Is the ECI sensitive to the method of aggregation? an update

A previous Monthly Labor Review *article by the first two authors indicated that the* ECI *is relatively insensitive to the choice of aggregation formula used in its construction; data from 1995 to 2002 show that this is still the case*

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The Employment Cost Index, or ECI, measures changes in employers' cost of compensating workers, controlling for changes in the industrial-occupational composition of jobs. Employers' labor cost has two components: wages and salaries, and the cost of all nonwage benefits, including employer costs for workers' health insurance, employer contributions to workers' pension plans, and employer Social Security contributions.

The ECI is a quarterly index that is computed from survey information on a sample of establishments and jobs, weighted to represent the universe of establishments and occupations in the economy. In computing the national ECI, the quotes reporting compensation for individual jobs must be aggregated into a single index number. The aggregation process involves two key steps: (1) estimating the mean compensation for each of the various classes of labor defined on the basis of industry and major occupation and (2) weighting the cell means for the different types of labor to obtain a single index number. Using both arithmetic and geometric cell means, Michael K. Lettau, Mark A. Loewenstein, and Aaron Cushner constructed fixed-weight, current-weight, and superlative indexes of the increase in private employers' compensation costs.[1] They found that the estimation of compensation growth is not very sensitive to the choice of index formula employed.

The Consumer Price Index (CPI) faces methodological issues similar to those which confront the ECI—issues discussed at length in the Boskin report.[2] In August 2002, the Bureau of Labor Statistics began publishing a new index called the Chained Consumer Index for All Urban Consumers (C-CPI-U). This index employs a Törnquist formula and uses expenditure data in adjacent periods to eliminate substitution bias across expenditure categories. An experimental version of the index for the first half of the 1990s suggests that it grew annually by 0.2 percentage point less, on average, than the CPI-U. This difference has increased significantly in the years since then.[3]

In their analysis of the ECI, Lettau, Loewenstein, and Cushner reported on indexes from September 1981 to December 1994.[4] There now are 6½ years of additional data. In light of the continued interest in the CPI methodology, it is useful to update the original study.

Quarterly changes in indexes

The ECI is calculated as the weighted sum of the compensation relatives for the various categories of labor, where the weight for category i is simply the ith category's share of total labor compensation in the base period. This type of index is known as a *Laspeyres index*. Other weighting

Table 1. Three-month percent change in four unchained total-compensation indexes, March 1995–June 2002

Year and quarter	Laspeyres index		Paasche index		Fisher index		Törnquist index	
	Percent change	Standard error	Percent change	Standard error	Percent change	Standard error	Percent change	Standard error
1995:								
March	0.876	0.088	0.876	0.088	0.876	0.088	0.876	0.088
June	.719	.083	.714	.083	.717	.083	.716	.083
September	.639	.089	.644	.090	.642	.090	.642	.090
December	.454	.080	.442	.077	.448	.078	.447	.079
1996:								
March	985	.120	1.025	.121	1.005	.120	1.005	.120
June	.819	.094	.806	.085	.813	.089	.812	.088
September	.699	.075	.694	.080	.696	.077	.697	.076
December	.617	.074	.606	.083	.612	.077	.612	.077
1997:								
March	.817	.100	.789	.106	.803	.102	.796	.102
June	.783	.091	.792	.102	.787	.095	.783	.095
September	.879	.067	.917	.068	.898	.067	.894	.067
December	.893	.140	.912	.140	.903	.140	.903	.140
1998:								
March	.903	.080	.887	.086	.895	.080	.891	.080
June	.832	.072	.848	.085	.840	.077	.837	.077
September	1.015	.105	1.076	.100	1.046	.102	1.045	.102
December	.559	.117	.599	.130	.579	.122	.578	.123
1999:								
March	.686	.099	.724	.102	.705	.099	.692	.101
June	1.061	.118	1.048	.133	1.054	.124	1.054	.124
September	.906	.120	.912	.129	.909	.124	.905	.124
December	.864	.065	.835	.068	.850	.066	.845	.066
2000:								
March	1.497	.105	1.489	.117	1.493	.110	1.489	.109
June	1.121	.075	1.125	.076	1.123	.074	1.119	.074
September	.990	.113	1.026	.119	1.008	.115	1.002	.114
December	.689	.075	.694	.086	.691	.080	.687	.080
2001:								
March	1.378	.109	1.324	.118	1.351	.112	1.331	.113
June	.936	.084	.971	.087	.954	.084	.946	.084
September	.990	.084	1.042	.077	1.016	.079	1.009	.080
December	.810	.082	.767	.093	.789	.087	.788	.087
2002:								
March	1.132	.106	1.092	.137	1.112	.121	1.103	.121
June	1.019	.122	1.032	.149	1.025	.135	1.020	.137

schemes also are possible.[5] A *Paasche index* uses current-period quantities to aggregate across the various price relatives. The *Fisher ideal index* is simply a geometric average of the Laspeyres and Paasche indexes. The *Törnquist index* is a weighted geometric mean of the price relatives, where the weights are the average shares of spending on the various inputs in the 2 years. The latter two indexes, sometimes called *superlative indexes*, allow for the possibility that employers substitute one type of labor input for another in response to a change in relative wages.[6]

Table 1 presents 3-month percent changes in the Laspeyres, Paasche, Fisher ideal, and Törnquist indexes for total compensation from 1995 to 2002. The table also presents estimated standard errors, calculated with the use of balanced repeated replication, for these changes. The annual average percent change in the Laspeyres index is 3.59. The corresponding figures for the Paasche, the Fisher ideal, and the Törnquist indexes are 3.61, 3.60, and 3.58, respectively.

As in the earlier study by Lettau and colleagues, differences among the various indexes are very small and are swamped by the standard errors of the estimates themselves.[7]

Chained indexes

Let $L_{\tau-1,\tau}(a)$ be the Laspeyres index in period τ relative to period $\tau-1$ when period a is used as the base year. This index is given by

$$(1) \qquad L_{t-1,t}(a) = \frac{\sum_i E_{ia} W_{it}^{u}}{\sum_i E_{ia} W_{it-1}^{u}},$$

where E_{ia} denotes employment in cell *i* during period *a* and W_{it}^{u} represents the updated average compensation in cell *i* during period τ. The chained index in period *t* is then given by

$$L_t^c = L_{0,1}(0)L_{1,2}(1)\cdots L_{t-1,t}(t-1). \quad (2)$$

That is, the chained Laspeyres index in period *t* is constructed by chaining together the series of one-period Laspeyres indexes, each of which has a different base and thus uses a different weight. The chained Paasche, chained Fisher ideal, and chained Törnquist indexes are defined similarly. Table 2 presents percent changes in the chained indexes from 1995 to 2002. These changes are very close to each other and to those for the unchained indexes.

Chained geometric cell means

The previous section analyzed the sensitivity of the ECI to the method chosen to aggregate over the various industry-occupation cells. The current section focuses on the process by which individual job quotes are aggregated to obtain cell means. In that process, compensation in cell *i* during period τ is estimated by chaining together the proportionate changes in compensation in cell *i* during all previous periods, with the proportionate change in compensation during period τ calculated as the ratio of the mean compensation in period τ + 1 to the mean compensation in period τ. That is, the updated compensation used in equation (1) is given by

Table 2. Three-month percent change in chained total-compensation indexes, March 1995–June 2002

Year and quarter	Laspeyres index		Paasche index		Fisher index		Törnquist index	
	Percent change	Standard error	Percent change	Standard error	Percent change	Standard error	Percent change	Standard error
1995:								
March	0.883	0.088	0.876	0.088	0.879	0.088	0.879	0.088
June	.708	.082	.702	.082	.705	.082	.705	.082
September	.644	.092	.647	.093	.646	.092	.646	.092
December	.440	.081	.428	.078	.434	.079	.433	.079
1996:								
March	1.007	.126	1.036	.124	1.022	.125	1.022	.125
June	.822	.091	.807	.085	.815	.087	.814	.087
September	.672	.076	.672	.082	.672	.078	.673	.078
December	.610	.078	.596	.085	.603	.080	.603	.080
1997:								
March	.799	.102	.772	.109	.786	.104	.779	.104
June	.772	.089	.786	.101	.779	.094	.775	.094
September	.862	.070	.910	.070	.886	.069	.882	.069
December	.900	.146	.929	.146	.914	.145	.915	.146
1998:								
March	.900	.081	.882	.092	.891	.084	.887	.083
June	.835	.077	.847	.093	.841	.083	.837	.083
September	1.036	.107	1.104	.102	1.070	.104	1.069	.104
December	.566	.143	.614	.158	.590	.148	.590	.149
1999:								
March	.618	.141	.656	.135	.637	.137	.621	.146
June	1.069	.132	1.043	.154	1.056	.141	1.056	.141
September	.909	.133	.918	.147	.913	.139	.910	.140
December	.838	.065	.820	.069	.829	.066	.825	.066
2000:								
March	1.467	.110	1.466	.124	1.466	.115	1.463	.115
June	1.105	.075	1.102	.079	1.104	.075	1.100	.075
September	.999	.118	1.033	.121	1.016	.118	1.011	.117
December	.664	.077	.658	.086	.661	.081	.657	.081
2001:								
March	1.389	.108	1.333	.118	1.361	.111	1.344	.112
June	.950	.081	.980	.089	.965	.084	.958	.084
September	.979	.085	1.036	.078	1.007	.080	.999	.081
December	.794	.090	.733	.102	.763	.095	.763	.096
2002:								
March	1.123	.124	1.082	.159	1.102	.141	1.094	.141
June	1.040	.118	1.041	.148	1.041	.132	1.036	.134

$$(3)\quad W_{it}^{u} = \sum_{j\epsilon I_0^i} s_{ij0}W_{ij0} \frac{\sum_{j\epsilon I_1^i} s_{ij1}W_{ij1}}{\sum_{j\epsilon I_1^i} s_{ij1}W_{ij0}} \frac{\sum_{j\epsilon I_2^i} s_{ij2}W_{ij2}}{\sum_{j\epsilon I_2^i} s_{ij2}W1} \cdots \frac{\sum_{j\epsilon I_t^i} s_{ijt}W_{ijt}}{\sum_{j\epsilon I_t^i} s_{ijt-1}W_{ijt-1}},$$

where I_t^i denotes the subsample of jobs during periods $\tau - 1$ and τ belonging to cell i, s_{ijt} is the sample weight for the jth quote in cell i during period $\tau - 1$ and τ, and W_{ijt} is compensation paid for the jth job in cell i. Instead of using arithmetic means to calculate the proportionate changes in compensation each period, one can use geometric means.

Table 3 presents quarterly changes in the geometric mean indexes.[8] By construction, a geometric mean index will grow at a slower rate than its counterpart arithmetic mean index in calculating the proportionate change in cell compensation. However, as in Lettau and colleagues' earlier study, the difference of the average annual growth rate for the geometric mean index and that for the arithmetic mean index is very small—0.07 percentage point, to be exact.[9]

The use of geometric means has a more sizable effect on the estimated CPI: "From December 1990 through February 1997, the CPI-U-XG [a Laspeyres index using geometric means] rose 16.2 percent, which is equivalent to an annual growth rate of 2.46 percent. During that same time, the CPI-U-XL [the corresponding index using arithmetic means] rose 18.6 percent, which is equivalent to an annual growth rate of 2.80 percent, for an annualized difference of 0.34 percent."[10]

Estimator using actual compensation

The simplest way to estimate the compensation relative for category-i labor would be to compare the average com-

Table 3. Three-month percent change in total-compensation indexes, March 1995–June 2002

Year and quarter	Laspeyres index		Paasche index	
	Arithmetic cell means	Geometric cell means	Arithmetic cell means	Geometric cell means
1995:				
March	0.859	0.850	0.870	0.851
June	.711	.616	.696	.610
September	.603	.623	.641	.642
December	.446	.389	.398	.392
1996:				
March	.940	.921	1.059	1.007
June	.813	.785	.779	.720
September	.644	.672	.615	.624
December	.577	.605	.634	.690
1997:				
March	.859	.761	.802	.667
June	.804	.816	.704	.744
September	.818	.800	.864	.818
December	.916	.842	.987	.902
1998:				
March	.894	.996	.881	.989
June	.845	.814	.820	.785
September	1.065	.913	1.134	.962
December	.600	.586	.710	.730
1999:				
March	.348	.626	.589	.709
June	1.133	.962	.932	.882
September	.870	.815	.954	.854
December	.866	.859	.825	.835
2000:				
March	1.529	1.451	1.523	1.448
June	1.149	1.190	1.097	1.140
September	1.010	.941	1.082	.901
December	.641	.714	.591	.703
2001:				
March	1.310	1.344	1.317	1.334
June	.963	.960	.954	.938
September	.932	.956	1.101	1.077
December	.872	.886	.800	.821
2002:				
March	1.068	.946	1.082	.972
June	1.105	1.030	1.059	.972

pensation for category-*i* jobs in the current period with the average compensation for category-*i* jobs in the base period. However, because the ECI sample changes over time, that would involve comparing averages across jobs that might be dissimilar. To avoid this problem, the current estimator obtains the compensation relative by chaining together the previous one-period compensation relatives, where compensation in each period relative to the previous period is estimated only from those jobs which are in the sample in both periods.

The current estimator chains at the cell level. Another way of dealing with the rotating ECI sample is to chain at the aggregate level.[11] Specifically, one can calculate the ECI in each period relative to the previous period as the weighted sum of compensation relatives estimated by using jobs that are in the sample in both periods. The ECI in the current period can then be obtained by chaining together the previous one-period ECI relatives. That is, let

$$W_{it} = \sum_j s_{ijt} W_{ijt} \tag{4}$$

denote the average observed compensation in period τ, and let

$$\tilde{L}_{t-1,t}(0) = \frac{\sum_i E_{i0} W_{it}}{\sum_i E_{i0} W_{it-1}} \tag{5}$$

denote the Laspeyres index in period τ relative to period $\tau - 1$, using period 0 as the base year and using each cell's average sample compensation (rather than its updated compensation).[12] Then the alternative Laspeyres index using observed sample wages rather than updated wages is given by

$$\tilde{L}_t = \tilde{L}_{0,1}(0)\tilde{L}_{1,2}(0)\cdots\tilde{L}_{t-1,t}(0) \, . \tag{6}$$

This index is simpler to construct than one using updated wages, in that it is not necessary to carry over updated compensation from one period to the next.[13]

Table 4 presents quarterly percent changes in the indexes using actual compensation. These quarterly changes are very close to those produced by indexes using updated compensation.

Table 4. Three-month percent change in total-compensation index, March 1995–June 2002

Year and quarter	Percent change	Standard error
1995:		
March	0.848	0.086
June	.693	.090
September	.605	.097
December	.476	.096
1996:		
March	.920	.119
June	.850	.103
September	.655	.079
December	.549	.072
1997:		
March	.873	.111
June	.787	.087
September	.779	.080
December	.859	.145
1998:		
March	.952	.093
June	.857	.083
September	1.022	.107
December	.505	.147
1999:		
March	.390	.228
June	1.098	.124
September	.891	.121
December	.874	.061
2000:		
March	1.519	.120
June	1.157	.071
September	.986	.128
December	.644	.084
2001:		
March	1.322	.103
June	1.000	.081
September	.899	.095
December	.849	.119
2002:		
March	1.110	.133
June	1.064	.138

DATA FROM SEPTEMBER 1981 TO DECEMBER 1994 indicate that the choice of aggregation formula has little effect on the estimated annual percent change in labor compensation, a key component of the ECI. Data from 1995 to 2002 show that this is still the case. The situation is in contrast to that pertaining to the CPI, for which the choice of aggregation formula does make some difference.

Notes

[1] See Michael K. Lettau, Mark A. Loewenstein, and Aaron Cushner, "Is the ECI sensitive to the method of aggregation?" *Monthly Labor Review*, June 1997, pp. 3–11.

[2] Michael J. Boskin, Ellen Dulberger, Robert Gordon, Zvi Griliches, and Dale Jorgenson, *Toward a More Accurate Measure of the Cost of Living*, Final Report to the U.S. Senate Finance Committee (Washington,

DC, December 1996). For a summary of these issues and of the Boskin report itself, see the winter 1998 issue of the *Journal of Economic Perspectives* and Roger J. Gordon, "The Boskin Commission Report and Its Aftermath," National Bureau of Economic Research Working Paper No. 7759, June 2000.

[3] See "Note on a New, Supplemental Index on Consumer Price Change," Aug. 16, 2002, available on the Internet at **http://www.bls.gov/cpi/superlink.htm**.

[4] Lettau, Loewenstein, and Cushner, "Is the ECI sensitive?"

[5] *Ibid.*

[6] A more detailed discussion of the various indexes, as well as their formulas, can be found in Lettau, Loewenstein, and Cushner, *Ibid*.

[7] *Ibid*. Table 1 of that study inadvertently omitted the estimates of the four indexes for December 1994. The omitted estimates, which the table reported as index *numbers* rather than percent changes, were 176.5, 179.2, 177.9, and 178.1 for the Laspeyres, Paasche, Fisher, and Törnquist indexes, respectively.

[8] The geometric mean index set forth for the ECI in this article differs from the one that has been constructed for the CPI. In obtaining the geometric mean of compensation in cell *i* during a given period here, employment shares, and not budget shares, are used as weights. Doing this is possible because the ECI aggregates across labor services that are all measured in the same units—dollars per hour—whereas the CPI aggregates across disparate goods that are measured in different units.

[9] Like table 1, table 4 of that study also inadvertently omitted the estimates for December 1994. They were 139.8, 139.4, 141.0, and 140.8 for the Laspeyres arithmetic, Laspeyres geometric, Paasche arithmetic, and Paasche geometric indexes, respectively. The series with the arithmetic means presented in table 3 of the current article differ slightly from the Laspeyres and Paasche series reported in table 1. Their calculation was modified slightly to make them identical to the geometric mean series other than the means calculation.

[10] See "The Experimental CPI using Geometric Means (CPI-U-XG)," Oct. 16, 2001; on the Internet at **http://www.bls.gov/cpi/cpigmrp.htm**.

[11] See Mark A. Loewenstein, "An Alternative Chaining Approach to Handle ECI Sample Changes," mimeo, February 2002.

[12] Note that the updated average wage for cell *i* is identical to the observed average wage for cell *i* in period *t* if the sample has not changed between period 0 and period *t*.

[13] The ECI was initially modeled on the CPI. The alternative approach using observed rather than updated prices requires that the units in which prices are measured be constant over time. Thus, this approach will not work with the CPI.