Standard Errors in the U.S. Regional Price Parities (RPPs)

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Background on RPPs

Relative price levels for all the U.S. states and metropolitan regions were estimated in Aten, Figueroa and Martin (2011, 2012, forthcoming 2013)[1]. We use the term RPPs and relative price levels interchangeably since no currency conversion is necessary within the U.S. This is similar to the Eurozone, but unlike the International Comparison Program (ICP) where PPPs are in different currencies.

The price and expenditure inputs for the RPPs are from two sources: (1) detailed Consumer Price Index (CPI) micro-data and corresponding expenditure weights derived from the Consumer Expenditure survey from the Bureau of Labor Statistics (BLS), and (2) the American Community Survey on Housing from the Census Bureau. We focus first on the former as they cover all consumption goods and services, in addition to rents and owner-equivalent rents.

The drawback of the CPI-BLS data is that they are constrained to 38 geographic index areas that correspond to large metropolitan areas and urban regions[2]. However, there are 207 item strata, for these 38 areas, enabling us to look in detail at the price variation for one year as well as the changes over the 2005-2010 period. In practice, we do not use the 207 item level detail for the computation of the RPPs because of the difference in coverage between the BLS index areas and more commonly used geographies such as states. We first aggregate the items to 16 expenditure classes or headings, then allocate these heading price levels and weights to the counties within the BLS areas based on the country share of money income[3] in each area.

Once allocated to the counties, the state and metropolitan area price levels are calculated as the weighted geometric averages of the counties. Rents are treated separately, because we have direct price level information from the Census Housing ACS at each level of geography. We substitute the ACS estimates for the BLS rent and owner equivalent rent estimates since the data from the ACS provides more precision. At this stage we can examine the variance of the final inputs to the RPPs, that is, the 16 headings such as Food, Apparel and Transportation, for the 50 states plus the District of Columbia.

[1] The 2011 RPPs have not yet been released for publication.
[2] Out of the 38 index areas, 31 are large metropolitan areas with more than 1.5 million people, four represent mid-size cities with more than 50,000 and less than 1.5 million people, and three index areas represent small, urban, non-metropolitan regions with less than 50,000 people .
[3] The ACS money income definition may be found at http://quickfacts.census.gov/qfd/meta/long_INC910211.htm; it differs from BEA's personal income by not including capital gains, "in kind" income for medical care, tax refunds or employer contributions. For a full discussion, see Ruser, Pilot and Nelson (2004).

Measuring Uncertainty

We base this work on a section of a working paper by Angus Deaton (2012), titled '*Calibrating measurement uncertainty in purchasing power parity exchange rates*'. Deaton's focus is on the international computation of PPPs (purchasing power parities) and on deriving both bilateral and multilateral standard errors for countries in the ICP.

We compute bilateral standard errors for the 38 areas, at the 207 item level as well as the 16 heading level. We examine in more detail the covariance structure of the bilateral comparisons by relaxing some of the assumptions in Deaton's derivations, allowing us to evaluate how valid they are for our particular data sets. We also examine the price variation separately, within each heading level, and then across the headings.

The U.S. areas represented in this paper are arguably more similar than the ICP countries, but there are still some large differences in the composition of prices and quantities, for example, between New York City and smaller Midwest urban areas. The analysis helps us understand the sources of variation from year-to-year, and may better inform us as to possible problems in the consistency of our input data.

Overall Results

The bilateral standard errors of a Törnqvist index at the item level average about 8.5%, while within headings they average 9%. The highest standard errors are for the Medical and Education headings. At the aggregate state level, they average 4.0% across all headings. The largest standard errors are between Pittsburgh and San Diego, and Pittsburgh and San Francisco (22%) at the detailed level, and between Hawaii and Arkansas, Mississippi and West Virginia (13%) at the aggregate level.

Hawaii has the highest price level while the latter three states have price levels among the lowest in the U.S. This pattern of greater variance across areas with larger multilateral price level differences holds true at both the detailed and aggregate levels, and will be discussed below.

Figures 1a and 1b show the multilateral price levels for the 38 areas and the 51 states in 2010, respectively. They are estimated using the Geary aggregation. Results for the 38 areas using other multilateral price levels are shown in *Table 1*[4]. Values range from 0.80 in the Midwest smaller urban areas to 1.42 in New York City. The large metro areas with the lowest price levels are Cleveland and Pittsburgh (0.85), St. Louis and Kansas City (0.86), and Cincinnati (0.88). As Deaton points out, the differences in multilateral aggregation methods are overshadowed by the differences in the input prices, which we examine in the next section.

In what follows, we have estimated three levels of results for the variances of the price ratios and the standard errors of the bilateral Törnqvist index:

a) At the 207 item strata by 38 areas
b) Within 9 separate headings: Food, Apparel, Transport, Housing, Education, Recreation, Other, Medical, and Rents for 38 areas

[4] Table 1 is found in the appendix.

c) Across 16 headings (the 9 above divided into Goods and Services, except for Apparel – only Goods, and Rents – only Services) at the 51 state level

The focus is mainly on a), the most detailed level, but it should be noted that for the final RPP estimates, the inputs consist of the price levels at the c) level. This is in part because of the geographic constraints in the BLS data, but also because new rent data became available for states and metro areas beginning in 2005, and we incorporate those prices directly (i.e. there is no allocation stage). Lastly, the BLS sample for headings other than Rents can be sparse, so final RPPs are based on a multi-year average of the BLS price levels.

Details

Deaton's paper describes the relationship between several types of measures of price variation – 1) the Paasche-Laspeyres spread, 2) the residuals of a CPD estimate and 3) the bilateral Törnqvist price index. These measures are summarized below.

1) Log of the Laspeyres to Paasche Price Index

This is the log of the "Paasche-Laspeyres spread (ρ)". For area *a* and base area *1* (for example, Washington DC),

$$\ln \rho_{1a} = \ln\left[\sum_{i=1}^{n} s_{i1}\left(\frac{p_{ia}}{p_{i1}}\right)\right] + ln\left[\sum_{i=1}^{n} s_{ia}\left(\frac{p_{i1}}{p_{ia}}\right)\right] \qquad (1)$$

The first subscript is the base area, ρ is the Paasche-Laspeyres spread, s_{ia} is the share of item *i* in total expenditure of area a, p_{ia} is the price of item *i* in area *a*, and there are *n* items.

For example, in 2010, with Washington, DC as the base area, the Paasche-Laspeyres spread (ρ) ranged from 1.05 relative to the Northeast mid-size cities (Northeast Bs) to 1.18 for Pittsburgh. When we look at all possible pairs of areas, the Paasche-Laspeyres spread (ρ) ranged from a high of 1.31 between Pittsburgh and Honolulu to a low of 1.02 between the Northeast Bs and the New York city metropolitan area. In 2011, the spread between Northeast Bs and New York city drops just below one, to 0.99, resulting in a negative log Laspeyres-Paasche ratio.

A graphic of the *log* of the spread (*ln*ρ) is shown in *Figure 2*, with lower values in green and higher ones in red. The areas are ranked in increasing price level order. Red cells indicate higher spreads between two areas, and they are more prevalent in the lower left-hand corner and upper right-hand corners. That is, between areas with low price levels and high price levels, as expected.

2) Residuals of a CPD Regression

The second way of looking at price differences between pairs of areas follows the CPD developed by Summers (1973), where the log of the price is a function of the area price, the item price and the residual term. Again, following Deaton's notation *Equation (2)*:

$$\ln p_{ia} = \alpha_a + \beta_i + \varepsilon_{ia} \qquad (2)$$

Here α_a is the area effect, β_i is the item effect and ε_{ia} is the residual.

Figure 3 is a chart of the residuals for each observation in *Equation (2)* plotted against the share weight of the area-item. The largest share weights are for Rents, ranging from 19% (Northeast Bs) to 30% (New Jersey suburbs), and the largest residuals are for low share weight area-items. For example, a residual of -1.53 for GD02 (Funeral Expenses) in Western smaller urban areas (West Cs), and 1.63 for FB01 (Bread) in Pittsburgh. The share weights for these large residuals are only 0.002, or 0.2% of the areas total expenditures. Beginning in 2006 we implemented a more comprehensive system of outlier detection, and this difference may be seen when contrasting the 2005 plot of residuals with the plots of subsequent years (not shown).

The log of the ratio of prices between two areas is:

$$ln\left(\frac{p_{ib}}{p_{ia}}\right) = \ln p_{ib} - \ln p_{ia} = (\alpha_b - \alpha_a) + (\varepsilon_{ib} - \varepsilon_{ia}) \qquad (3)$$

The difference between two area coefficients, $(\alpha_a - \alpha_b)$, is the logarithm of area *a's* price index to area *b's* price index. This difference may also be written as the geomean of the price ratios over all goods, and is the log of the geomean price parity between *a* and *b*:

$$\ln P_{ab}^{geomean} = \frac{1}{n}\sum_{i=1}^{n} \ln\left(\frac{p_{ib}}{p_{ia}}\right) \qquad (4)$$

Under the assumption that the covariances across items or areas is zero and the variances are the same for all items, Deaton derives the standard error of the log of the geomean price parity :

$$s.e.\ln\left(P_{ab}^{geomean}\right) = \sqrt{\frac{\sum_{i=1}^{n} (\varepsilon_{ib} + \varepsilon_{ia})^2}{n}} \qquad (5a)$$

Under these assumptions, the variance of the log price ratios is the log Laspeyres to Paasche ratio. If we include non-zero covariances:

$$(\varepsilon_{ib} - \varepsilon_{ia})^2 \neq (\varepsilon_{ib}^2 + \varepsilon_{ia}^2)$$

$$s.e.\ln\left(P_{ab}^{geomean}\right) = \sqrt{\frac{\sum_{i=1}^{n} (\varepsilon_{ib} - \varepsilon_{ia})^2}{n}} \qquad (5b)$$

Figures 4a and 4b show a plot of the log Laspeyres to Paasche ratio from *Equation (1)* on the vertical against the variance of the price ratios from *Equations (5a) and (5b)* for 2010. The bilaterals for DC are in red, all the others are in blue. *Figure 4a* assumes zero covariances while *Figure 4b* does not. The overall variances are higher in *Figure 4b*, but the correlation is slightly lower, as indicated by the regression lines on each graph.

In both figures, there are high variances among Honolulu, Anchorage, Pittsburgh and West C areas and low variances between Midwestern smaller urban areas and Southern mid-size cities. Covariances range from -0.03 (Cincinnati-Houston) to 0.03 (Pittsburgh-Northeast Bs).

Table 2 is a summary of the areas with high variances or large L/P ratios, sorted by number of high variance occurrences. Eleven pairs of areas had price ratio variances greater than 0.25, and three pairs had L/P ratios greater than 1.25. Pittsburgh, Honolulu, Atlanta, Anchorage and St. Louis had both.

Table 2. Areas with High Price Ratio Variances or Large L/P Ratios

2010	Variance > .25		L/P ratio >1.25 or <0.80
Houston-Pittsburgh Houston- St. Louis Houston- Cincinnati Houston- West Cs Houston- Honolulu	5		0
Pittsburgh-Portland Pittsburgh-Anchorage Pittsburgh-Houston Pittsburgh-Atlanta	4	Pittsburgh-Honolulu	1
San Diego-West Cs San Diego-Phoenix	2		0
Honolulu-Philadelphia Honolulu-Houston	2	Honolulu-Pittsburgh	1
West Cs-Houston West Cs-San Diego	2		0
Cincinnati-Houston	1		0
Portland-Pittsburgh	1		0
Atlanta-Pittsburgh	1	Atlanta-San Francisco	1
Phoenix-San Diego	1		0
Anchorage-Pittsburgh	1	Anchorage-St.Louis	1
Philadelphia-Honolulu	1		0
St.Louis-Houston	1	St.Louis-Anchorage	1
		San Francisco-Atlanta	1
Sum	22 (11 pairs)		6 (3 pairs)

3) Bilateral Törnqvist Price Index

Unlike the price ratios in *Equation (2)*, the bilateral Törnqvist indexes include expenditure weights, and they may also be formulated as a stochastic regression. By substituting the log price ratios from *Equation (3)* into the Törnqvist index formula in *Equation (6)* below, we get an expression for the Törnqvist with the residuals of the CPD, shown in *Equation (7).*

$$\ln P_{ab}^{T} = \frac{1}{2}\sum_{i=1}^{n}(S_{ia} + S_{ib})\ln\left(\frac{p_{ib}}{p_{ia}}\right) \quad (6)$$

Substituting the log price ratios from *Equation (3)*,

$$\ln P_{ab}^{T} = (\alpha_b - \alpha_a) + \frac{1}{2}\sum_{i=1}^{n}(S_{ia} + S_{ib})(\varepsilon_{ib} - \varepsilon_{ia}) \quad (7)$$

If the expenditure shares are identical for all items, *Equation (7)* reduces to *Equation (3)* and the Törnqvist is identical to the geomean of the price ratios.

The variance of the log Törnqvist will have a close relationship to the variance of the log geomean and the log of the Laspeyres-Paasche ratio. That is,

$$Var\ (\ln P_{ab}^{T}) = \sum_{i=1}^{n} \left(\frac{s_{ia} + s_{ib}}{2}\right)^2 ({\varepsilon_{ib}}^2 + {\varepsilon_{ia}}^2) \qquad (8a)$$

With covariances different than zero, we get the expression below.

$$Var\ (\ln P_{ab}^{T}) = \sum_{i=1}^{n} \left(\frac{s_{ia} + s_{ib}}{2}\right)^2 (\varepsilon_{ib} - \varepsilon_{ib})^2 \qquad (8b)$$

Figure 5 shows the square root of the log of the Laspeyres-Paasche ratio divided by the square root of the number of items (207), against the standard error of the log Törnqvist from *Equation (8b)*. As before, DC is shown in red, and all other bilaterals in blue.

Table 3 shows the areas with standard errors greater than 0.20, totaling nineteen pairs of areas. The second and third columns in *Table 3* are marked with those areas that are also in *Table 2*. The cut-offs are arbitrary, but suggest that areas such as Pittsburgh and Honolulu, which appear frequently on both scales, may have quite different price and weight structures than the other areas.

Table 3. Areas with Large Standard Errors

2010	Stderr Törnqvist Bilateral > .20	High Variance price ratios	Large L/P ratio
San Diego	6	*	
San Francisco	5		*
Pittsburgh	4	*	*
Kansas City	4		
LA	4		
Honolulu	4	*	*
Midwest Cs	4		
South Cs	4		
West Cs	2	*	
Midwest Bs	1		
Sum	38 (19 pairs)		

Other variances

We turn to the prices and weights within nine broad expenditure classes or headings to see if there are one or two groupings that particularly influence the overall variances. That is, we run nine separate CPDs and estimate the within-group variances of the price ratios and the standard errors of the within-group bilateral Törnqvists.

Rents constitute the greatest expenditure class (30%) on average for these data, but the price ratios and bilateral standard errors within the three categories of rents (rents, owner-occupied rents and second-home rents) are very small. The average bilateral standard error is only 1.9% for rents, while it is 15.5% for Education and 14.2% for the Medical heading. *Table 4* shows the average share weight of each heading and its standard error, averaged across all possible area pairs (38x38) of the bilateral Törnqvists.

Table 4. Bilateral Törnqvist Standard Errors within Headings

Heading	Number of Items (n)	Obs in CPD (nobs)	Average % share weight	Rank	Standard Error
Apparel	20	760	3.6%	8	7.5%
Education	16	608	6.3%	5	15.5%
Food	62	2,356	14.9%	3	6.3%
Housing	34	1,292	10.7%	4	10.0%
Medical	11	418	6.2%	6	14.2%
Other	14	532	3.5%	9	13.7%
Recreation	26	988	6.2%	7	9.4%
Rents	3	114	30.4%	1	1.9%
Transport	21	798	18.1%	2	7.6%
Overall	**207**	**7,866**	**100%**		**8.3%**

Figures 6a-6i plot the separate variances of the price ratios for each heading against the overall variances in 2010, with *Figure 6j* showing all of the headings in on graph. *Figure 7* is a summary graphic of the distribution of the bilateral standard errors for each heading. The effect of share weights on reducing the variances can be seen in *Figure 7*, particularly for Medical, Education, Recreation and Other headings.

The final set of standard errors is at the 16 aggregate heading levels and for 51 states. Here the range drops to a mean of 4.0%. The state level variances are in most cases mitigated because they are composed of prices from more than one BLS area. For example, Hawaii versus Pennsylvania would compare goods and services price data from Honolulu, and rent data from all of Hawaii, versus goods and services price data from Philadelphia, Pittsburgh, and the Northeast B areas, along with rent data covering all of Pennsylvania. Therefore, large standard errors present when comparing Honolulu versus Pittsburgh are not present in a state-to-state comparison. In addition, for our final RPPs, we use a five-year average of BLS prices rather than the annual data presented here[5]. This further reduces the variances for the bilateral comparisons in all but the rent data.

Table 5 is a summary of the bilateral standard errors for the detailed and the aggregate levels from 2005 to 2011. Lastly, *Figure 8a and 8b* show the state price ratio variances and the bilateral standard errors, mirroring *Figures 4a and 4b*.

Table 5. Bilateral Törnqvist Standard Errors 2005-2011

Level	2005	2006	2007	2008	2009	2010	2011
Detailed Items for 38 areas	8.2%	8.4%	8.8%	8.8%	8.9%	8.3%	8.5%
Aggregate Headings for 51 states	4.1%	4.2%	4.3%	4.1%	4.2%	4.0%	4.0%

Conclusions

The standard errors are large for some pairs of areas, for example, over 20% for the Pittsburgh-Honolulu bilateral Törnqvist comparison in 2010. This is at the 207 item level, which ranges from weights of 0.001% (Frozen Noncarbonated Juices and Drinks) to 30% for Owner Equivalent Rents.

When we look at the variation within groups of expenditure classes or headings, it is clear that the greatest variances are in the Education and Medical headings, with mean bilateral standard errors of 15.5% and 14.2% respectively. But the headings with greater share weights overall -- Food, Transport and Rents -- all have mean standard errors below 8%. Further, if we only consider the inputs to the RPPs at the aggregate 16 heading level, the bilateral standard errors drop by half, to a mean of 4%, and a maximum of 13% for the Hawaii-West Virginia comparison.

We also saw a large increase in the residual distribution of the CPDs before 2006 (and a significant decrease in 2011). This was due to improvements in the outlier detection procedures. In the future it may be helpful to estimate the bilateral standard errors as a second check on the input data.

In general, the patterns of price variation and bilateral Törnqvists are consistent across the years. Averaging the 207 item level price data over 5 years greatly reduces the standard errors of the comparisons, but it would be helpful in the future to obtain more direct price observations for a number of headings, especially those with a large service sector component, such as Medical and Education.

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[5] For the 2007-2011 period, we use annual price data from BLS averaged over those five years at 15 heading levels, plus 2010 rent data from the ACS. These 16 headings are then aggregated to an overall RPP for 2010.

Appendix

Table 1. Price levels 2010 using different aggregation formulas (in ascending Geary order)

Area name	Index area	GEKS Törnqvist	GEKS Fisher	WCPD	Geary	Diff Geary-Torn
MW Cs	D200	0.801	0.801	0.810	0.801	0.0%
South Cs	D300	0.830	0.832	0.834	0.830	0.1%
Cleveland	A210	0.848	0.847	0.847	0.849	0.1%
Pittsburgh	A104	0.867	0.869	0.864	0.851	-1.9%
St.Louis	A209	0.873	0.873	0.870	0.858	-1.6%
Kansas City	A214	0.874	0.875	0.871	0.862	-1.3%
Cincinnati	A213	0.889	0.889	0.885	0.881	-0.9%
MW Bs	X200	0.883	0.885	0.885	0.892	0.9%
West Cs	D400	0.909	0.912	0.912	0.898	-1.2%
Atlanta	A319	0.932	0.940	0.922	0.915	-1.9%
Milwaukee	A212	0.918	0.917	0.915	0.916	-0.2%
South Bs	X300	0.907	0.907	0.903	0.917	1.2%
Detroit	A208	0.926	0.927	0.929	0.925	0.0%
Phoenix	A429	0.937	0.937	0.939	0.938	0.1%
West Bs	X499	0.937	0.935	0.934	0.939	0.1%
NE Bs	X100	0.950	0.952	0.949	0.951	0.1%
Tampa	A321	0.977	0.975	0.972	0.967	-1.1%
Dallas	A316	0.983	0.986	0.980	0.980	-0.3%
Portland	A425	1.001	1.001	0.998	0.993	-0.8%
Houston	A318	0.999	1.003	0.997	0.994	-0.5%
Minneapolis	A211	1.006	1.007	1.007	1.007	0.2%
Denver	A433	1.017	1.017	1.014	1.017	0.1%
Miami	A320	1.042	1.041	1.038	1.044	0.2%
Seattle	A423	1.040	1.036	1.035	1.044	0.4%
Chicago	A207	1.067	1.067	1.064	1.078	1.1%
Philadelphia	A102	1.084	1.085	1.077	1.083	-0.2%
Anchorage	A427	1.113	1.117	1.110	1.095	-1.7%
Baltimore	A313	1.102	1.103	1.102	1.102	0.0%
Greater LA	A420	1.156	1.152	1.154	1.132	-2.0%
Boston	A103	1.149	1.146	1.150	1.145	-0.3%
DC	A312	1.206	1.209	1.208	1.207	0.1%
LA	A419	1.262	1.255	1.272	1.239	-1.8%
San Diego	A424	1.259	1.250	1.286	1.240	-1.5%
NJ sub	A111	1.248	1.246	1.259	1.241	-0.6%
Honolulu	A426	1.336	1.327	1.342	1.277	-4.4%
NY sub	A110	1.315	1.314	1.320	1.304	-0.8%
San Francisco	A422	1.339	1.331	1.351	1.307	-2.4%
NY city	A109	1.405	1.401	1.431	1.421	1.1%
	max	1.405	1.401	1.431	1.421	1.2%
	min	0.801	0.801	0.810	0.801	-4.4%
	range	0.604	0.601	0.621	0.620	5.6%

Figure 1a. Multilateral Price Levels (Geary aggregation) for 38 areas

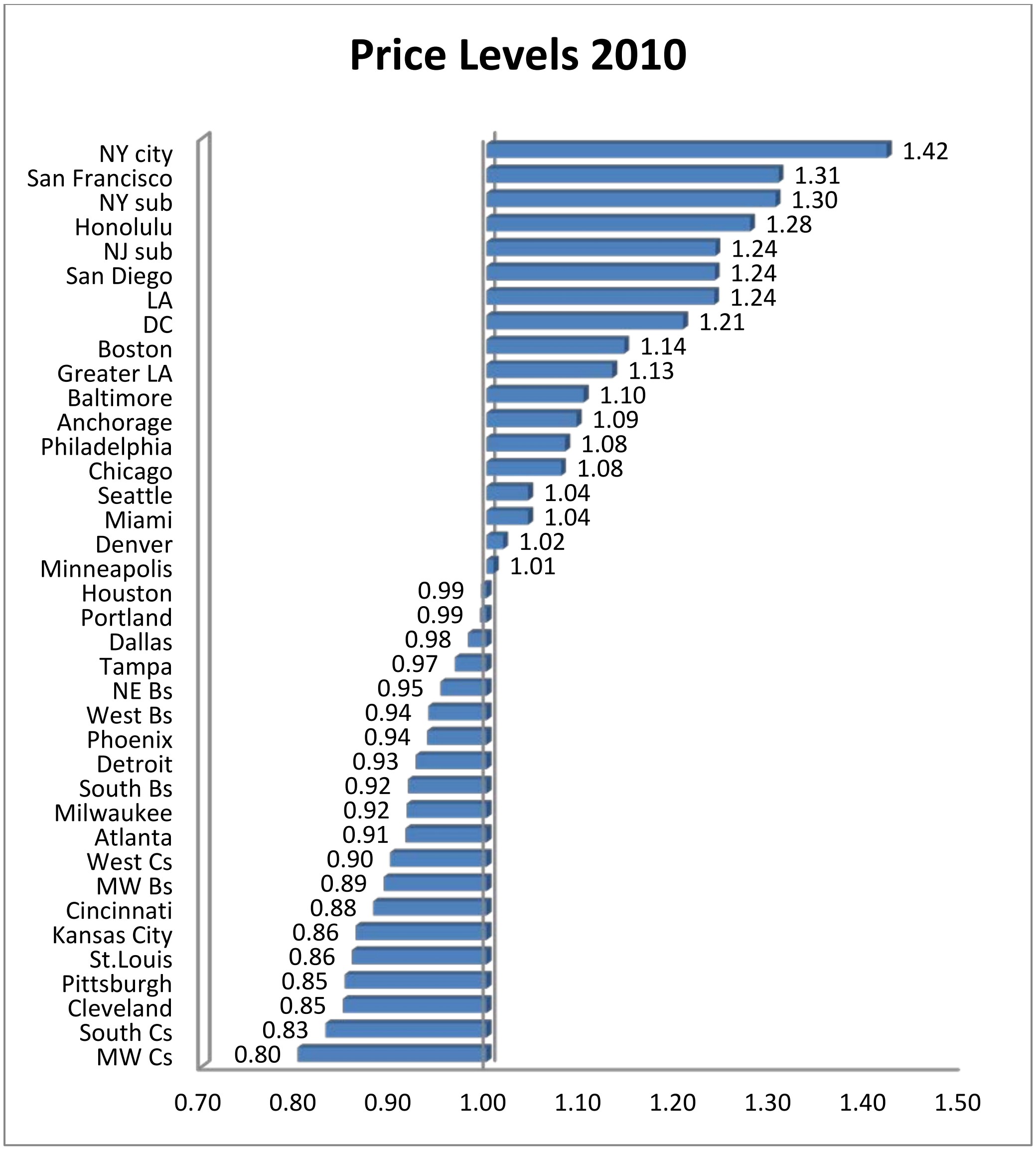


Figure 1b. Multilateral Price Levels (Geary aggregation) for 51 states

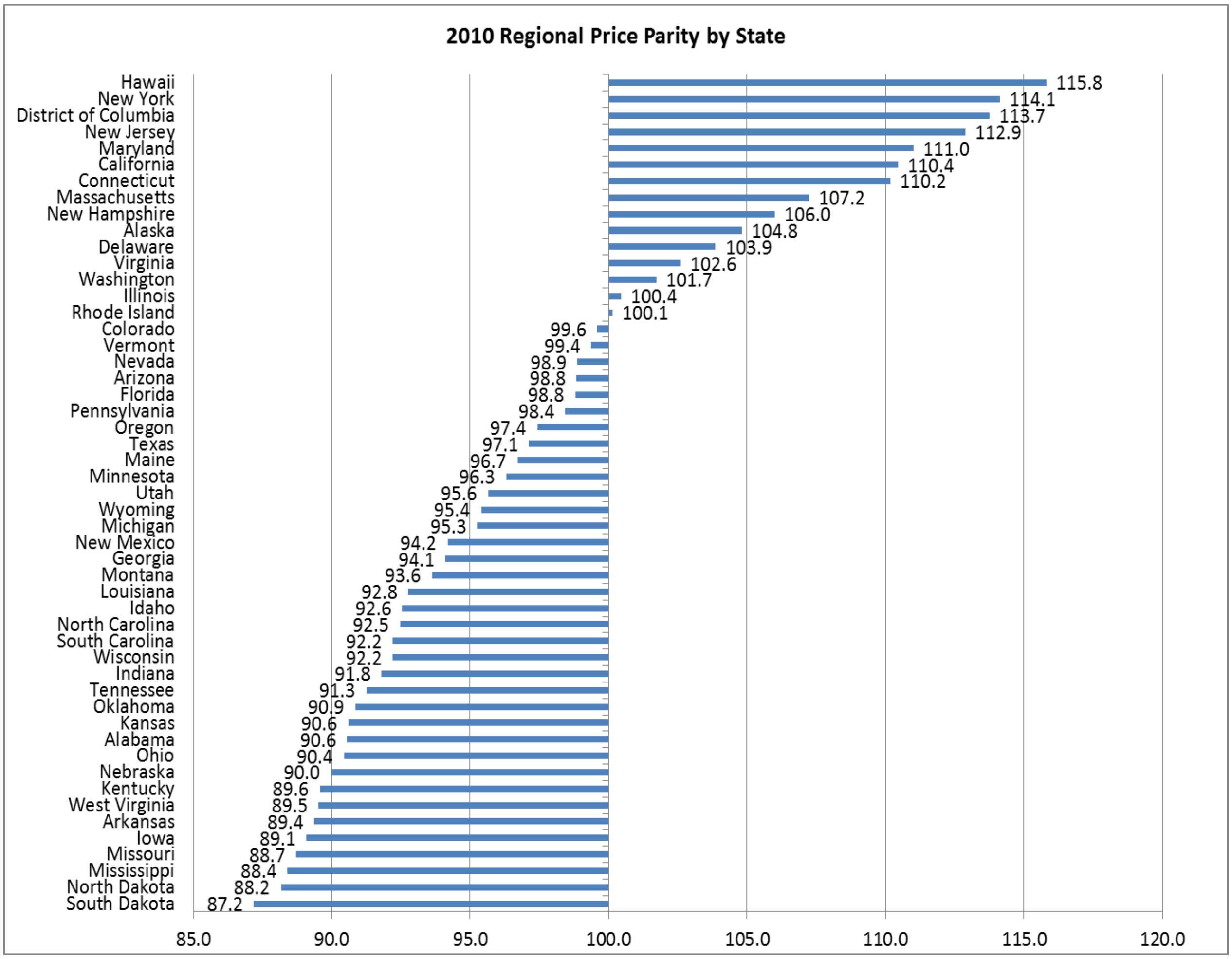


Figure 2. Log L/P ratios for 38 areas 2010

Area	Geary 2010	Log LP		D200	D300	A210	A104	A209	A214	A213	X200	D400	A319	A212	X300	A208	A429	X499	X100	A321	A316	A425	A318	A211	A433	A320	A423	A207	A102	A427	A313	A420	A103	A312	A419	A424	A111	A426	A110	A422	A109
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
MW Cs	0.801	D200	1		0.06	0.05	0.09	0.09	0.10	0.06	0.04	0.09	0.12	0.06	0.03	0.08	0.05	0.04	0.08	0.10	0.07	0.09	0.06	0.07	0.06	0.06	0.05	0.04	0.08	0.14	0.07	0.14	0.09	0.10	0.12	0.12	0.12	0.20	0.13	0.15	0.05
South Cs	0.830	D300	2	0.06		0.06	0.09	0.07	0.08	0.07	0.05	0.09	0.07	0.07	0.03	0.07	0.05	0.08	0.08	0.08	0.08	0.09	0.08	0.06	0.05	0.05	0.07	0.05	0.07	0.13	0.06	0.13	0.10	0.07	0.12	0.12	0.09	0.18	0.11	0.15	0.06
Cleveland	0.849	A210	3	0.05	0.06		0.10	0.11	0.10	0.08	0.04	0.10	0.12	0.06	0.04	0.08	0.05	0.06	0.06	0.10	0.11	0.10	0.11	0.08	0.10	0.07	0.06	0.06	0.08	0.14	0.06	0.11	0.09	0.09	0.10	0.10	0.11	0.18	0.11	0.14	0.05
Pittsburgh	0.851	A104	4	0.09	0.09	0.10		0.12	0.12	0.13	0.08	0.16	0.19	0.11	0.08	0.12	0.11	0.10	0.08	0.18	0.13	0.17	0.15	0.10	0.13	0.13	0.13	0.11	0.12	0.22	0.11	0.21	0.18	0.16	0.22	0.19	0.18	0.27	0.21	0.21	0.13
St.Louis	0.858	A209	5	0.09	0.07	0.11	0.12		0.12	0.10	0.07	0.12	0.10	0.12	0.07	0.09	0.09	0.12	0.08	0.13	0.12	0.15	0.15	0.12	0.11	0.10	0.12	0.09	0.13	0.16	0.10	0.17	0.13	0.11	0.15	0.15	0.13	0.23	0.16	0.19	0.10
Kansas City	0.862	A214	6	0.10	0.08	0.10	0.12	0.12		0.12	0.06	0.10	0.12	0.11	0.07	0.07	0.09	0.09	0.10	0.12	0.09	0.14	0.12	0.08	0.10	0.10	0.12	0.07	0.09	0.13	0.07	0.15	0.13	0.11	0.15	0.13	0.12	0.17	0.16	0.15	0.10
Cincinnati	0.881	A213	7	0.06	0.07	0.08	0.13	0.10	0.12		0.06	0.09	0.11	0.10	0.07	0.08	0.09	0.10	0.08	0.13	0.11	0.12	0.14	0.07	0.08	0.08	0.09	0.07	0.13	0.13	0.09	0.16	0.11	0.10	0.13	0.14	0.13	0.19	0.15	0.17	0.11
MW Bs	0.892	X200	8	0.04	0.05	0.04	0.08	0.07	0.06	0.06		0.06	0.07	0.05	0.02	0.04	0.04	0.04	0.05	0.08	0.04	0.06	0.06	0.04	0.04	0.05	0.04	0.02	0.05	0.09	0.04	0.10	0.06	0.05	0.09	0.07	0.06	0.15	0.09	0.11	0.04
West Cs	0.898	D400	9	0.09	0.09	0.10	0.16	0.12	0.10	0.09	0.06		0.08	0.13	0.08	0.07	0.11	0.11	0.12	0.11	0.07	0.11	0.11	0.09	0.08	0.08	0.11	0.06	0.09	0.10	0.06	0.14	0.11	0.09	0.16	0.14	0.10	0.19	0.12	0.16	0.08
Atlanta	0.915	A319	10	0.12	0.07	0.12	0.19	0.10	0.12	0.11	0.07	0.08		0.15	0.09	0.04	0.10	0.18	0.10	0.11	0.10	0.11	0.13	0.10	0.13	0.12	0.14	0.10	0.18	0.14	0.11	0.17	0.16	0.07	0.19	0.19	0.11	0.23	0.14	0.25	0.15
Milwaukee	0.916	A212	11	0.06	0.07	0.06	0.11	0.12	0.11	0.10	0.05	0.13	0.15		0.05	0.07	0.06	0.05	0.07	0.10	0.08	0.12	0.09	0.07	0.10	0.07	0.08	0.06	0.10	0.14	0.08	0.12	0.09	0.12	0.10	0.10	0.10	0.16	0.12	0.14	0.05
South Bs	0.917	X300	12	0.03	0.03	0.04	0.08	0.07	0.07	0.07	0.02	0.08	0.09	0.05		0.05	0.04	0.05	0.05	0.06	0.05	0.07	0.06	0.04	0.05	0.04	0.04	0.02	0.06	0.11	0.04	0.09	0.06	0.05	0.09	0.08	0.07	0.14	0.09	0.10	0.04
Detroit	0.925	A208	13	0.08	0.07	0.08	0.12	0.09	0.07	0.08	0.04	0.07	0.04	0.07	0.05		0.07	0.09	0.07	0.09	0.07	0.07	0.09	0.06	0.08	0.07	0.09	0.05	0.09	0.10	0.06	0.12	0.08	0.07	0.13	0.11	0.06	0.15	0.10	0.16	0.07
Phoenix	0.938	A429	14	0.05	0.05	0.05	0.11	0.09	0.09	0.09	0.04	0.11	0.10	0.06	0.04	0.07		0.06	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.06	0.08	0.06	0.09	0.14	0.06	0.15	0.10	0.09	0.12	0.14	0.11	0.18	0.12	0.16	0.05
West Bs	0.939	X499	15	0.04	0.08	0.06	0.10	0.12	0.09	0.10	0.04	0.11	0.18	0.05	0.05	0.09	0.06		0.11	0.09	0.08	0.08	0.07	0.06	0.05	0.07	0.08	0.05	0.05	0.11	0.08	0.12	0.08	0.10	0.11	0.10	0.09	0.16	0.12	0.10	0.04
NE Bs	0.951	X100	16	0.08	0.08	0.06	0.08	0.08	0.10	0.08	0.05	0.12	0.10	0.07	0.05	0.07	0.08	0.11		0.10	0.07	0.11	0.12	0.06	0.11	0.06	0.08	0.04	0.10	0.12	0.05	0.09	0.05	0.04	0.06	0.06	0.05	0.11	0.06	0.09	0.02
Tampa	0.967	A321	17	0.10	0.08	0.10	0.18	0.13	0.12	0.13	0.08	0.11	0.11	0.10	0.06	0.09	0.08	0.09	0.10		0.09	0.08	0.08	0.08	0.11	0.05	0.08	0.08	0.09	0.10	0.08	0.11	0.09	0.08	0.10	0.10	0.09	0.13	0.09	0.14	0.07
Dallas	0.980	A316	18	0.07	0.08	0.11	0.13	0.12	0.09	0.11	0.04	0.07	0.10	0.08	0.05	0.07	0.08	0.08	0.07	0.09		0.09	0.06	0.06	0.08	0.07	0.07	0.05	0.08	0.11	0.06	0.12	0.07	0.06	0.12	0.09	0.08	0.17	0.09	0.13	0.07
Portland	0.993	A425	19	0.09	0.09	0.10	0.17	0.15	0.14	0.12	0.06	0.11	0.11	0.12	0.07	0.07	0.08	0.08	0.11	0.08	0.09		0.07	0.09	0.09	0.09	0.09	0.06	0.09	0.10	0.09	0.13	0.09	0.07	0.11	0.11	0.07	0.16	0.09	0.14	0.06
Houston	0.994	A318	20	0.06	0.08	0.11	0.15	0.15	0.12	0.14	0.06	0.11	0.13	0.09	0.06	0.09	0.08	0.07	0.12	0.08	0.06	0.07		0.10	0.09	0.07	0.08	0.06	0.07	0.13	0.09	0.13	0.09	0.08	0.14	0.12	0.11	0.20	0.11	0.14	0.06
Minneapolis	1.007	A211	21	0.07	0.06	0.08	0.10	0.12	0.08	0.07	0.04	0.09	0.10	0.07	0.04	0.06	0.07	0.06	0.06	0.08	0.06	0.09	0.10		0.05	0.06	0.07	0.05	0.08	0.09	0.06	0.12	0.10	0.05	0.09	0.08	0.07	0.13	0.11	0.11	0.05
Denver	1.017	A433	22	0.06	0.05	0.10	0.13	0.11	0.10	0.08	0.04	0.08	0.13	0.10	0.05	0.08	0.07	0.05	0.11	0.11	0.08	0.09	0.09	0.05		0.08	0.05	0.04	0.11	0.10	0.09	0.12	0.10	0.06	0.10	0.10	0.09	0.15	0.11	0.12	0.08
Miami	1.044	A320	23	0.06	0.05	0.07	0.13	0.10	0.10	0.08	0.05	0.08	0.12	0.07	0.04	0.07	0.06	0.07	0.06	0.05	0.07	0.09	0.07	0.06	0.08		0.07	0.05	0.08	0.13	0.06	0.11	0.08	0.09	0.11	0.13	0.08	0.16	0.09	0.14	0.06
Seattle	1.044	A423	24	0.05	0.07	0.06	0.13	0.12	0.12	0.09	0.04	0.11	0.14	0.08	0.04	0.09	0.08	0.08	0.08	0.08	0.07	0.09	0.08	0.07	0.05	0.07		0.05	0.09	0.11	0.07	0.10	0.07	0.07	0.08	0.07	0.10	0.12	0.07	0.08	0.06
Chicago	1.078	A207	25	0.04	0.05	0.06	0.11	0.09	0.07	0.07	0.02	0.06	0.10	0.06	0.02	0.05	0.06	0.05	0.04	0.08	0.05	0.06	0.06	0.05	0.04	0.05	0.05		0.07	0.08	0.06	0.06	0.04	0.05	0.07	0.08	0.07	0.12	0.07	0.09	0.05
Philadelphia	1.083	A102	26	0.08	0.07	0.08	0.12	0.13	0.09	0.13	0.05	0.09	0.18	0.10	0.06	0.09	0.09	0.05	0.10	0.09	0.08	0.09	0.07	0.08	0.11	0.08	0.09	0.07		0.10	0.08	0.13	0.10	0.11	0.12	0.10	0.12	0.18	0.11	0.12	0.06
Anchorage	1.095	A427	27	0.14	0.13	0.14	0.22	0.16	0.13	0.13	0.09	0.10	0.14	0.14	0.11	0.10	0.14	0.11	0.12	0.10	0.11	0.10	0.13	0.09	0.10	0.13	0.11	0.08	0.10		0.11	0.12	0.10	0.09	0.10	0.07	0.08	0.11	0.08	0.12	0.09
Baltimore	1.102	A313	28	0.07	0.06	0.06	0.11	0.10	0.07	0.09	0.04	0.06	0.11	0.08	0.04	0.06	0.06	0.08	0.05	0.08	0.06	0.09	0.09	0.06	0.09	0.06	0.07	0.06	0.08	0.11		0.12	0.08	0.06	0.11	0.08	0.08	0.17	0.09	0.14	0.07
Greater LA	1.132	A420	29	0.14	0.13	0.11	0.21	0.17	0.15	0.16	0.10	0.14	0.17	0.12	0.09	0.12	0.15	0.12	0.09	0.11	0.12	0.13	0.13	0.12	0.12	0.11	0.10	0.06	0.13	0.12	0.12		0.05	0.08	0.06	0.08	0.07	0.08	0.06	0.08	0.08
Boston	1.145	A103	30	0.09	0.10	0.09	0.18	0.13	0.13	0.11	0.06	0.11	0.16	0.09	0.06	0.08	0.10	0.08	0.05	0.09	0.07	0.09	0.09	0.10	0.10	0.08	0.07	0.04	0.10	0.10	0.08	0.05		0.07	0.05	0.07	0.06	0.10	0.04	0.07	0.06
DC	1.207	A312	31	0.10	0.07	0.09	0.16	0.11	0.11	0.10	0.05	0.09	0.07	0.12	0.05	0.07	0.09	0.10	0.04	0.08	0.06	0.07	0.08	0.05	0.06	0.09	0.07	0.05	0.11	0.09	0.06	0.08	0.07		0.09	0.08	0.05	0.13	0.06	0.10	0.07
LA	1.239	A419	32	0.12	0.12	0.10	0.22	0.15	0.15	0.13	0.09	0.16	0.19	0.10	0.09	0.13	0.12	0.11	0.06	0.10	0.12	0.11	0.14	0.09	0.10	0.11	0.08	0.07	0.12	0.10	0.11	0.06	0.05	0.09		0.05	0.07	0.09	0.04	0.07	0.05
San Diego	1.240	A424	33	0.12	0.12	0.10	0.19	0.15	0.13	0.14	0.07	0.14	0.19	0.10	0.08	0.11	0.14	0.10	0.06	0.10	0.09	0.11	0.12	0.08	0.10	0.13	0.07	0.08	0.10	0.07	0.08	0.08	0.07	0.08	0.05		0.07	0.08	0.07	0.06	0.07
NJ sub	1.241	A111	34	0.12	0.09	0.11	0.18	0.13	0.12	0.13	0.06	0.10	0.11	0.10	0.07	0.06	0.11	0.09	0.05	0.09	0.08	0.07	0.11	0.07	0.09	0.08	0.10	0.07	0.12	0.08	0.08	0.07	0.06	0.05	0.07	0.07		0.12	0.06	0.11	0.05
Honolulu	1.277	A426	35	0.20	0.18	0.18	0.27	0.23	0.17	0.19	0.15	0.19	0.23	0.16	0.14	0.15	0.18	0.16	0.11	0.13	0.17	0.16	0.20	0.13	0.15	0.16	0.12	0.12	0.18	0.11	0.17	0.08	0.10	0.13	0.09	0.08	0.12		0.10	0.09	0.13
NY sub	1.304	A110	36	0.13	0.11	0.11	0.21	0.16	0.16	0.15	0.09	0.12	0.14	0.12	0.09	0.10	0.12	0.12	0.06	0.09	0.09	0.09	0.11	0.11	0.11	0.09	0.07	0.07	0.11	0.08	0.09	0.06	0.04	0.06	0.04	0.07	0.06	0.10		0.08	0.04
San Francisco	1.307	A422	37	0.15	0.15	0.14	0.21	0.19	0.15	0.17	0.11	0.16	0.25	0.14	0.10	0.16	0.16	0.10	0.09	0.14	0.13	0.14	0.14	0.11	0.12	0.14	0.08	0.09	0.12	0.12	0.14	0.08	0.07	0.10	0.07	0.06	0.11	0.09	0.08		0.08
NY city	1.421	A109	38	0.05	0.06	0.05	0.13	0.10	0.10	0.11	0.04	0.08	0.15	0.05	0.04	0.07	0.05	0.04	0.02	0.07	0.07	0.06	0.06	0.05	0.08	0.06	0.06	0.05	0.06	0.09	0.07	0.08	0.06	0.07	0.05	0.07	0.05	0.13	0.04	0.08	

Figure 3. Residuals of CPD and share weights

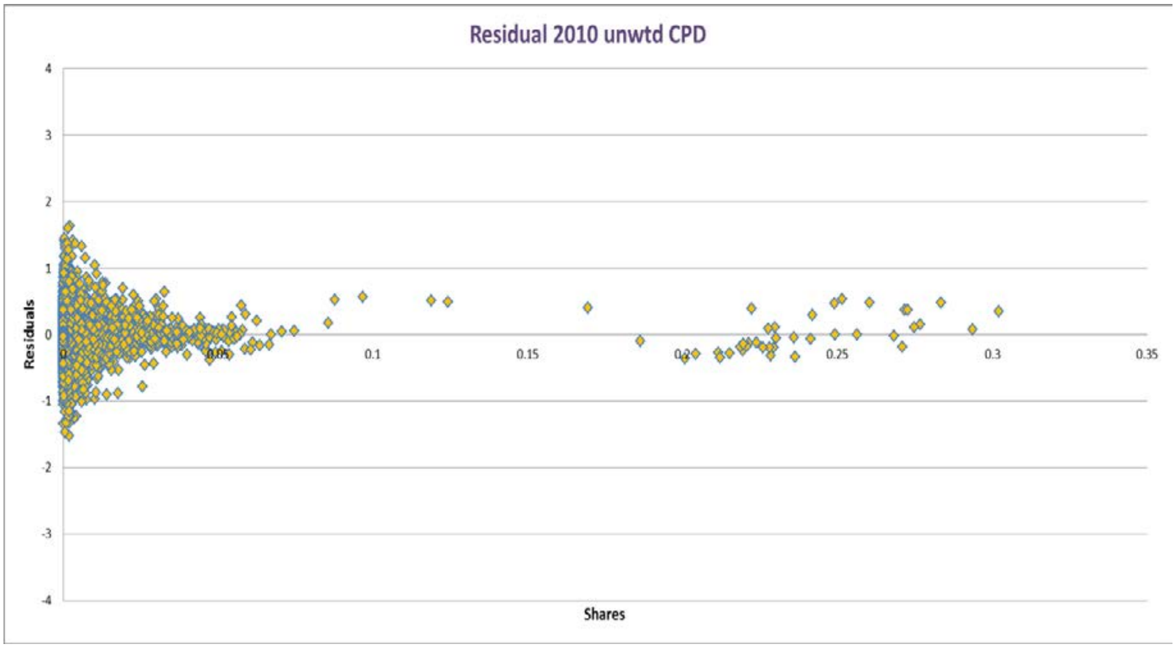


Figure 4a. Log L/P ratio and Variance of Price ratios (zero covariances)

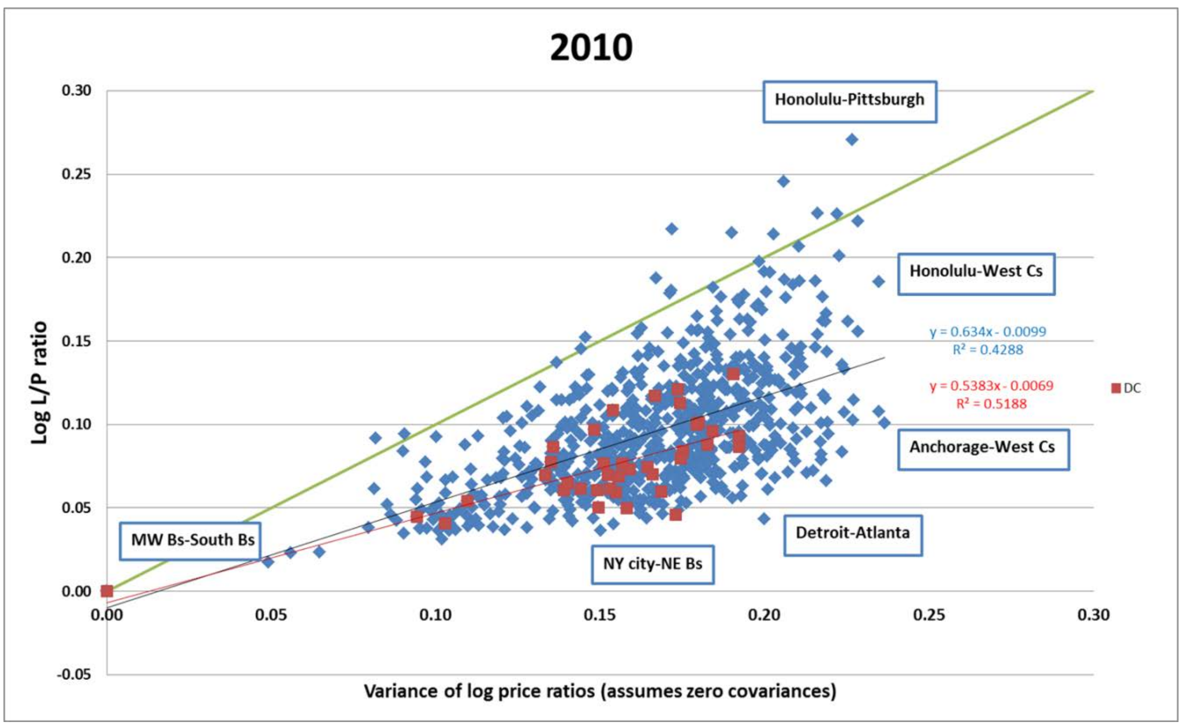
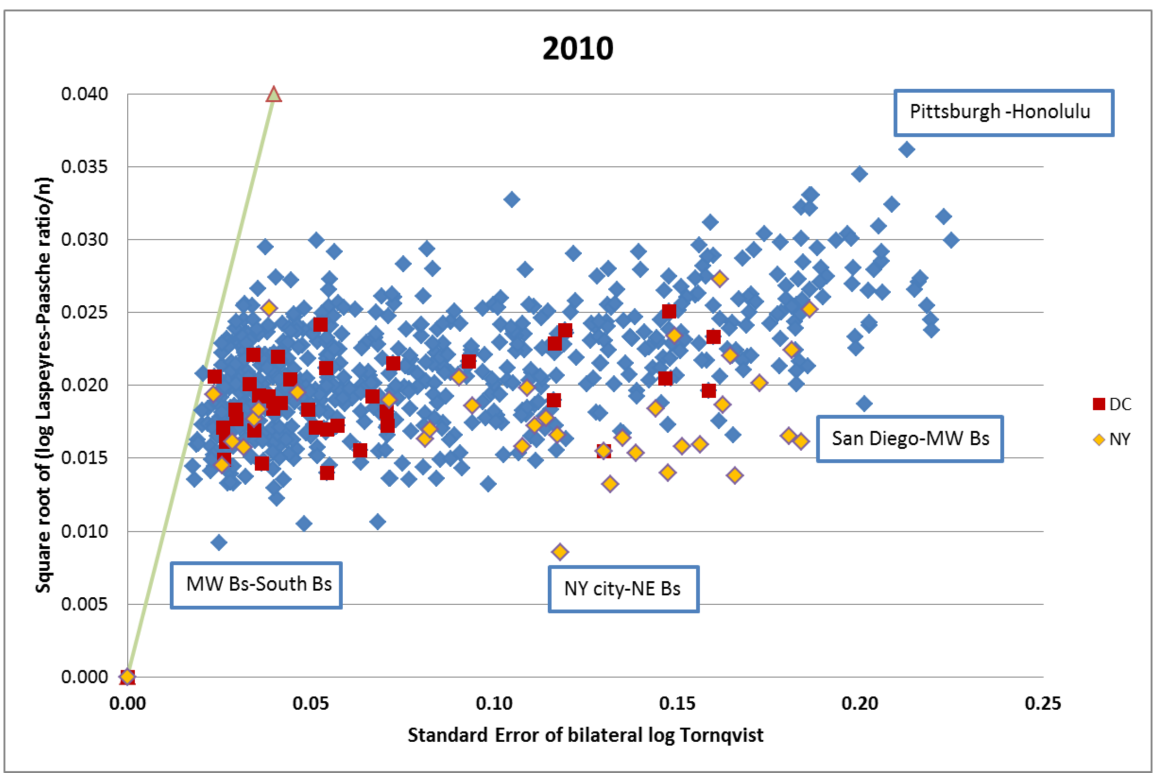


Figure 4b. Log L/P ratio and Variance of Price ratios (non-zero covariances)

Figure 5. Square root of (Log L/P ratio/n) and Standard Error of the log Törnqvist bilaterals

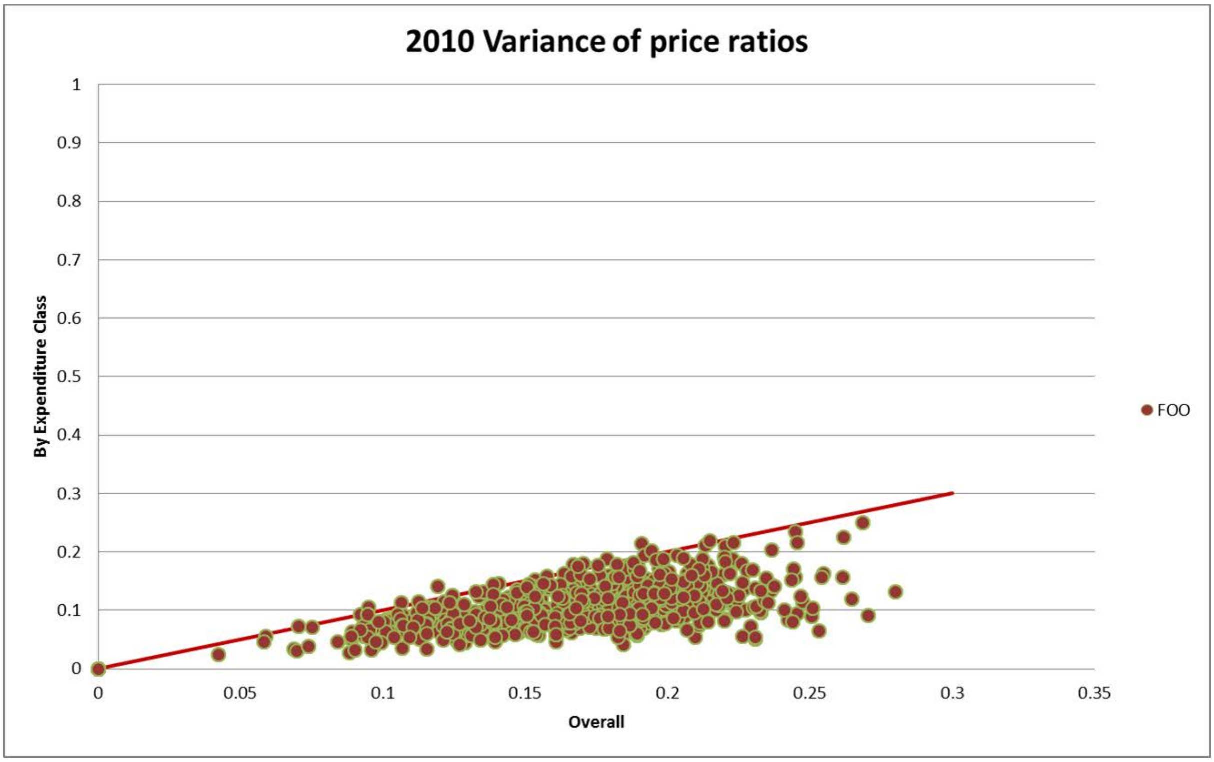


Figures 6a-6i. Standard Error of the log Törnqvist bilaterals within Headings

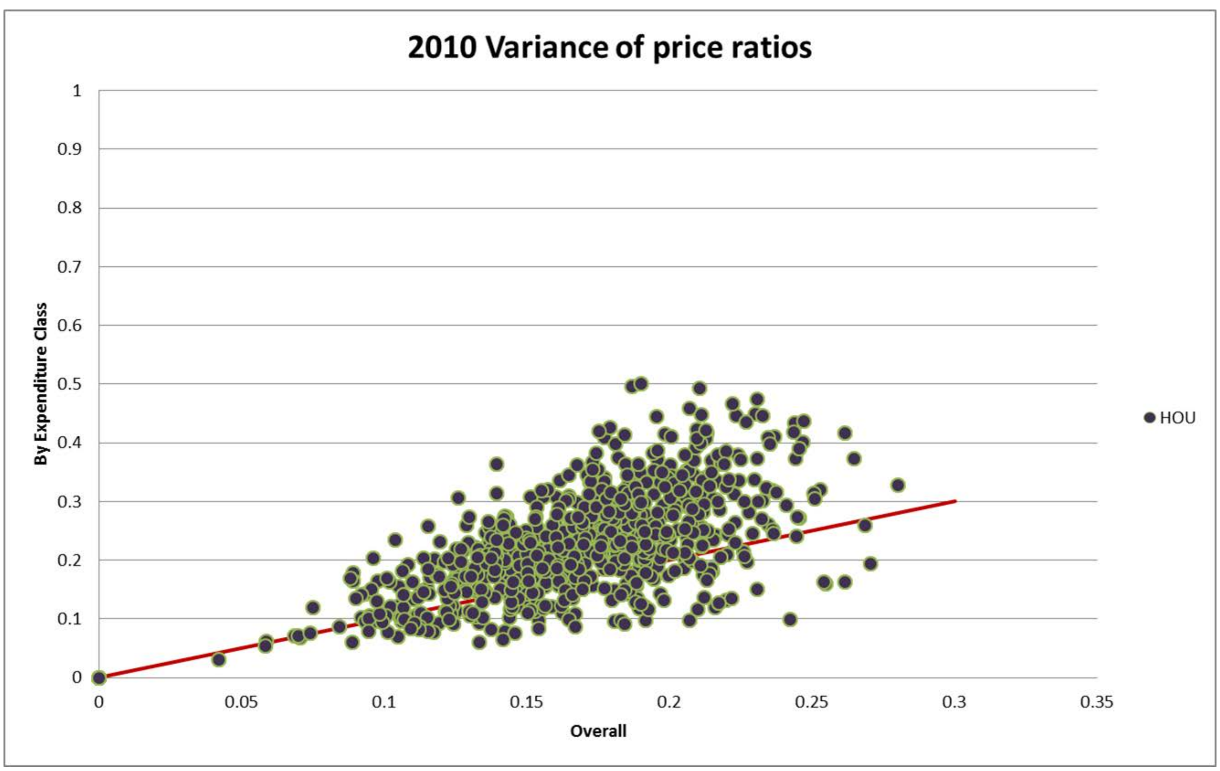
6a. APPAREL

6b. EDUCATION

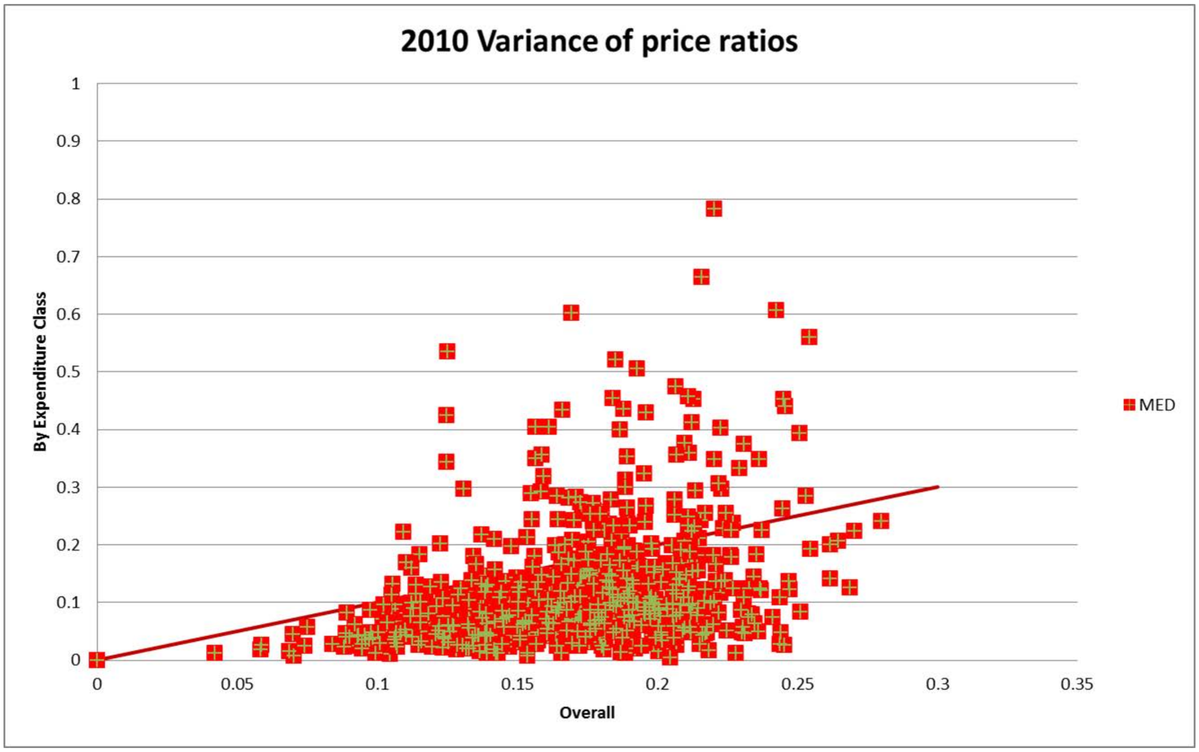
6c. FOOD



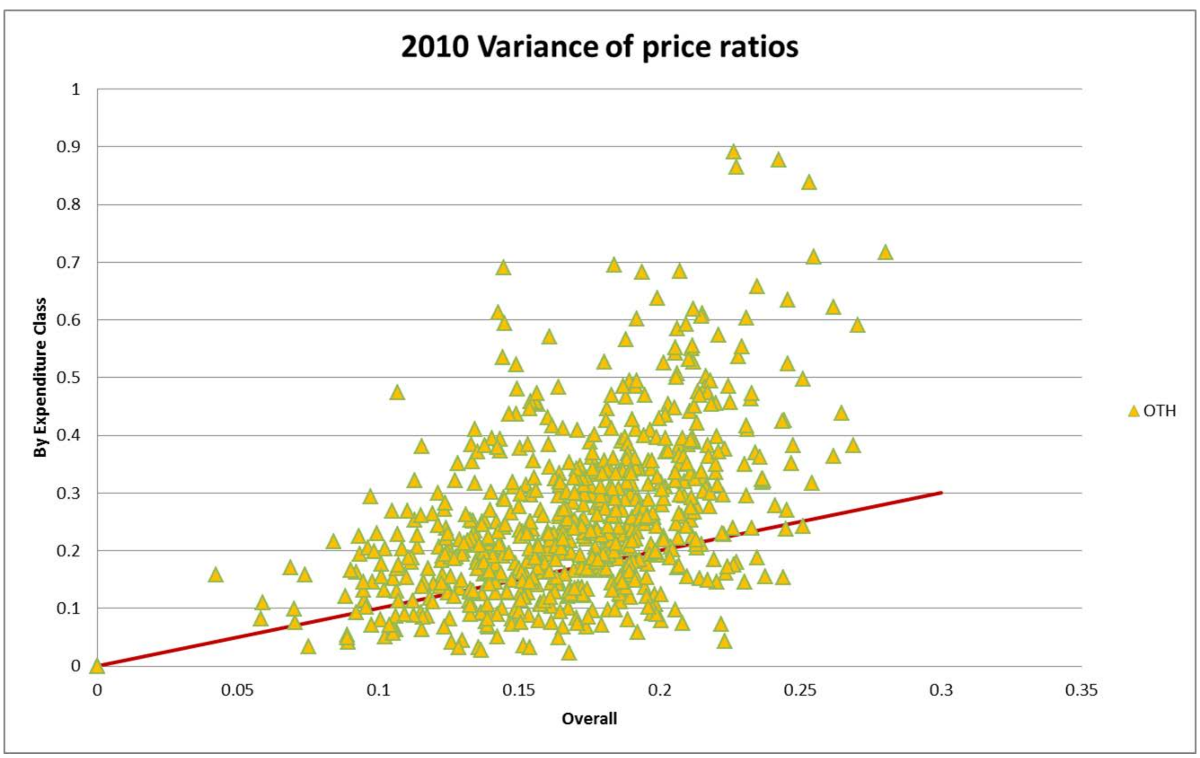
6d. HOUSING



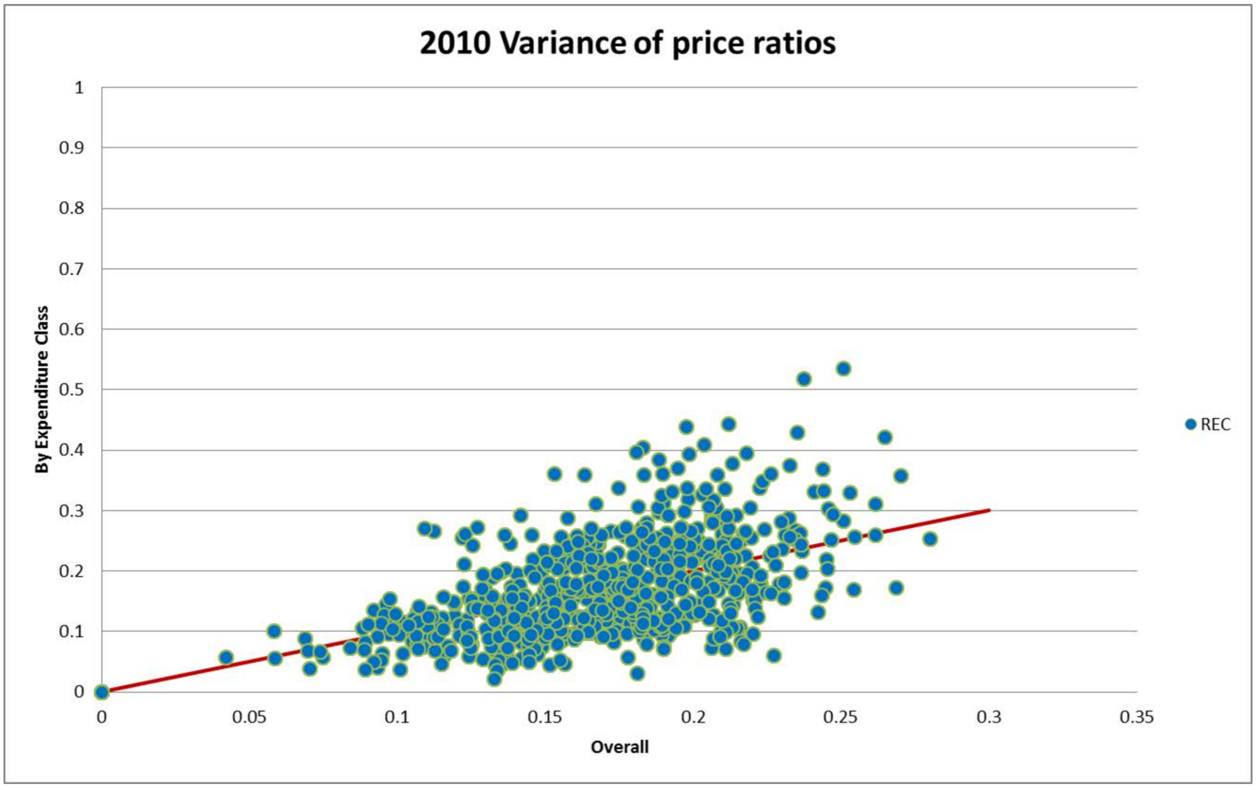
6e. MEDICAL



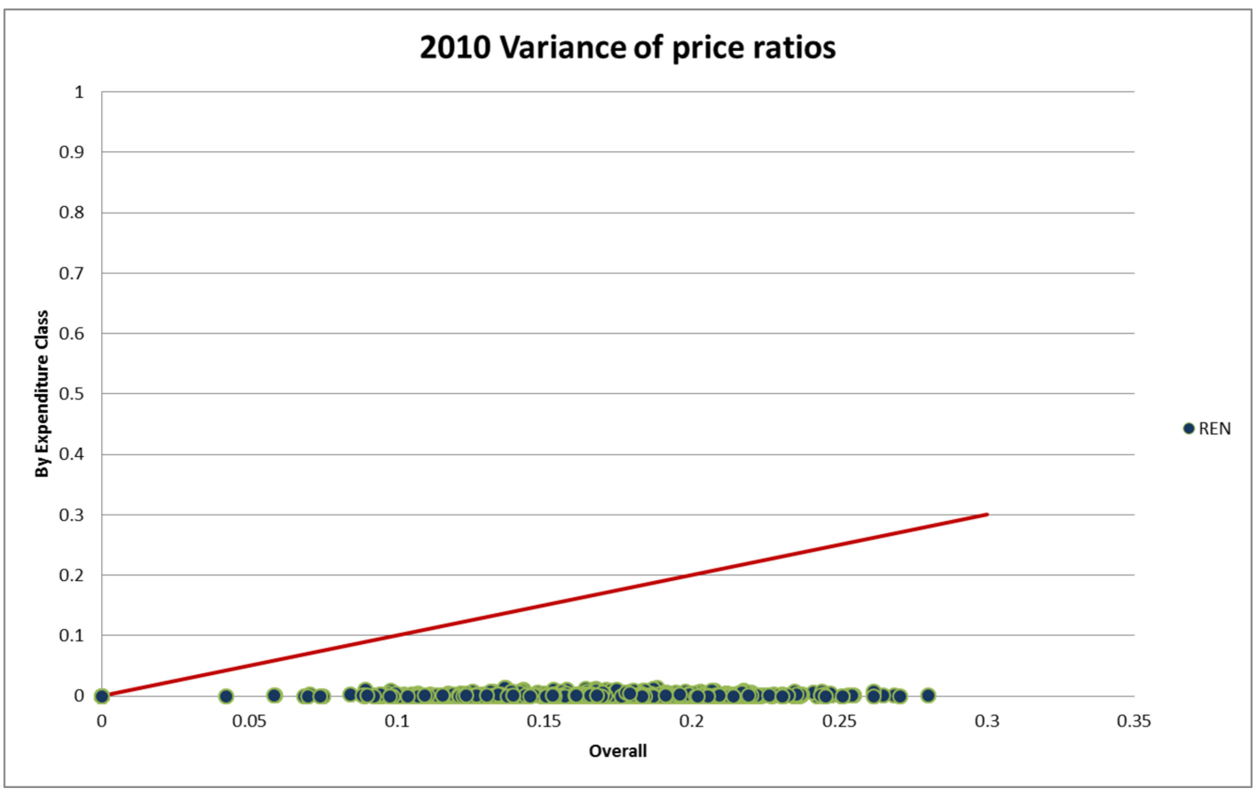
6f. OTHER



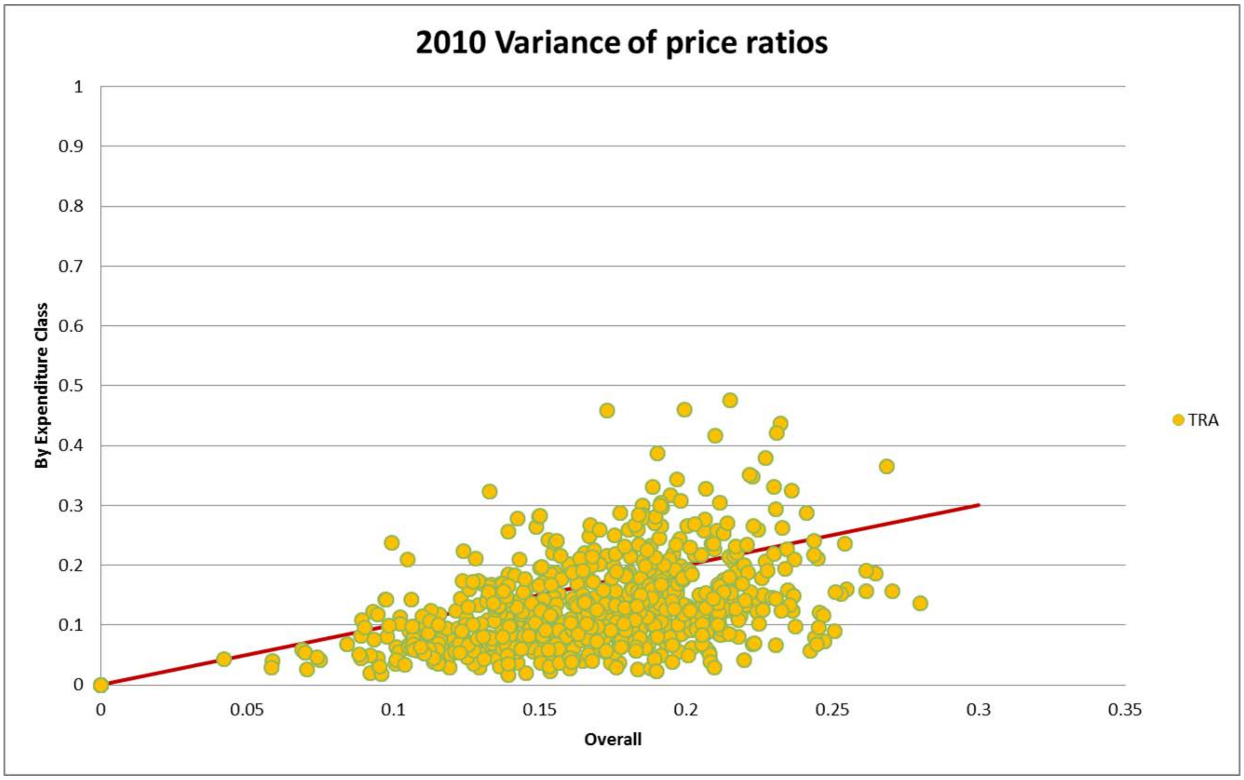
6g. RECREATION



6h. RENTS



6i. TRANSPORT



6j. ALL HEADINGS

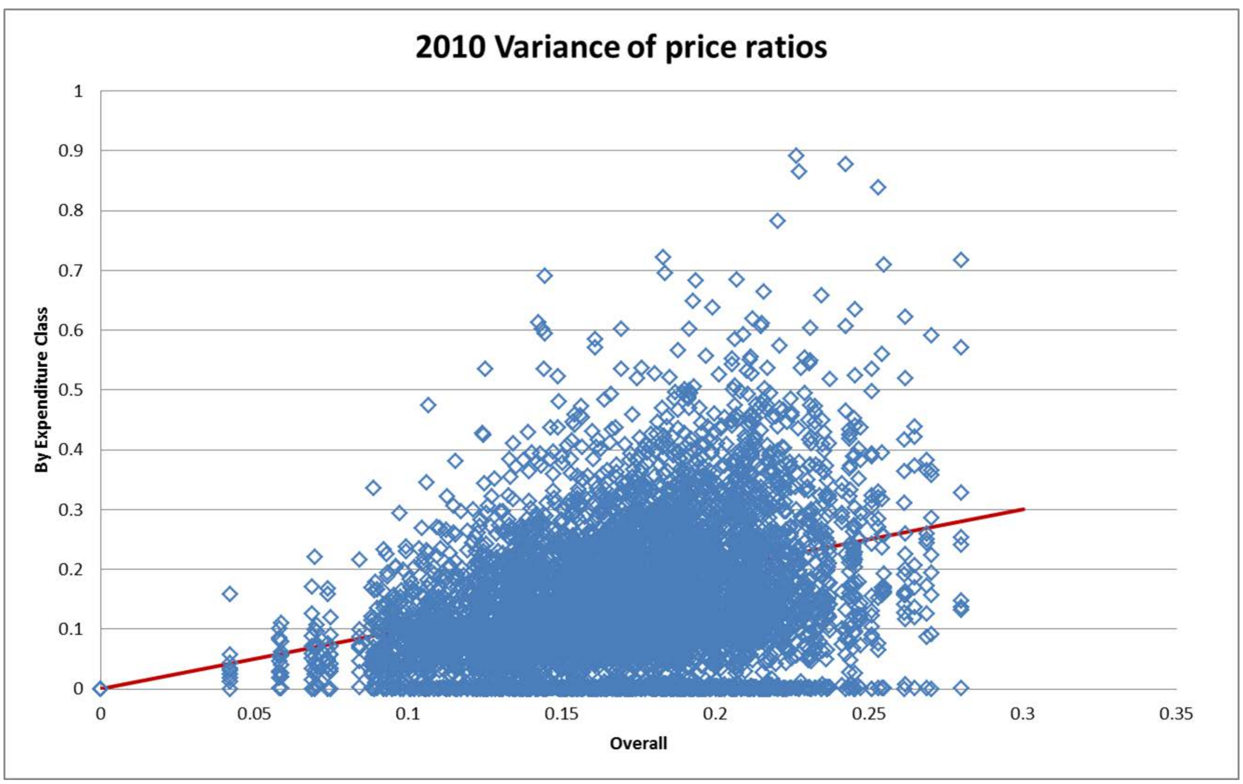


Figure 7. By Heading: Standard error of Bilateral Törnqvists

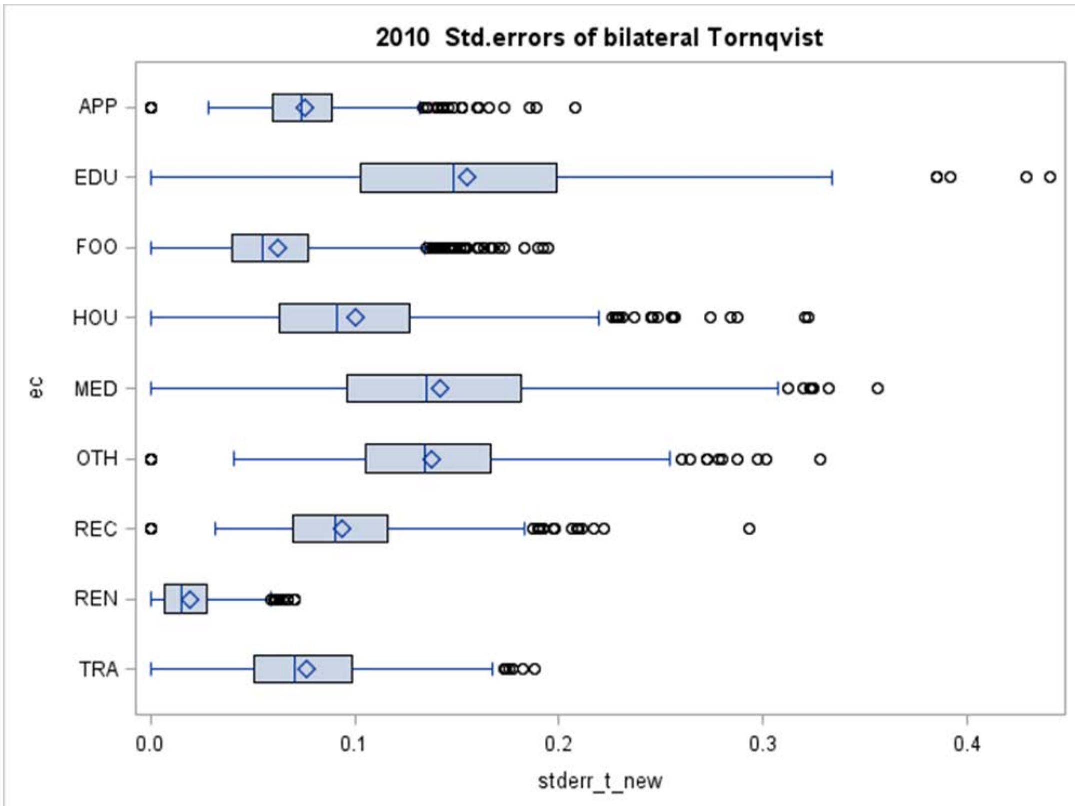


Figure 8a. Aggregate Headings (51 states): Variance of price ratios and Log L/P ratios

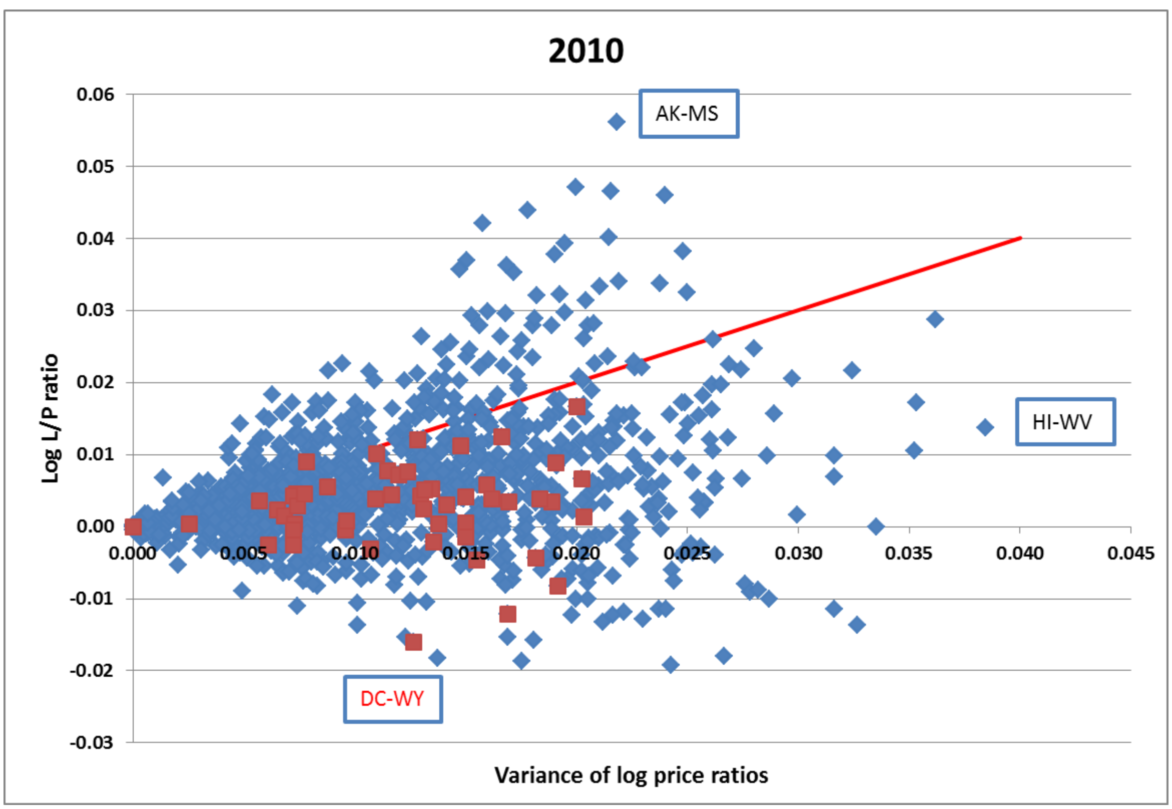


Figure 8b. Aggregate Headings (51 states): Standard error of Bilateral Törnqvists

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