

Real Personal Income and Regional Price Parities February 2021

Regional price parities (RPPs) are price indexes that measure geographic price level differences for one period in time within the United States. For example, if the RPP for Washington, DC, is 120, prices in Washington are on average 20 percent higher than the U.S. average. An RPP is a weighted average of the price level of goods and services for the average consumer in one geographic region compared to all other regions in the United States. BEA's estimates of real personal income consist of the current-dollar estimates adjusted by the RPPs and converted to constant dollars using the U.S. PCE price index.

Limitations: The RPPs use only price and expenditure-related survey data that are collected by U.S. federal agencies. These include the Consumer Price Index (CPI) survey data from the Bureau of Labor Statistics (BLS) and American Community Survey (ACS) data from the Census Bureau. The CPI data were not designed for place-to-place comparisons and do not fully represent smaller geographic units. We therefore use a 5-year rolling average of the CPI price data to smooth out inconsistencies that arise when there are items that are sparsely surveyed on a regular basis in the smaller geographies. The ACS data contain detailed geographic information on the cost of rental housing but limited information on owner-occupied housing values. In this case, we use annual data, but only the price level for renters, not for owners. We impute owner-occupied rent expenditures by combining the CPI housing estimates of owner-equivalent rents with the ACS data.

History: BEA, in a joint project with BLS, first estimated regional price parities for consumption goods and services for 38 metropolitan and urban areas of the United States for 2003 and 2004 (Aten 2005, 2006). These areas, for which BLS produces the CPI, represent about 93 percent of the total population. The method was expanded to cover the remaining rural portions of each state. Prototype estimates for 2005 and 2006 were reported in the *Survey of Current Business* in November 2008 (Aten 2008 and Aten and D'Souza 2008). Experimental estimates for 2007 incorporate the multiyear ACS, as do official estimates for 2008 forward. Publications describing these results may be found at <http://www.bea.gov/research/papers>.

Methods: The methods and results involve a two-stage, rolling average estimation process. The first stage estimates annual multilateral price level indexes for CPI areas¹ and for several consumption expenditure classes, such as apparel, food, and transportation. In the second stage, the price levels and expenditure weights² are allocated from CPI areas to all counties in the United States.³ They are then recombined for regions, such as states and metropolitan areas, and merged with ACS data on rents. The ACS provides more detailed geographic coverage than the CPI areas, including county-level data, thus allowing us to augment the allocated CPI price levels with observed housing observations.

¹ The Consumer Price Index (CPI) revised its geographic sample in 2018. For more information, see "Geographic Revisions to Source Data" on page 9.

² Expenditure weights used in the CPI are known as cost weights and are derived from BLS Consumer Expenditure (CE) survey data. See the "Consumer Price Index" in the *BLS Handbook of Methods*, Chapter 17 at www.bls.gov.

³ For a description of input data and methods used to estimate RPP expenditure weights, see Figueroa, Aten and Martin (2014).

The final RPPs are calculated by stacking 5 years of the first-stage results, plus the annual rent indexes, and calculating the multilateral aggregate price index for all goods and services and rents. For example, the 2010 RPP is a 5-year average of the 2008–2012 CPI-derived price indexes for goods and services excepting rents, plus the 2010 rent indexes from the ACS.

The following sections describe in more detail the methods used in the calculation of RPPs: the use of the price levels and expenditure data from the CPI and the housing data from the ACS, how their geographies are reconciled, and how the overall indexes are computed.

1. Price Levels for Consumer Price Index Areas

CPI price data cover a wide array of consumer goods and services, ranging from high-expenditure goods, such as new automobiles, to low-expenditure services, such as haircuts. Over a million price quotes are collected each year and are classified into more than 200 item strata, each consisting of detailed entry level items (ELIs), which may be further divided into clusters. The item strata can be combined into nine expenditure groups: apparel, education, food, housing, medical, recreation, rents, transportation, and other goods and services.⁴

Because the CPI was not designed to measure geographic price level differences, items with identical characteristics are not always priced in all areas. Therefore, for the ELIs and clusters in the 75 highest item strata (accounting for roughly 85 percent of expenditure weights), we estimate hedonic regressions that take into account the variation in the characteristics of the sampled items.

For the “Women’s Tops Excluding Active and Outerwear” cluster, for example, we use a hedonic price model to adjust for the type of clothing (jacket, sweater, or blouse), the fiber content, the length of the sleeves, the closure type, the size range, the brand category (exclusive/luxury, national, or private), country of origin, and the type of outlet where it was sold. An example of an item-specific hedonic regression may be found in Aten (2006).

For the remaining item strata, we use a shortcut approach consisting of a single weighted regression only on areas and ELIs (and clusters when available) as independent variables. Overall results do not differ greatly whether detailed hedonic regressions are run on all item strata, or only on the top 75 in combination with this shortcut approach (Aten 2006).

After the ELI price levels are estimated, they are aggregated to yield item strata price levels using a weighted country product dummy (CPD-W) approach, with weights corresponding to the importance of the ELIs within the item strata.⁵ Both the ELI and the item strata price levels undergo an outlier checking process described in detail in Aten, Figueroa and Martin (2011). Briefly, it is modeled after the

⁴ See the “Consumer Price Index,” in the *BLS Handbook of Methods*, chapter 17 at www.bls.gov.

⁵ The CPD-W is the weighted geometric mean when there are no missing observations. For a complete description, see Rao (2004).

Quaranta tables.⁶ We flag observations that are, i) either very large or small relative to the mean in that area and ELI, ii) that are either large or small relative to the variance of the ELI observations, or iii) are large or small once they have been adjusted for the relative price level of the area. It is an iterative process that looks at the raw price data as well as the relative prices after the hedonic adjustment.

Lastly, the item strata price and expenditure levels in each of the CPI areas are aggregated to 16 expenditure classes using the Geary multilateral index (Balk 2009).⁷ One of the advantages of the Geary index is that it is additive at various levels of aggregation. Previous research on the RPPs (Aten and Marshall 2010) has shown that other methods such as the EKS-Törnqvist and Fisher indexes, the CPD-W approach, and a GAIA index, tend not to deviate greatly from the Geary.⁸

The Geary multilateral price level index, P_{Geary} , is given by:

$$P_{Geary}^c = \frac{\sum_{n=1}^N (pq)_n^c}{\sum_{n=1}^N \pi_n q_n^c}$$

$$\pi_n = \sum_{c=1}^M \frac{(pq)_n^c}{P_{Geary}^c \sum_{d=1}^M q_n^d}$$

Where: p is the relative price of the item stratum or expenditure class

π is the national average price of the item stratum or expenditure class

q is the notional quantity equal to $(pq)/p$

c and d are regions, which take a value of 1 through M

n is the item stratum or expenditure class, which takes a value of 1 through N

II. Regional Price Parities for States and Metropolitan Areas

The second stage begins with the allocation of price levels and expenditure weights from CPI areas to counties. Price levels for each county are assumed to be those of the CPI sampling area in which the county is located. For example, counties in Pennsylvania are assigned price levels from either the Philadelphia or Pittsburgh areas or from the CPI Middle Atlantic region. Rural counties are not included in any of the urban sampling areas for which stage one price levels are estimated, therefore these counties are assigned price levels of the CPI regional index area in which they are located.

⁶ The process is modeled after the Quaranta method used by the Organisation for Economic Co-operations and Development, Eurostat, and the International Comparison Program of the World Bank (www.worldbank.org).

⁷ The 16 expenditure classes are derived from the 9 groups subdivided into goods and services: apparel has only goods, rents only consists of services, and the other seven groups have both goods and services.

⁸ The Geary formula is solved simultaneously for the area RPPs and the expenditure class price levels (notation and formulas follow Deaton and Heston 2010).

Expenditure weights in the second stage include CPI data for rural regions, and thus in combination with the urban areas, cover all U.S. counties. Weights are allocated from each CPI area and rural region to the component counties in proportion to household income.⁹ The county-level allocations undergo two adjustments. First, the distribution of rent weights is replaced with one based on directly observed rent expenditures from the 5-year ACS file plus imputed owner-equivalent rent expenditures. The latter are obtained as follows:¹⁰

1. The ratios of monthly tenant rents to owner-equivalent rents in the CPI housing file are estimated for several types of housing units, from studio apartments to detached houses with three or more bedrooms. The components of these ratios, that is, tenant rents and owner-equivalent rents for each housing type, are the weighted geometric means of all the observations in the CPI.
2. The ratios are applied to the observed unit rents in the ACS, resulting in an estimated monthly owner-equivalent rent value for each housing type, by county.^{11 12}
3. This estimated owner-equivalent rent value is multiplied by twelve and by the number of owner-occupied housing units in each type, resulting in an annual estimate of owner-occupied housing expenditures, by county.

Note that the ratio of tenant rents to owner-equivalent rents is across all BLS sampling areas, that is, there is only one vector of ratios for each housing type. The same ratio is applied to different geographies in the ACS file, with only the distribution of rents and number of units varying across geographies.¹³ Total expenditures by tenants and owners is equal to the sum of the observed annual rent expenditures and the estimated owner-occupied expenditures from step 3 above.

The second adjustment to the county level weights is to control the national shares of the 16 expenditure classes to BEA's personal consumption expenditure shares. This yields weights consistent with BEA's national accounts.¹⁴ The adjustment shifts the distribution of weights across expenditure classes, notably reducing the share of rents expenditures from total consumption in the United States from 31.6 percent to 23.4 percent (chart 1).

⁹ The allocation uses county-level ACS money income. Money income is defined as income received on a regular basis (exclusive of certain money receipts such as capital gains) before payments for personal income taxes, Social Security, union dues, Medicare deductions, etc. Therefore, money income does not reflect the fact that some families receive part of their income in the form of noncash benefits. For more information, see www.census.gov. In past papers, population was used to distribute the weights; for a comparison, see Figueroa, Aten and Martin (2014).

¹⁰ The imputation of owner-occupied housing expenditures is undergoing a revision and will be updated in a future release.

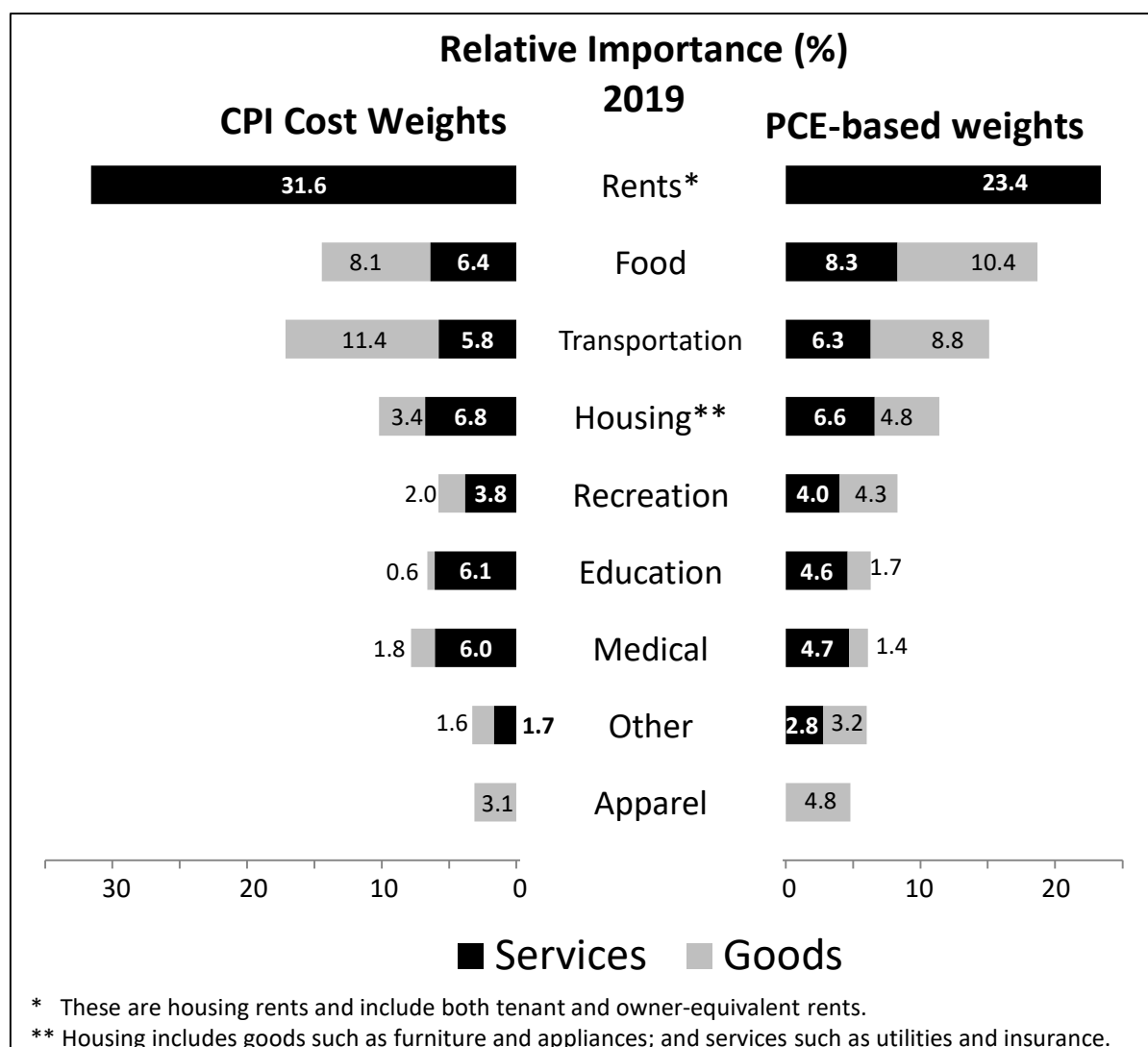
¹¹ Unit rents are the sum of rent expenditures divided by the number of units of each housing type for each area.

¹² In earlier work (Aten 2005, 2006), we imputed BLS owner-equivalent rent price levels to other geographies. Here, we only use the BLS data to obtain owner-equivalent rent expenditures; we do not impute owner-equivalent rent price levels.

¹³ For more information on how the RPP program estimates expenditures on owner-occupied rents, see Figueroa, Aten, and Martin (2014).

¹⁴ The adjustment is based on BLS research providing PCE-valued weights for CPI item strata (Blair 2012).

Chart 1. Relative Expenditure Weights: Consumer Price Index (CPI) and Personal Consumption Expenditures (PCE)-Based



Once the county price levels and expenditure weights have been obtained for each class and for each year as outlined above, we take the weighted geometric mean of the price levels for states, state metropolitan and nonmetropolitan portions, and metropolitan areas. This weighted geometric mean is a 5-year rolling average for goods and services other than rents.

Rent price levels are estimated directly from tenant rent observations in the ACS: annually for states and across 3 years for metropolitan areas. No imputation of owner-occupied rents is used in the price levels, instead we use rent price levels for both renters and owners.¹⁵ The rent price level estimates are quality-

¹⁵ In Aten and D'Souza (2008), the imputation for county-level owner-occupied rent levels used owner's monthly housing cost data from the 5-year ACS housing file, together with the annual CPI Housing Survey from BLS. In more current work (Aten, Figueroa, and Martin 2011, 2012), only observed rent price levels from the ACS were used, making no imputations for the owner-occupied rent levels. The monthly housing costs in the ACS include mortgage payments, but do not specify the term or interest rate of the loan. The coverage and distribution of the reported payments was highly variable, and using that information has been postponed until more data or further research is completed.

adjusted using a hedonic model that controls for basic unit characteristics such as the type of structure, the number of bedrooms and the total number of rooms, when the structure was built, whether it resides in an urban or rural location, and if utilities are included in the monthly rent. Additional research comparing rent price levels estimates using the ACS and CPI Housing surveys is available in Martin, Aten, and Figueroa (2011).

In the second multilateral aggregation we use the 5-year rolling average for the 15 expenditure classes derived from the CPI, together with the 1-year state level rents and 3-year metropolitan area rents from the ACS to estimate the final all items RPPs. For expenditure weights, we use 1-year files for states and 3-year files for metropolitan areas.

The multiyear rolling averages imply that for 2010, for example, final state-level RPPs are composed of rent price levels in 2010 plus an average of the price levels for goods and services other than rents between 2008 and 2012 (table 1).

III. Using Regional Price Parities to Estimate Real Personal Income

An important application of the RPPs is to control for price level differences across regions when measuring economic activity such as income levels. The price level differences measured by the RPPs are specific to one point in time. At BEA, we make an additional adjustment to convert the regional current-dollar values to constant values, resulting in price-adjusted regional incomes at constant dollars, which we call “real” personal income.¹⁶

Real personal income in constant (2012) dollars for a region begins with current-dollar personal income divided by its RPP for a given year and balanced so that the sum of personal income remains the same before and after the adjustment.¹⁷ The balancing uses a factor equal to sum of the adjusted income divided by the sum of the current-dollar income.

These RPP-adjusted results (equal to current-dollar income in regional prices) are divided by the U.S. PCE price index, which converts the current-dollar value to 2012 constant dollars.¹⁸

In 2012, the U.S. nominal and real personal income totals will be equal. For each region, nominal and real personal incomes will differ only by the balanced RPP (the RPP multiplied by the balancing factor).

¹⁶ Personal income is defined as the income received by all persons from all sources. It is the sum of net earnings by place of residence, property income, and personal current transfer receipts. For more information, see www.bea.gov/regional.

¹⁷ The national price level is the RPP reference (U.S. = 100.0) so the adjustment with the RPPs should not change the sum of personal income across areas.

¹⁸ The U.S. PCE price index is a chained dollar estimate. In previous versions we used the term “chained” when converting current-dollar incomes to constant dollars, but our real personal income estimates themselves are not chained, so we will refer to them only as constant-dollar estimates.

Below is an example of the price adjustment for the state of Montana in 2019 (billions of dollars): ¹⁹

$$\begin{aligned} \text{Balancing factor}_{States,2019} &= \sum_{i=1}^{51} \left(\frac{\text{Current \$ } PI_i}{RPP_i} \right) / \sum_{i=1}^{51} (\text{Current \$ } PI_i) \\ &= 18,464 / 18,542 \\ &= 0.996 \end{aligned}$$

subscript $i = 1 \dots 51$ States and the District of Columbia

$$\begin{aligned} RPP \text{ Adjusted Personal Income } (PI)_{Montana} &= \frac{(\text{Current \$ } PI)_{Montana}}{RPP_{Montana} * \text{balancing factor}_{States,2019}} \\ &= \frac{\$53.2}{0.935 * 0.996} \\ &= \$57.1 \end{aligned}$$

$$\begin{aligned} \text{Real Personal Income}_{Montana} (\text{Constant 2012 \$}) &= \frac{RPP \text{ Adjusted } PI_{Montana}}{PCE \text{ Price Index}} \\ &= \frac{\$57.1}{1.099} \\ &= \$52.0 \end{aligned}$$

The implicit regional price growth rate is the change in the balanced RPPs between two years times the change in the U.S. PCE price index (see Box below titled “Implicit Price Growth Rates”).

¹⁹ The example uses current-dollar state personal income estimates that were released on September 24, 2020.

Implicit Price Growth

The RPP indexes express a region's average price relative to the U.S. average, that is,²⁰

$RPP_{i,t} = (P_i / P_{US})_t$ where i is the region and t is the time period.

The implicit price growth or implicit regional inflation may be calculated as:

$$(P_{i,t} / P_{i,t-1}) = (RPP_{i,t} / RPP_{i,t-1}) * (P_{US,t} / P_{US,t-1})$$

Where: *RPPs are balanced*

US price change is measured by the national PCE price index.

The real personal income statistics in this article use the national PCE price index to measure U.S. price change over time and RPPs to capture the change in price level differences across regions.

IV. Publication Schedule

Estimates of real personal income and regional price parities are published annually. Starting in 2020, the regular release of data is in December, 12 months after the end of the reference year. This schedule is due to the complexity of RPP estimation methods and the release schedule of inputs, in particular the rents data from the ACS that are available only in the fall months following the reference year.

The estimates are published for three sets of geographies: states (including the District of Columbia), state metropolitan and nonmetropolitan portions, and metropolitan statistical areas. RPPs for metropolitan areas include the nonmetropolitan portion of the United States to provide complete coverage of all U.S. counties.

The estimates are regularly revised, in part to reflect revisions in current dollar personal income—see methodologies for State and Local Area personal income on the BEA website—but also because of the availability of new source data for constructing the RPPs. As discussed above, the estimation uses 5-year rolling average data for price levels other than rents. When initially released, the RPPs use rolling average data ending in the reference year. For example, in May 2020, the newly released estimates for 2018 used a rolling average price level dataset covering 2014 to 2018. In December 2020, these “initial” estimates for 2018 were revised using a dataset covering 2015 to 2019. In December 2021, these “revised” estimates will become “final” with the availability of a rolling average dataset for 2016 to 2020, centered on the 2018 reference year.

²⁰ The Geary RPP indexes are multilateral indexes that compare area prices with national prices. National prices are defined as quantity-weighted averages of the local area prices of each good. The national prices and the RPPs are solved for simultaneously (see the section “Data and Methodology”).

Table 1. Revision status and price level source data, by RPP reference year:

			2008	2009	...	2015	2016	2017	2018
Price Level	Region	Source	Final	Final		Final	Final	Revised	Initial
Rents	States and Portions	ACS	2008	2009	...	2015	2016	2017	2018
	Metropolitan Areas	ACS	2006-2008	2007-2009	...	2013-2015	2014-2016	2015-2017	2016-2018
Other	All	CPI	2006-2010	2007-2011	...	2013-2017	2014-2018		

Geographic Revisions to Source Data

Source data used to estimate regional price parities (RPPs) and real personal income (PI) periodically undergo revisions to their area definitions:

- The CPI program updated its geographic sample in 2018, revising area definitions that had been in place since 1998. Data using the revised areas will be introduced year-by-year into 5-year rolling averages described in section II. For more information about the CPI area revisions, see www.bls.gov/cpi.
- BEA's regional estimates of personal income use area delineations defined by the Office of Management and Budget (OMB). When these are revised, the changes are reflected in real PI for that reference year and the 2 prior years. No other years are revised. For more information about BEA's statistical area delineations, see <https://apps.bea.gov/regional/docs/msalist.cfm>

Acknowledgements

This work would not be possible without the collaboration of the Bureau of Labor Statistics and the Census Bureau. In particular, we thank the staff of the Consumer Price Index (CPI) program in the Office of Prices and Living Conditions at BLS and the staff of the Social, Economic and Housing Statistics Division of the Census Bureau for their technical and programmatic assistance.

Disclaimer

The BEA Regional Price Parity statistics are based in part on restricted access Consumer Price Index data from the Bureau of Labor Statistics. The BEA statistics expressed herein are products of BEA and not BLS.

References

- Balk, Bert, 2009, "Aggregation Methods in International Comparisons: an Evaluation", in D. S. Prasada Rao (ed.), *Purchasing Power Parities of Currencies, Recent Advances in Methods and Applications*, Edward Elgar Publishing.
- Blair, Caitlin (2012), 'Constructing a PCE-Weighted Consumer Price Index.' National Bureau of Economic Research (NBER) Working Paper (March); www.nber.org.
- Deaton, Angus and Alan Heston (2010), 'Understanding PPPs and PPP-Based National Accounts', *American Economic Journal: Macroeconomics* 2, no.4 (October): 1-35.
- Rao, D.S. Prasada (2004), 'On the Equivalence of Weighted Country-Product-Dummy (CPD) Method and the Rao System for Multilateral Price Comparisons', *Review of Income and Wealth*, 51, 571-580.