Analysis of Divergence between Chained CPI-U and Regular CPI-U for the All_US–All_Items Indexes (2000-2002)

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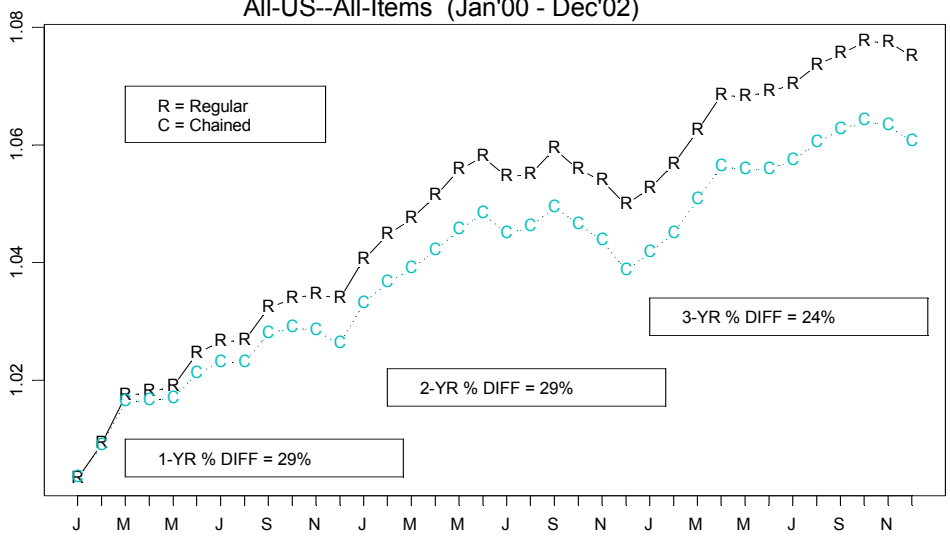
In February, 2004, the BLS calculated and published its third annual set of C-CPI-U indexes --- for the 12 months of 2002. The C-CPI-U (Chained Consumer Price Index – Urban) is calculated and published every year, with a one year lag, using a Tornqvist formula, and its set of weights are updated yearly, so that a unique set of monthly weights are available for both time *t* as well as for time *t-n*. The C-CPI-U can thus be labeled a "superlative" index. By contrast the Regular CPI-U uses weights that are, at a minimum, at least two years old, and uses a combination (Hybrid) of Geomeans and Laspeyres formulas as its final estimator. The set of All_US–All_Items Chained C-CPI-U index results continue to diverge (lower) from Regular CPI-U index results. We investigate the nature of this divergence. We also analyze the two different weight structures, possible response biases, and the standard errors that we calculate for these indexes.

Fig 1. Regular INDEX vs. Chained INDEX
All-US--All-Items (Jan'00 - Dec'02)

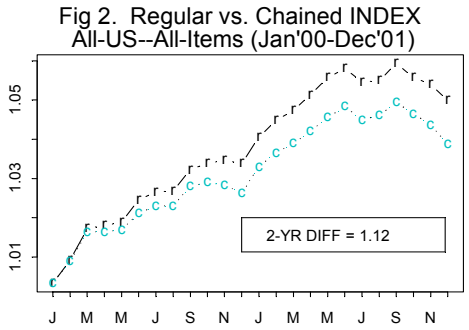


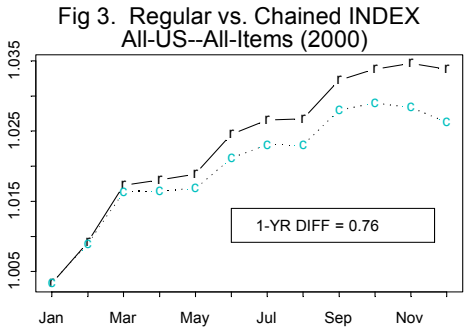
Price Change (PC) = (INDEX – 1) * 100
% DIFF = $(PC_R / PC_C - 1) * 100$

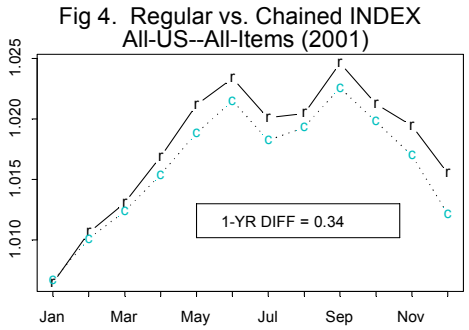
1. Divergence of Regular vs. Chained "Superlative" indexes

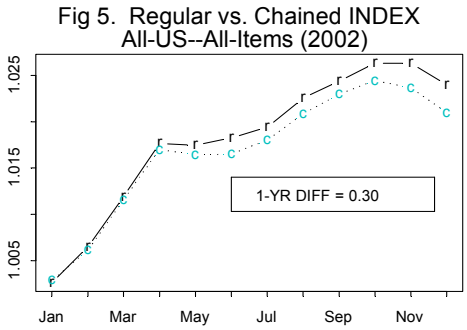
BLS' new Chained Index, in its final and "Superlative" form, is published once a year, in the January-February time frame, with a one-year time lag. For example, the 12 months of Final Chained Indexes for the Year 2002 was published in early 2004. The new Chained Index was launched in January 2000 and we now have three full years of superlative indexes (2000-2002) to look at. In Fig 1 above we compare the Chained Index with BLS' official (Regular) CPI-U for these same 36 months. There is a clear divergence between the two indexes, but the question is not that there is a divergence (with the Chained CPI-U tracking consistently lower than the Regular CPI-U) but whether that divergence is growing and whether it is inappropriately large.

As Fig 1 demonstrates, the divergence does not appear to be growing. The percentage difference in price change stays steady or even declines. But the second issue is salient, as the graphs below illustrate.









$$\text{Price Change DIFF} = PC_R - PC_C$$

Fig 2 demonstrates the 2-year trend between the two indexes, but is not particularly instructive. It is the yearly difference between the respective 12-month price changes that tells the tale. There is an anticipated and even predicted lowering of the All-US–All-Items Index if BLS' new Superlative (Chained) Index is used instead of Regular CPI. The 12-month difference is not expected to be any more than "0.4 percentage points per annum"[1] This estimate of "substitution bias" inherent in the then current CPI-U is from the 1996 Boskin Commission Report. At most a Superlative Index should be exhibiting a lowered index of no more than 0.4 percentage points. However, in 2000, the first year of the Superlative Index, the 1-year difference was

[1] See Boskin, et. al. Final Report on the Advisory Commission to Study the Consumer Price Index. Committee on Finance, United States Senate: S. Prate. 104-72, December 1996, p. 44.

0.76, or nearly *twice* what was estimated to be an *upper* bound of bias inherent in the official (i.e., regular) CPI. In 2001 and even more clearly in 2002 that difference dipped well within appropriate bounds (0.34 for 2001 and 0.30 in 2002). So the over-sized divergence between the two indexes seems to be attributable to something untoward occurring in the 2000 data, either with Regular CPI or with the Superlative Index.

2. Divergences between Regular and Superlative in the 8 Major Groups

The CPI, whether in its Regular or Superlative version, is an aggregation structure, consisting of 211 Item-Strata and 38 Index-Areas (PSUs). The aggregation system builds up from each Item-Stratum–Index-Area combination, up thru higher aggregates until we get to the eight Major Groups, which then aggregate up to the All-US Cities–All-Items Index. So if we breakdown the two indexes (Regular CPI and Superlative CPI) into smaller and smaller sub-aggregate units we may be able to uncover the source of the over-sized differences observed in the earlier indexes. Now these differences may turn out to be evenly spread over the entire structure and so not easily discernible to a data analysis, but such turns out not to be the case. At each sub-aggregate stage of the breakdown the further comparisons reveal clearly where the differences lie.

On the following two pages (see Fig 6 and Fig 7), we graph the comparative sub-aggregate indexes for the All-US Cities by Major Group. In Fig 7, for the year 2002, as expected, there appear to be no discernible divergences at the Major Group level, with the possible exception of Recreation. However, closer analysis of the Recreation graph shows that the apparent difference there is just that: apparent. The range of the Recreation index is so narrow that the small discrepancy between the Regular and Superlative indexes here is actually smaller than for most of the others. Effectively the small (and expected) 0.30 difference between the two 12-month indexes in 2002 is evenly spread across all eight major groups. But returning to Fig 6, which contains the eight Major Group graphs for the two earlier years, we see immediately the two possible sources of out-sized divergences: in Education & Communications and in Recreation. The other six major groups display little or no divergence at all, even after a full two years. We will investigate the two possible sources of divergence separately.

3. Regular vs. Superlative Weight Differences (in Telephone Services)

The largest divergence between the two indexes seems to come from within Education & Communication. Without displaying all the pertinent comparison graphs, as we decompose down to the Item-Stratum level, we will simply state the results at each successive stage. First, we decompose down to Education versus Communication at the All-US Cities level. Here, Education reveals no divergence, with all the divergence occurring in the Communication aggregate. Then within this Communication sub-aggregate there are three Expenditure Classes (ECs): Postage and Delivery Services, Telephone Services and Information Services Other Than Telephone. Of these three ECs only Telephone Services shows any divergence between the two indexes. Telephone Services further decomposes down to its three basis level Item-Strata: Local Telephone Services, Long Distance Services and Cellular Services. Yet here at the lowest Item-Stratum level divergence disappears. All three Item-Strata show little or no divergence between the two indexes --- even though the EC they constitute *does* show clear divergence. It would seem we are stymied in our data analysis search. However, there is one telling anomaly: Local Services indexes are steeply rising over this two year period, while the Cellular Services indexes are steeply declining. Conceivably, if there were to be found a clear discrepancy between the two respective sets of weights between the Regular and Superlative Indexes here, that might explain the anomaly. As it turns out, such is the case.

Fig 6. REGULAR vs. CHAINED INDEXES (Jan '00–Dec '01)

All-US Cities by Major Group

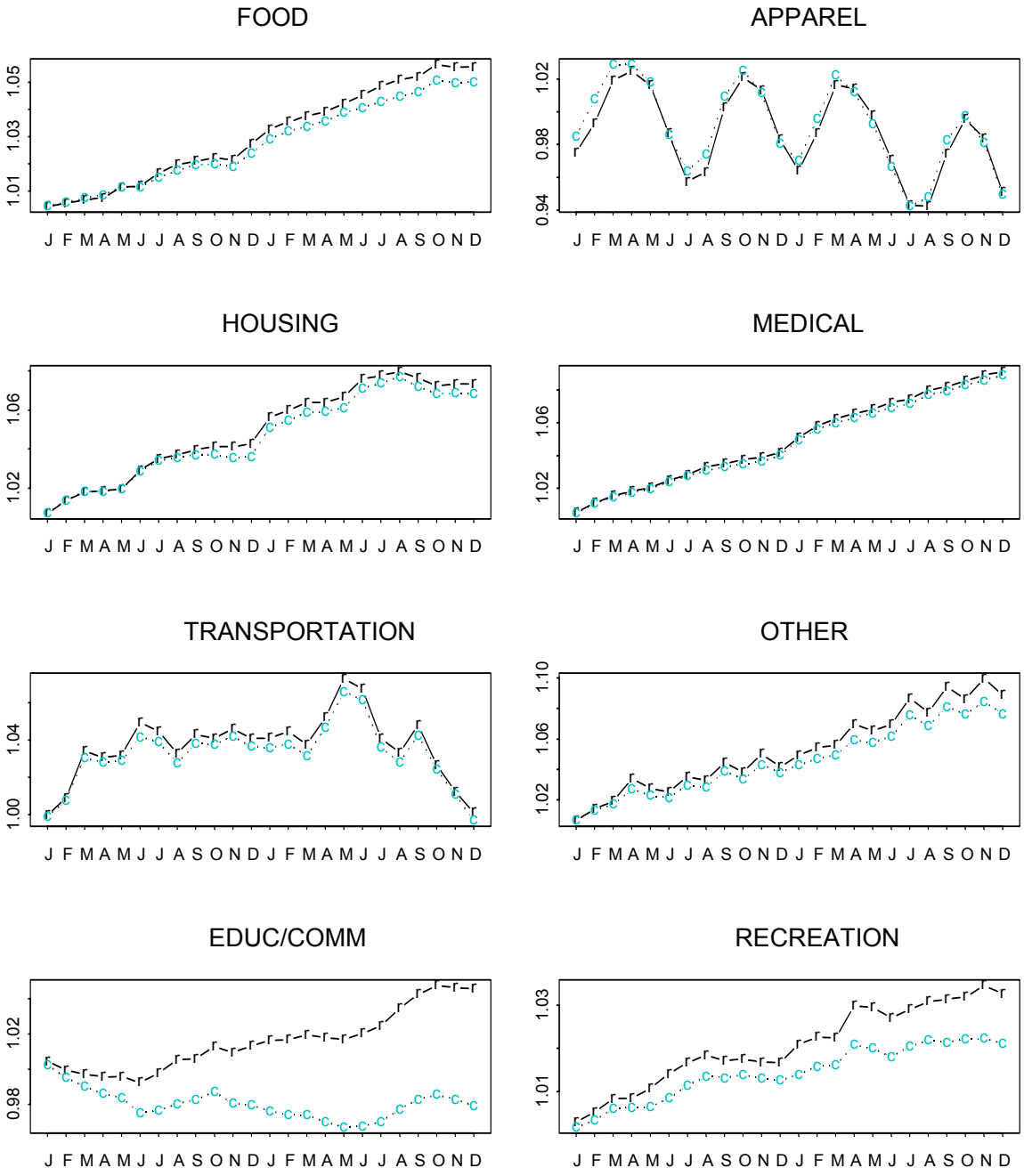
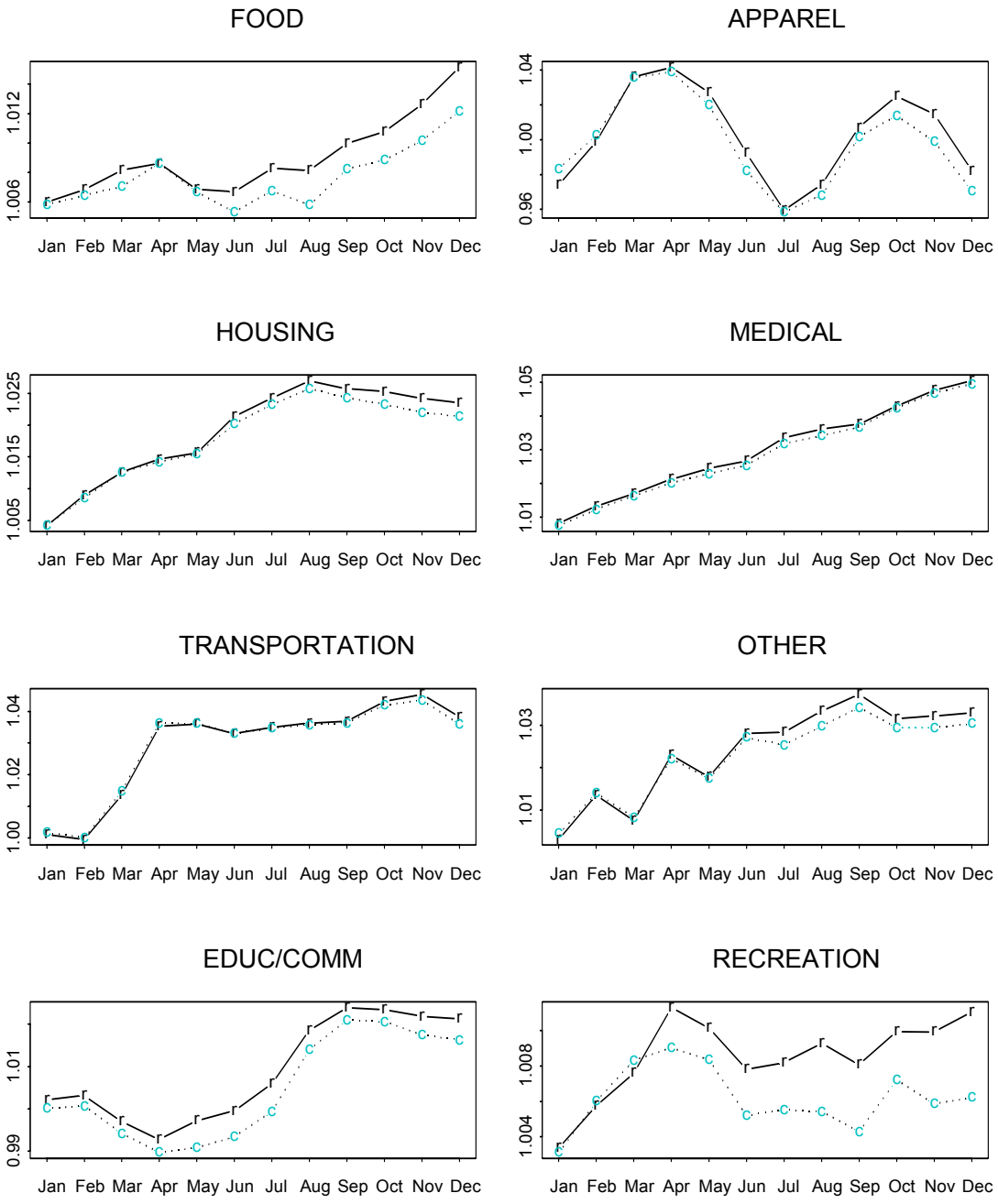


Fig 7. REGULAR vs. CHAINED INDEXES – 2002

All-US Cities by Major Group



Several important characteristics distinguish the Superlative Index from the Regular Index. For one thing, the Superlative Index employs a Superlative Index Formula, the Tornqvist, which, in simplest terms, is the geometric mean of two Geomeans formulas, one at time *t* and the other at time *t*-1.

The Superlative 1-month formula is

$$IX^{T}_{I,A,r[t-1;t]} = \prod_{i\in I, a\in A}\left(\frac{ix^{t}_{i,a,r}}{ix^{t-1}_{i,a,r}}\right)^{\left(\frac{s^{t}_{i,a,r}+s^{t-1}_{i,a,r}}{2}\right)},$$

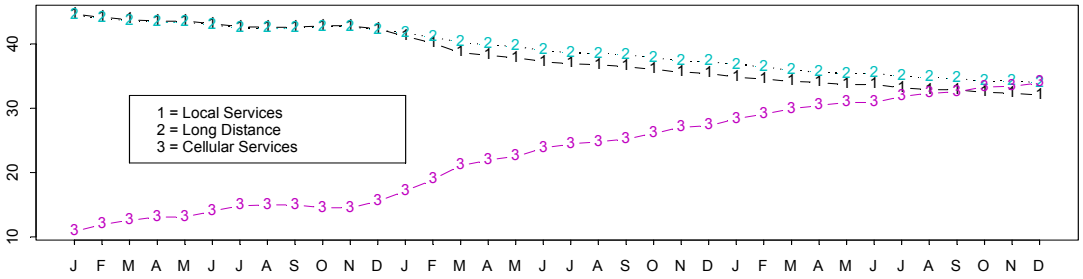
where *ix* is a elementary price index, and *s* is a monthly expenditure share.

The Regular Index uses a Laspeyres formula at this its higher level of calculation. (Note that both Regular and Superlative use the same basic-level price relatives in their respective computations.) But the critical difference between the two indexes is in their respective weights. Both indexes draw from the same pool of Consumer Expenditure weights, but the Regular CPI uses aggregate weights that are anywhere from two to four years old, whereas the Superlative Index uses timely up-to-date weights for both time *t* and time *t*-1. The resultant differences are not usually dramatic, but occasionally, like here, they are.

The percentage weights in this one small EC (Telephone Services) vary quite dramatically across the three years of data we have been investigating. In Fig 8 we see the minimal percentage of the weight within this EC that was being attributed to Cellular Services, particularly in the years 2000-2001, while Local Telephone Services carries nearly half the weight within the EC. These 2000-2001 percentages are reflective of weights from the years 1996-1998. Even when a new set of aggregate weights (from 1999-2000) are introduced and used in the 2002 Regular Indexes, the percentage for Cellular Services is still quite small.

Fig 8. Regular (%) Weights --- Telephone Services (2000-2002)

Fig 9. Chained (%) Weights --- Telephone Services (2000-2002)



Compare these percentages to the ever-growing percentage of Cellular Services (Fig 9) weights from the Superlative system (which are reflecting the most current expenditures for these respective services). The minimal weight given to the steep-declining Cellular Services in the Regular Index resulting in a larger weight going to the steep-rising Local Phone Services has been producing a Regular Index in this sector of the index considerably higher than its Superlative counterpart. While it is difficult to claim that these weight percentage differences account for the entirety of the index discrepancy at the higher levels in the Education & Communication Major Group, they are clearly the main source of this difference.

4. Divergence due to Response Bias

The second Major Group which displays a clear divergence between its Regular and Superlative indexes is Recreation (see Fig 6 again). While this difference (0.1 percentage points) is only one-sixth as large as the difference obtaining in Education & Communication, it is still over-sized.

Recreation consists of seven Expenditure Classes (ECs). Only one of these ECs shows any divergence: Video and Audio. Moreover, as we continue the narrowing-down process, as we did before in Section 3, we find that only one of the seven Item-Strata (Audio Equipment) within the Video and Audio EC reveals any divergence. Fig 10, on the following page, shows the dramatic divergence that occurs in the Item-Stratum, Audio Equipment, in the April to May period in 2000. The Regular CPI shoots up nearly 0.1 percentage points while the Superlative Index for that same time period actually goes down a little. This is not a large growing divergence but a dramatic one-time surge in the Regular CPI that is not matched in the Superlative.

What happened was that a Hedonic quality adjustment, made on some CD Player prices in San Diego, in that time frame, was allowed in the PRC (Price Relative Calculation) and produced in this one Item-Stratum in the San Diego PSU a 3.24 price relative, a more than *three-fold increase*.

The question needs to be asked as to why this one out-sized price relative in San Diego did not produce the same dramatic bump-up using the Superlative Index as it did in the Regular CPI, since the same price relative went into both calculations. The partial answer is that the Superlative system is able, thanks to its time lag, to smooth the off-cycle indexes (using a geometric averaging, which transforms a 2-month price relative of 3.24 to two 1-month price relatives of 1.8). Moreover, the geometric nature of the Superlative formula seems to smooth the sharp price relative spikes within its calculation better than does the Laspeyres formula that is used in the Regular CPI.

5. Comparative Analysis using Standard Errors

In an earlier paper[2], the Regular and Chained 1-, 2, 6- and 12-month price changes for 2000-2001 were tested for significant differences using simple paired t-tests. The differences were all found to be significant at an $\alpha = .025$ level (in fact at an $\alpha = .01$ level). Standard errors were also calculated for the new Superlative 1-, 2-, 6- and 12-month price changes for 2000 and 2001, and the methodology explained in the paper[3]. Using the same Stratified Random Groups Method, new standard errors for 2002 have been calculated. The results remain in line with the earlier results (average 2000-2001 12-month SEs $\approx$ .11 and average 2002 12-month SEs $\approx$ .12). Since inflation rates are promulgated as per annum results, the most pertinent results are the 12-month standard errors. In Fig 11 below we use these standard errors to construct 95% Confidence Intervals around our Superlative price change results, and then graphically compare those to the Regular CPI results. While the two indexes remain significantly ($\alpha = .025$) apart from each other, the gap is clearly narrowing in the last 12 months, i.e., in 2002.

[2] Shoemaker, Owen J. "Estimation and Comparison of Chained CPI-U Standard Errors with Regular CPI-U Results (2000-2001)". ASA Proceedings, December 2003.

[3] Ibid.

Fig 10. Regular vs. Chained INDEX (2000-2002) All-US—Audio Equipment

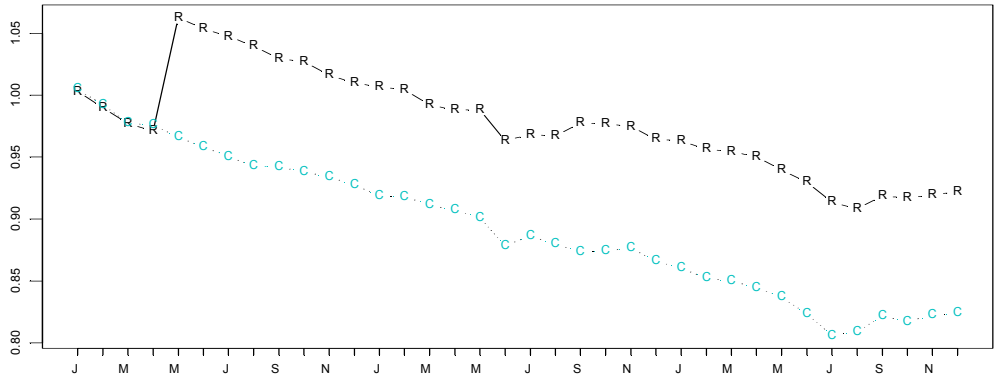
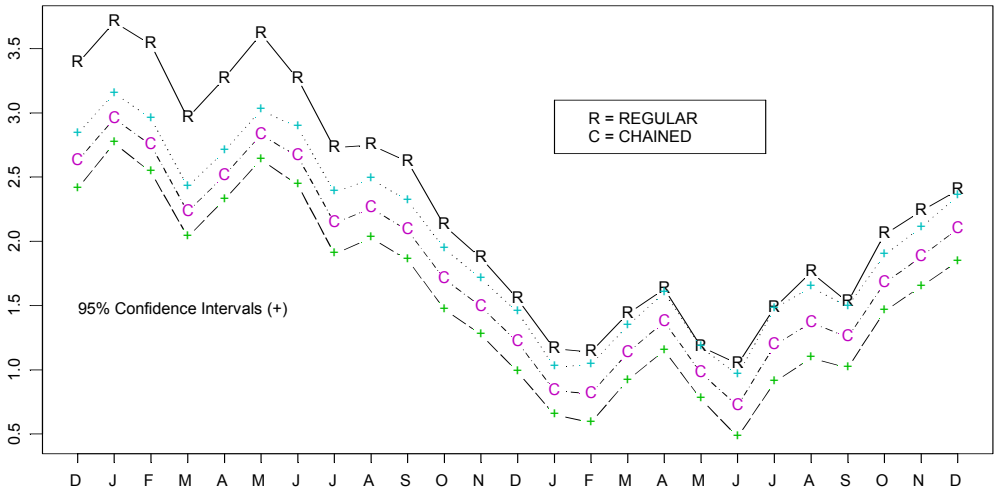


Fig 11. 12-Mon Price Changes (Dec'00--Dec'02)



6. Summary

- The divergence between Regular CPI-U and Chained CPI-U did spike steeply in 2000, but settled down in 2001 and 2002 to a difference well within the 0.4 percentage point upper bound bias expectation.
- Data analysis traced the 2000 spike to Cellular Services (in EDUC/COMM) and Audio Equipment (in RECREATION).
- The newer larger up-to-date Superlative Index weights used in the *de*flating Cellular Services item stratum increased the difference between the Chained and Regular Indexes in 2000 and 2001.
- The Audio Equipment item stratum (from San Diego) that surged in April-May 2000 induced the Regular CPI-U to jump dramatically while inducing the Chained CPI-U not to go up at all.
- Standard errors calculated for the All-US–All-Items Chained Index were used to construct Confidence Intervals for the 12-month Superlative price changes. The Superlative Index price changes continue to be significantly lower than their Regular Index counterparts, but the gap is narrowing.
- Further investigation may show even less significant differences between the two indexes in the smaller sub-aggregations