^{1-\eta} \right]^{1/(1-\eta)}$$

¹³ See Hansen (2007) and Pike (2007), which use CPI data from Denmark and New Zealand, respectively.

¹⁴ ICLS (2003), paragraph 25.

¹⁵ See ILO (2004), paragraphs 17.61-17.64. If $\eta=0$ the Lloyd-Moulton index reduces to the Laspeyres form, and it takes the geometric mean (Cobb-Douglas) form if $\eta=1$.

Because of its economy of parameters the CES or Lloyd-Moulton form has been used frequently in price index studies, such as Feenstra (1994), Shapiro and Wilcox (1997), Balk (1999), and Broda and Weinstein (2007). Cage *et al.* (2007) fitted Lloyd-Moulton indexes to the C-CPI-U and demonstrated that for different time periods and levels of aggregation the optimal fit was consistently obtained by using CES substitution parameters between 0 and 1, that is, between corresponding Lowe and geometric mean indexes. For this paper we take a different approach; we make use of the fact that the Sato-Vartia index is exact for the CES preference system.¹⁶ That is, under the (strong) assumption that preferences do take the CES form, and given the availability of both current and base-period expenditure shares, the cost-of-living index can be calculated without knowing the substitution parameter η by computing the Sato-Vartia formula:

$$\ln IX_{t,0}^{SV} = \sum_k w_{t,0k} \ln(p_{tk} / p_{0k})$$

The above formula is similar to the Törnqvist except that the weights are the log-means of the reference and comparison period shares, defined as $(s_{tk} - s_{0k}) / (\ln s_{tk} - \ln s_{0k})$, normalized to sum to unity over all cells k . We also employ a result by Feenstra and Reinsdorf (2003) that shows how the substitution parameter can be conveniently estimated consistent with the Sato-Vartia index.

In this paper we use movements in superlative indexes as the standard against which we will judge alternative operational index formulas. The theory and advantages of superlative indexes were developed by Diewert (1976) and are discussed at length in the international CPI manual.¹⁷ Sweden produces an approximation to a superlative CPI,¹⁸ and other countries have examined superlative CPI series computed retrospectively.

Empirical analysis of simulated US superlative CPI series, and comparison of these to the CPI-U, goes back to Aizcorbe and Jackman (1993). Design of the C-CPI-U as a monthly chained, Törnqvist index is explained in Cage *et al.* (2003). Other BLS studies of the final C-CPI-U include Shoemaker (2005) and Zadrozny (2008), who examines alternatives to the geometric mean formula for the preliminary C-CPI-U index values.

III. Analysis of Substitution Behavior in BLS Expenditure Data

In this section we estimate annual and biennial price indexes using BLS data and several different price index formulas. The expenditure data used for our analyses are taken from the CE Survey, which as noted above provides all weights for the CPI-U and C-CPI-U. Our data are drawn from the CPI expenditure weight database and thus are computed and classified in the same way as for the official indexes. In each period we have expenditure totals for 211 item categories and 38 areas, for a total of 8,018 cells.

It is worth noting that there are very wide cross-sectional variations in the cell weights. Summed over all areas, the largest of the 211 item categories, Owners' Equivalent Rent of Primary Residence, had a relative importance in the CPI-U of about 24.4 percent in December 2008.¹⁹ Other examples with large weights are Rent of Primary Residence

¹⁶ See, for example, Sato (1976).

¹⁷ ILO (2004), for example in paragraphs 1.97-1.101.

¹⁸ See Ribe (2005).

¹⁹ The percentages here are updated from the weight reference period.

(6.0 percent), New Vehicles (4.5 percent), and Gasoline (3.0 percent). At the other end of the scale, there are numerous item categories with weights under 0.05 percent, such as Flour and Prepared Flour Mixes; Frozen Noncarbonated Juices and Drinks; Watches; and Musical Instruments and Accessories. The 38 area weights also differ greatly.²⁰

We computed five different indexes between each of the adjacent years from 1999 through 2007 and between each adjacent biennial CPI-U base period from 1999-2000 through 2005-2006. Note that we present these indexes for analysis of demand shifts, not as operational alternatives. They are only feasible retrospectively, not in “real time,” because in each case there is no lag between the price reference period and the end of the weight reference period. Our results are shown in Table 1, along with the log-changes in the published annual-average values of the CPI-U and the C-CPI-U.

These results reveal several relationships, most of which are consistent with expectations. First, the two annual superlative series, using the well-known Fisher Ideal and Törnqvist index formulas, are quite close together in every year but one, 2000, although the year-to-year changes in the Törnqvist are always slightly higher. The apparent divergence in the first year is entirely due to the greater sensitivity of the Fisher index to extreme data points. One item-area index fell by more than 99 percent between 1999 and 2000, while its associated annual expenditures increased slightly. If we recode that index change to zero, the log-changes for the Fisher and Törnqvist indexes in 2000 increase to a nearly identical 0.0287 and 0.0288, respectively. (Similarly, recoding of that extreme observation would reduce the Fisher-Törnqvist difference in the first line of the biennial panel in Table 1 from 0.0026 to 0.0006.)

Second, the table shows that the Sato-Vartia changes based on the CES assumption are slightly higher than the Törnqvist changes except in one year, 2005, when the latter’s log-change exceeds the former’s by approximately 0.00001. This closeness of the Sato-Vartia to the superlatives provides support for our use of the CES form to obtain a summary consumer substitution statistic for BLS data.

Not surprisingly, in each year the Fisher, Törnqvist, and Sato-Vartia index changes are well within the Paasche and Laspeyres bounds. (The Fisher changes are identically the average of the Paasche and Laspeyres changes.) In the last row of the table we show the results of aggregating the eight annual log-changes to construct annually-chained index series. Over the whole period the chain Laspeyres index rises about 2.9 percentage points more than the chain Paasche. Meanwhile, the eight-year growth of our chain Törnqvist index is about 0.1 percentage point less than that of the Sato-Vartia index and 0.5 percentage point more (0.4 in 2000 alone) than that of the Fisher. On a per-year basis, the Laspeyres index rises about 0.18 percentage point per year more rapidly, and the Paasche about 0.18 percentage point more slowly, than the Fisher.

Turning to a comparison of our estimated indexes with the official BLS series, we first note that the published CPI-U has risen much more rapidly—about 0.2 percentage point per year—than the chain Laspeyres index. The differences are especially wide in 2000 and 2001, when the CPI-U was still employing relatively old expenditure weights from

²⁰ CPI-U relative importances for 2008 are on the BLS website at <https://www.bls.gov/cpi/cpiri2008.pdf>.

the 1993-1995 period.²¹ Even in the later years, however, the log-change in the CPI-U always exceeds that of our chain Laspeyres series, which is computed identically except for the expenditure base period. These results imply that using more recent expenditure weights would typically have a downward effect on the index. For example, in 2007 the 0.0281 log-change in the CPI-U was based on 2003-2004 weights, whereas our 0.0267 Laspeyres index change is based on 2006 weights, which were not available for use at the BLS until 2008.

The final comparison in Table 1 is between the C-CPI-U published annual-average changes and those of our simulated superlative series. These differences are perhaps wider than one would expect, given that the Chain CPI uses a Törnqvist superlative formula. In two years, 2005 and 2006, the C-CPI-U log-change is lower even than our Paasche change. The differences from the published and simulated Törnqvist indexes likely result from the fact that the former is a monthly- rather than annually-chained series. Moreover, due to volatile fuel prices the years 2005 and 2006 were both characterized by extremely sharp upward movements in the CPI during the summer months, followed by equally dramatic decreases in autumn. Such intra-year volatility would presumably increase the impact of the C-CPI-U's monthly chaining process. Nevertheless, over the seven years 2001-2007, the aggregate increase in the C-CPI-U is much closer to our annual Törnqvist than to either the Laspeyres or the Paasche.²²

We next turn to examining the results of estimating the CES η parameter using the Feenstra/Reinsdorf regression approach. For example, we used price and share data from 1999 and 2000, weighted in proportion to the log-mean of the shares, to estimate an equation of the form

$$d \log s = -0.00780 + 0.27294 d \log p + e$$

Feenstra and Reinsdorf show that the coefficient on $d \log p$ is an estimate of $1-\eta$, while the constant term equals $\eta-1$ times the Sato-Vartia log-change between 1999 and 2000 (here, $-.27294 \times .02857 = -.00780$). Table 2 presents the estimates of η along with the standard error of the $1-\eta$ coefficient estimate for each annual and biennial comparison.

The annual results show a remarkable similarity from year to year, except for 2007. The values of η vary only within a range of about 0.52 to 0.73 from 2000 to 2006. This range narrows even further if we recode the extreme price change in 2000 mentioned above. When that change is recoded to zero, the estimated η for that year falls from 0.727 to 0.637, and the 2000-2006 range is only from 0.52 to 0.66. In 2007, however, the regression coefficient falls to only 0.065 and is insignificantly different from zero (i.e., η insignificantly different from unity). Using a pooled regression we constructed an F test that rejected the null hypothesis of equality of the η parameters across all years.

²¹ The CPI-U and C-CPI-U log-changes in Table 1 are computed from published index values, which until January 2007 were rounded to one decimal place. Consequently, the comparisons of the log-changes to our simulated indexes, which are derived from full-precision calculations, will be affected by rounding; see Williams (2006).

²² Because publication of the C-CPI-U began in January 2000, no annual-average index data are available for 1999. The C-CPI-U data for 2008 are not yet final.

We examined the 2007 results but found no evidence of a higher variance of price or share changes, of a predominant role of one item category, or of a greater frequency of influential observations, compared to other years. Pending further analysis, therefore, we tentatively conclude only that the average consumer substitution elasticity varies from year to year and that occasional outlier years will sometimes occur.

The three biennial estimates of η are about as widely spaced as the annual estimates covering the corresponding time periods, but have smaller standard errors. (The first biennial estimate falls from 0.776 to 0.740 when the outlier is recoded.) Both the annual and biennial estimates strongly reject the possibility of a zero substitution elasticity. None of our 11 regressions yields an elasticity less than 0.5. Zero elasticity is, of course, an implicit assumption justifying the Lowe index's formula both for updating expenditure weights and for calculating period-to-period price change.

Our primary overall conclusion from the results of these index simulations and substitution parameter estimates is that consumers vary their purchase quantities significantly, albeit inelastically on average, in response to relative price changes across the basic indexes of the CPI. Although this has long been an argument used against Laspeyres or Lowe indexes like the CPI-U, it also argues for the consideration of other BLS methodological changes that would stop short of abandoning the fixed-basket nature of the CPI-U. In particular, the evidence of substitution behavior supports research on accelerated expenditure weight updates in the CPI-U. It also suggests some potential value in alternative methods of updating expenditure weights between the base period and link month. Finally, the evidence that substitution is non-zero but inelastic would provide support for analysis of whether an alternative to the geometric mean formula would improve the accuracy of the preliminary C-CPI-U values.

IV. Comparisons of Update Simulations

In this section we present some exploratory results of simulating alternative monthly fixed-weight indexes using CPI data for 2002-2007. We consider different weight-updating rules (Lowe and Young) and different re-weighting frequencies (one-year and two-year). Each simulated index is compared to the official Lowe CPI-U and to the final values of the chained Törnqvist C-CPI-U.

We begin, however, with a very simple examination of the correlations among successive annual price changes at the elementary index level. Several authors, including Balk and Diewert (2003), Hansen (2006), and the authors of ILO (2004), have discussed the factors determining the relative rates of index growth of Lowe, Young, and superlative indexes. For example, the international CPI manual points out that a Lowe index will exceed a Laspeyres index whenever (1) there are persistent and divergent trends in the underlying individual component indexes, and (2) consumers tend to substitute away from components with increasing relative prices. In that case the weight updating process in the Lowe index will give a higher weight than the Laspeyres to the components with persistently increasing relative prices.²³ A Young index will tend to be higher than the Laspeyres when there are persistent trends in prices and consumer substitution is elastic. When consumer responses are inelastic, the Young index is likely to fall below the

²³ For example, see ILO (2004), paragraph 15.45 and Appendix 15.2.

Laspeyres.²⁴ Finally, we know that the Laspeyres will exceed a superlative index whenever consumers substitute away from goods and services with increasing relative prices after the price reference period.

We have established in Section III that basic index changes are negatively correlated with quantity changes in our CPI data, and positively correlated with expenditure shares, implying inelastic demand. We also found that the elasticities are closer to unity than to zero in absolute value. A question remains, however, whether there are systematic and divergent trends in relative prices in our data.

In order to answer that question at a simple but illustrative level, we first regressed each year's annual basic index relatives on the prior year's relatives. The regressions were weighted by the prior-year expenditures. For this exercise we confined our attention to index years beginning with 2002, because that was the first year in which the biennial revision process was applied to the CPI-U. Thus, for example, we regressed the December 2001-to-December 2002 12-month price relatives for the 8,018 CPI basic indexes against the corresponding 2000-2001 relatives, weighted by the 2001 expenditure shares. The results of this exercise are shown in the first column of Table 3. Of the six years shown, four had a positive and highly significant correlation between the index relatives in the current and prior year. One of the other two years had no significant correlation. The years 2001 and 2002, however, exhibit a significantly negative correlation, with the 2002 relative decreasing by almost 25 percent of any increase in the 2001 relative.

The second column of Table 3 presents somewhat more specific evidence on the role of weight updating. It measures the correlations between the basic index changes during three CPI weight-update periods and the corresponding changes during the years during which those weights are used in the CPI-U. For example, the last lines of the table show that the index relatives between the 2003-2004 average (expenditure reference period) index levels and the December 2005 (price reference period) index levels were strongly and positively correlated with the December-to-December index relatives during 2007 but insignificantly correlated with the 2006 December-to-December relatives. That would imply that the CPI-U's Lowe index price updating, which increases the relative weights of the items that grew in relative price during the updating period, would have little effect on overall index growth in 2006 but a comparatively large upward effect in 2007, as compared to a Laspeyres or Young index.

For the other years examined, we find large positive correlations for index year 2003 and 2005, with a smaller positive correlation for 2004 and a significant but relatively small negative correlation in 2002. Thus, on balance we would predict that a Young index would grow more slowly than the CPI-U in our data, except perhaps in 2002 and 2006.

Algebraically deriving comparisons among Lowe indexes with different lag lengths between the expenditure and price reference periods, among Lowe indexes with different expenditure reference period lengths, and between those indexes and their corresponding Young indexes, would be more tedious than instructive, we believe. Instead, we now turn to simulations of feasible fixed-weight indexes.

²⁴ ILO (2004), paragraphs 15.56-15.57.

Five indexes are compared in Table 4. The first is a biennially chained Lowe index with two-year weight reference periods—that is, the CPI-U.²⁵ The second index also uses 2-year weight reference periods, but the index is revised each year by introducing an overlapping two-year set of weights. For example, the “rolling” index introduces 2002-2003 weights in January 2005, whereas the CPI-U continued to use 2001-2002 weights. In January 2006, both series introduce 2003-2004 weights. The third Lowe index is annually chained with one-year weight reference periods—e.g., 2004 weights are introduced in January 2006.

Table 4 also presents the C-CPI-U along with a Young index for comparison to the Lowe indexes. The Young index uses the same expenditure base periods as the CPI-U, and thus differs from the first index in the table only by not updating weights to the price reference month. Note that the use of more timely base periods would be expected to lead to higher index changes, the opposite of the case for Lowe indexes. This occurs because under inelastic consumer demand behavior the inter-temporal growth in expenditure shares for goods with rising prices will have an effect similar, although weaker, than the Lowe weight-updating process.

The relationships in the table can be summed up as follows:

- Relative to each other, the Lowe indexes display slightly lower index movements as their base periods become more timely. By construction, the first two indexes change by identical amounts in even-numbered years, but in the odd-numbered years the CPI-U change is always smaller than the change in the index that uses overlapping two-year base periods. The Lowe index revised annually with one-year base periods increases by less than the rolling two-year index in four years out of six.
- Examination of monthly and annual index changes in the data underlying Table 4 gives no indication that the use of overlapping or one-year weight reference periods leads to more volatile indexes. This conclusion is tempered, however, by the fact that we have only examined all-items indexes. Lower-level sub-aggregates could be more sensitive.
- The Young index increases by less than any of the three Lowe indexes in four of the six years. The exceptions are 2002 and 2006, which is not surprising given the results about price correlations that we presented earlier in this section. The differences between the changes in the biennial Lowe index in the first column and the changes in the biennial Young are always greater in the odd-numbered years, when the weight reference periods are less timely.
- None of the differences between the fixed-base indexes are nearly as large as the gap between them and the C-CPI-U. Overall, after seven years, the difference between the CPI-U and Young index levels is 0.64 percentage point, while the Young index exceeds the C-CPI-U index level by 1.46 percentage point. Figure 1 graphically demonstrates the clustering of the fixed-base indexes and the distance between them and the superlative.

²⁵ Index levels and percent changes will differ from the published CPI-U and C-CPI-U due to the different index reference periods and different rounding procedures.

We can contrast the last conclusion above with the results of simulations in which we relax our one-year lower limit on the processing lag between the end of the weight reference period and the link month or price reference period. Figure 2 is similar to Figure 1 except that it includes two additional Lowe indexes: one is an index revised semi-annually by introducing weights drawn from a six-month weight reference period ending six months prior to the price reference month. The other is a corresponding series revised each quarter, using a three-month weight reference period ending three months prior to the price reference month. These two new series approach the C-CPI-U much more closely than the series in Figure 1. Perhaps surprisingly, they also are not noticeably more volatile than the other series despite their short weight reference periods and Lowe index formula.

Neither of the added series in Figure 2 is operationally feasible at the BLS at present. The purpose of the figure is only to suggest that reducing the processing lag could be as or more effective than increasing the frequency of weight revisions if one is attempting to approximate a superlative index with a fixed-base index.

Finally, in Figure 3 we display the CPI-U, C-CPI-U, and biennial Young indexes from Figure 1 and Table 4 along with two other series. The first addition is a Lowe index with weights updated on a hypothetical five-year cycle: in January 2002 (with 1999-2000 weights) and in January 2007 (with 2004-2005 weights). It is identical to the CPI-U until January 2004, when the latter underwent a weight revision, but subsequently the unrevised Lowe exhibits a higher growth rate, ending at a level of 119.50 compared to 118.88 for the CPI-U. This provides additional evidence that less timely weights yield increased growth rates in Lowe indexes.

The last series in Figure 3 is a so-called “Geometric Young” index, which like the usual Young index employs no price-updating of weights but which also uses a geometric mean formula for index calculation. It lies below the other indexes throughout the simulation period, ending at a level of 115.84, compared to 116.78 for the C-CPI-U. This is to be expected given the fact that the Geometric Young implicitly assumes a higher degree of consumer substitution than our superlative indexes indicate.

V. Conclusions and Further Issues

The analyses in this paper have confirmed, once again, that the consumer expenditure data underlying the US CPI imply consumer substitution away from goods and services with rising relative prices. This provides further evidence that Lowe index formulas like the CPI-U yield higher inflation estimates than would a true cost of living index. Using the Feenstra-Reinsdorf approach and data for 1999-2007, we can also conclude that the average CES elasticity is between zero and unity, but consistently closer to the latter.

In addition, we provide evidence on the impact of using more timely weight reference periods. Notably, using simulated monthly indexes for 2002-2007, we find that a Lowe index with “rolling” two-year weight reference periods but annual revision rises by an average of 0.03 percentage point less per year than the CPI-U. Another 0.01 percentage point, on average, is subtracted by imposing annual revision with one-year expenditure base periods. On average, using a Young index formula with the same base periods as the CPI-U subtracts another 0.04 percentage point annually; however, the ordering of the

movements of the Young and Lowe index varies from year to year, due in part to variation in the inter-temporal correlation of basic index changes.

None of these alternative fixed-weight index formulas comes close to eliminating the gap between the CPI-U and the Törnqvist C-CPI-U. This does not mean that those indexes are not worthy of further study. Thus far, we have seen no evidence that the advantages of using more timely weight data are offset by any increase in index volatility or other type of instability. Thus, the indexes simulated here may well offer better representation of current price change (because of the more timely weighting), as well as closer approximation to a cost-of-living index, while remaining operationally feasible (albeit with a potential need for some additional resources because of more frequent revisions).

Increased flexibility in weight revisions, such as the use of quarterly expenditure data, may be possible at the BLS in the near future due to improvements in CE survey processing. Further examination of the weighting issue therefore appears to be a potentially fruitful avenue of research.

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Table 1. Estimated Index Log-changes

Period		Index Formula					C-CPI-U	CPI-U
Base	Current	Paasche	Fisher	Tornqvist	Sato-Vartia	Laspeyres		
1999-2000	2001-2002	0.0349	0.0407	0.0433	0.0435	0.0465	...	0.0523
2001-2002	2003-2004	0.0357	0.0383	0.0384	0.0386	0.0408	0.0392	0.0436
2003-2004	2005-2006	0.0534	0.0565	0.0572	0.0571	0.0596	0.0552	0.0624
Total		0.1240	0.1355	0.1388	0.1391	0.1469	...	0.1583
1999	2000	0.0188	0.0245	0.0285	0.0286	0.0302	...	0.0331
2000	2001	0.0216	0.0229	0.0231	0.0232	0.0241	0.0223	0.0281
2001	2002	0.0115	0.0126	0.0127	0.0128	0.0138	0.0124	0.0157
2002	2003	0.0190	0.0201	0.0201	0.0203	0.0212	0.0206	0.0225
2003	2004	0.0225	0.0238	0.0238	0.0240	0.0250	0.0247	0.0263
2004	2005	0.0288	0.0300	0.0302	0.0302	0.0313	0.0285	0.0333
2005	2006	0.0294	0.0304	0.0304	0.0305	0.0313	0.0286	0.0317
2006	2007	0.0239	0.0253	0.0253	0.0255	0.0266	0.0250	0.0281
Total 1999-2007		0.1754	0.1895	0.1942	0.1950	0.2036	...	0.2188

Table 2. Estimated Substitution Parameters

Period		CES substitution parameter	
Base	Current	Estimate	Standard Error
1999-2000	2001-2002	0.776	0.027
2001-2002	2003-2004	0.602	0.030
2003-2004	2005-2006	0.544	0.031
1999	2000	0.727	0.043
2000	2001	0.521	0.051
2001	2002	0.631	0.053
2002	2003	0.583	0.052
2003	2004	0.655	0.054
2004	2005	0.553	0.059
2005	2006	0.650	0.060
2006	2007	0.935	0.062

Table 3. Correlations of Index Relatives

Index Year	Regression Coefficient of Current Year Relative:	
	On Prior Year Index Relative	On Biennial Update Period Relative
2002	-0.246	-0.035
2003	0.111	0.124
2004	0.054	0.057
2005	0.187	0.167
2006	-0.005	0.004
2007	0.163	0.271

Note: Coefficients in bold are not statistically significant.

Table 4. Alternative Simulated Index Values

	Lowe Indexes				
	Biennial Revisions (CPI-U)	Rolling 2-Year Revisions	Annual Revisions	Biennial Young	C-CPI-U
December Index Level					
2001	100.00	100.00	100.00	100.00	100.00
2002	102.40	102.40	102.36	102.44	102.02
2003	104.31	104.25	104.22	104.24	103.75
2004	107.72	107.66	107.64	107.59	107.03
2005	111.37	111.21	111.12	111.07	110.11
2006	114.23	114.07	113.97	113.92	112.61
2007	118.88	118.65	118.52	118.24	116.78
Percent Change					
2002	2.40	2.40	2.36	2.44	2.02
2003	1.87	1.81	1.82	1.76	1.70
2004	3.27	3.27	3.28	3.22	3.15
2005	3.39	3.29	3.24	3.23	2.88
2006	2.57	2.57	2.57	2.57	2.27
2007	4.07	4.02	3.99	3.79	3.70
Annual Average	2.50	2.47	2.46	2.42	2.24

Figure 1. Simulated Indexes With Fixed Lag Lengths

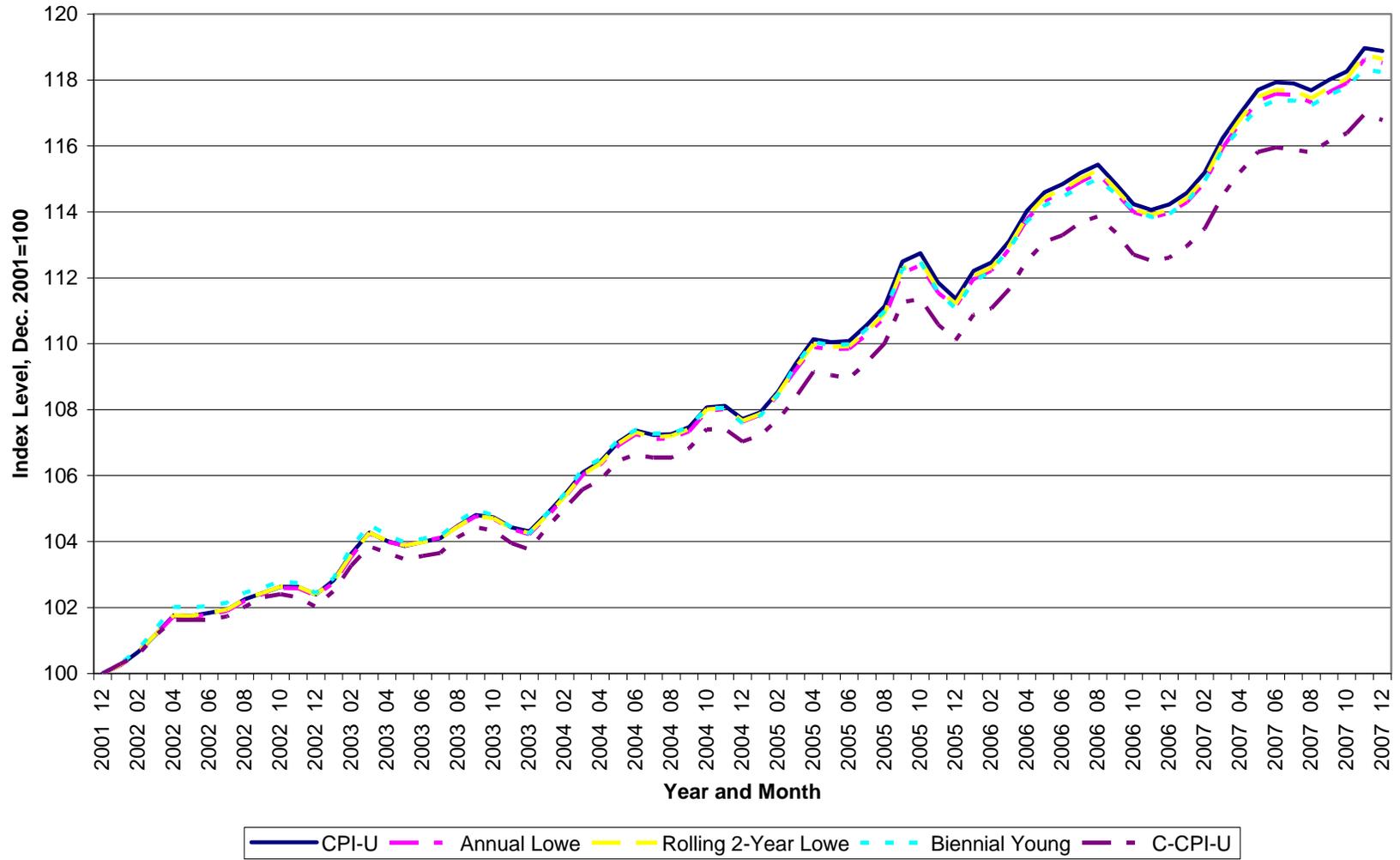


Figure 2: Simulated Index with Varying Lag Lengths

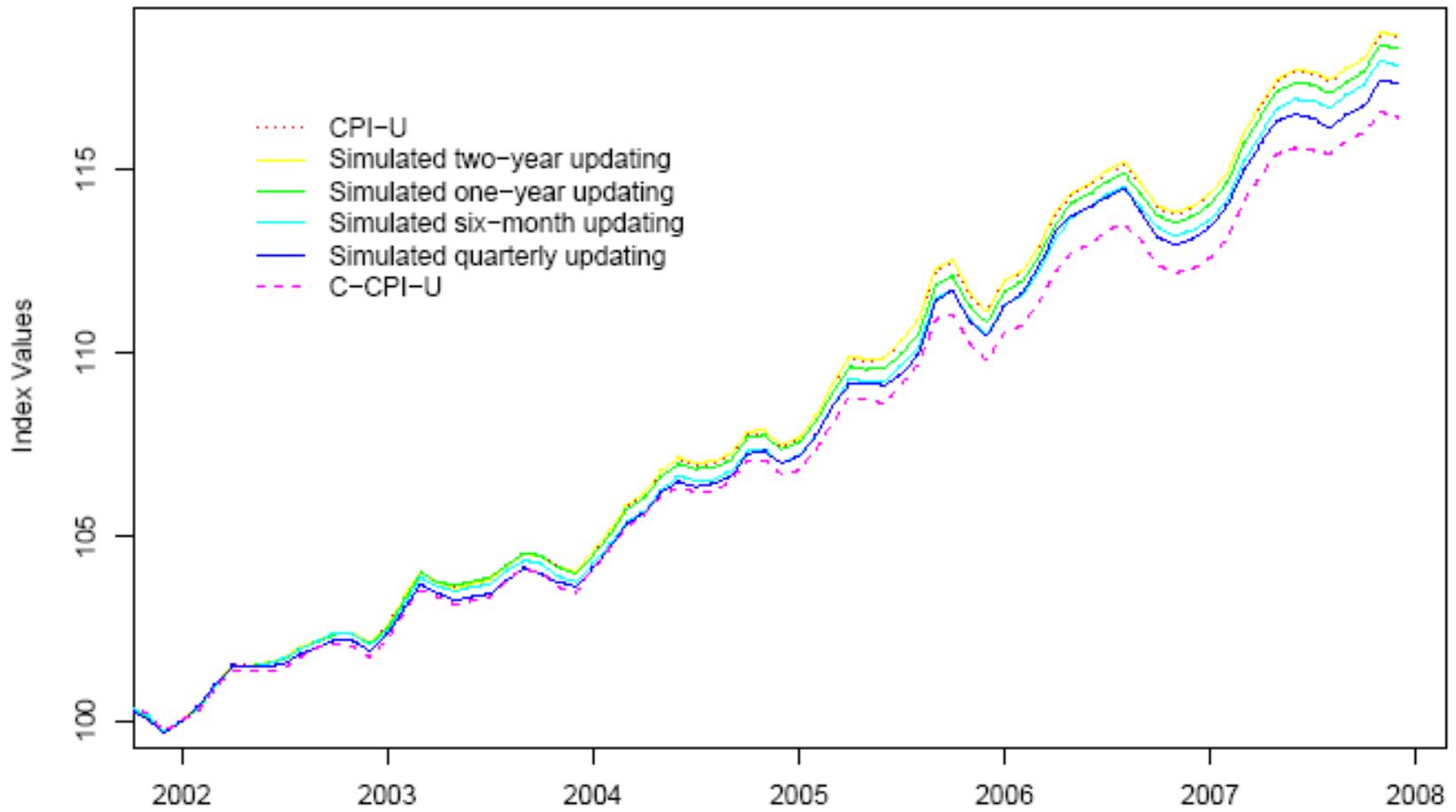


Figure 3. Selected Alternative Simulated Indexes

