

# A comparison of PCE and CPI: Methodological Differences in U.S. Inflation Calculation and their Implications November 2017

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## **Abstract**

Inflation is a key economic indicator reflecting the health of an economy. Its impact on measuring economic health is amplified by its use as an adjustment to other economic variables, including real GDP and real wage growth. There are a number of components to inflation estimation, and the methodology for each can differ, leading to different inflation estimates. The Consumer Price Index (CPI) and Personal Consumption Expenditures Price Index (PCE) are two U.S. inflation metrics that use different methodologies, and therefore produce different estimates. According to the Bureau of Economic Analysis (BEA), the differences can be grouped into four effects: formula, weight, scope, and ‘other.’ This research evaluates two effects, weight and scope, and discusses their implications. The weight effect is a result of differences in how consumer expenditure data are sourced. CPI sources data from consumers, while PCE sources from businesses. The scope effect is a result of the different types of expenditures CPI and PCE track. For example, CPI only tracks out-of-pocket consumer medical expenditures, but PCE also tracks expenditures made for consumers, thus including employer contributions. The implications of these differences are considerable. Many contracts and government programs are tied to inflation, from rental agreements to social security, valued in the trillions of dollars over time. Small differences in the estimated level of inflation can thus have far reaching impact, as even a tenth of a percent difference translates into billions of dollars.

**Key Words:** Price indexes, Consumer Price Index (CPI), Personal Consumption Expenditure Price Index (PCE), Inflation, Consumer Expenditure Survey (CE), Price Change Measurement

**Any opinions expressed in this paper are those of the author(s) and do not constitute policy of the Bureau of Labor Statistics.**

## **1. Introduction**

There is a large body of research investigating the difference between the Consumer Price Index (CPI) and the Personal Consumption Expenditure Price Index (PCE). The CPI and the PCE, and their core inflation counterparts, are two primary metrics of U.S. inflation. The Bureau of Labor Statistics (BLS) produces the CPI, while the Bureau of Economic Analysis (BEA) produces the PCE. CPI and PCE are the primary indicators used by policymakers and academics when evaluating inflation faced by households in the United States. Inflation is an important measure of an economy’s health; moreover, its importance is amplified because it is used to adjust other economic indicators, thus enabling

economists and policymakers to evaluate “real” changes in economic data rather than “nominal” ones. The variance between them raises a number of questions. What causes this difference? How and why are they different? Is one better than the other? If so, why produce both, especially in an era of federal budget tightening? Therefore, it is important to understand what each inflation metric offers to users, what their advantages and disadvantages are, what drives their differences, and why both provide useful, albeit different, insight into the economy.

According to the literature, the causes for the difference between CPI and PCE can be attributed to four effects: formula effects, scope effects, weight effects, and other effects. These are the effects that result from the various methodological differences in the construction of the two indexes. There are a number of methodological components involved in constructing inflation indexes. Formulas, weights, and scope are three such components, the impact of each being singled out—with the impact of the remaining components combined in the ‘other’ category. The formula effect is a result of the indexes using different formulas; the CPI uses a Laspeyres-type index formula, while the PCE uses a Fisher Ideal index formula. The scope effect reflects the difference in definitions between what the CPI and the PCE are trying to measure. The CPI considers only the urban population and out-of-pocket expenditures by consumers. The PCE considers both urban and rural populations, and includes all expenditures purchased on behalf of consumers, even if it is by a third party such as a non-profit. The weight effect is the result of sourcing consumer expenditure data—which are used to weight the price changes of items—from different surveys. Expenditures in the PCE Price Index use the Personal Consumption Expenditures from the National Income and Product Accounts (NIPA) tables, hence the name of the index. These expenditures measure what businesses sell to consumers. CPI expenditures are sourced from the Consumer Expenditure Survey (CE), which is a combination of two surveys of what consumers purchase from businesses. The PCE and CE surveys not only have different respondents and different goals, they have different survey methodologies. The scope and formula differences have ancillary weight effects in addition to the survey-derived weight effect. Finally, there are other differences that result from a combination of factors, such as the varying price data.

This research looks into which items in the CPI market basket drive the weight and differences. By building on research done by Caitlin Blair, this analysis uses the expenditures from the PCE to create a PCE-weighted CPI index. Doing this brings the two indexes closer together and isolates the impact of the survey source for expenditure data. Going further, the PCE-weighted CPI expenditure data are also adjusted to reflect scope differences in order to see the impact of the scope and weight effect combined, thereby accounting for scope-related weight effects. Finally, the indexes that were created are used to deflate nominal economic data. The importance of an accurate inflation measurement can be seen in its impact on economic data, in this case Social Security adjustments.

The paper ends with an overview of future research that could be conducted and a discussion of unresolved issues.

## **2. Literature Review**

They are constructed differently, leading to differences in their measurement of inflation. Constructing a consumer price index to measure inflation requires combining two primary

components, weights and prices, using an index formula. Before that, however, one should decide how to define inflation—in other words, the scope. Is inflation the price increase faced by consumers, urban consumers, or working consumers? Do price increases of goods and services consumers do not purchase themselves warrant inclusion? Once the scope has been determined, one needs to pick a market basket that reflects the goods and services consumers purchase. The change in prices for the goods in the market basket are then tracked. The price changes are subsequently weighted to reflect various items' proportional impact on consumers' budgets. Prices are weighted to reflect that different items affect consumers to a varying degree: a price change in rent will impact consumers more than one in photography equipment. These weights are created using expenditure data from surveys that determine what proportion of total spending various items contribute. For example, in a two-item economy, if consumers spend \$90 on rent and \$10 on photography equipment, the price changes of those items would be weighted 90% and 10%, respectively. Weights are updated periodically to reflect changes in consumer preferences. The weights and prices are combined using an index formula to create a price index.

According to the BLS Handbook of Methods, the CPI's scope is limited to out-of-pocket expenditures by non-institutional urban consumer households only. The BLS collects prices for the market basket items that comprise the index from outlets determined by the Telephone Point of Purchase Survey (TPOPS). TPOPS asks consumers where they purchased market basket items. The price changes are then weighted using data from the Consumer Expenditure Survey (CE). This survey asks consumers what they are buying and how much they spend. The prices and weights are then combined using a Laspeyres index formula.<sup>1,2</sup>

The PCE is constructed differently. According to the NIPA Handbook, the PCE's scope includes both urban and rural households; furthermore, it considers both expenditures on behalf of consumers by third parties and out-of-pocket expenditures. These third party expenditures can be from non-profits, the government, or the private sector—for example health insurance purchased for employees. This broader scope means there is a larger total amount of spending in PCE's calculation. Prices in the PCE come from a variety of sources, but most of them are the same as those used in the CPI. In some circumstances the prices are sourced elsewhere. The weights used in the PCE come from the eponymous Personal Consumption Expenditure data in NIPA. The prices and weights are combined using a Fisher Ideal index formula, which ameliorates substitution bias.<sup>3</sup>

Substitution bias arises in consumer price indexes—especially those using Laspeyres index formulas like CPI—as a result of holding weights fixed for a period of time. Consumers

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<sup>1</sup> Prices are weighted according to their expenditures reported in the TPOPS and aggregated using a geometric mean or Laspeyres formula to calculate local area indexes for each item. These basic indexes are then aggregated across items and areas using a Laspeyres formula. Technically this is a modified Laspeyres, or Lowe index; however, the literature primarily refers to CPI as a Laspeyres index, and the definitional difference is slight.

<sup>2</sup> This is a simplification of the construction of CPI. For more information, please see Chapter 17 of the BLS handbook.

“Chapter 17. The Consumer Price Index (Updated 06/2015),” Bureau of Labor Statistics, accessed July 12, 2017, <https://www.bls.gov/opub/hom/pdf/homch17.pdf>.

<sup>3</sup> For more on the construction of PCE, please see Chapter 5 of the NIPA handbook.

“Concepts and Methods of the U.S. National Income and Product Accounts (Chapters 1-10 and 12),” Bureau of Economic Analysis, accessed July 12, 2017, <https://www.bea.gov/national/pdf/allchapters.pdf>.

seeking to maximize their utility with a fixed budget will often substitute similar items based on price changes. A consumer might substitute apples for oranges based on a change in their relative prices, or shift spending from landline phones to mobile phones. Because the CPI uses a Laspeyres formula that holds weights fixed for two years, it is affected by substitution bias, as it is not accounting for changing quantities in that time period. Substitution bias generally overstates inflation, as it does not account for people switching to relatively cheaper goods.<sup>4</sup> PCE's Fisher Ideal formula mitigates substitution bias by incorporating weight data from current time periods to take into account new quantities. While this provides a more accurate inflation estimation, its limitation is that the time needed to collect current period expenditure data for weights leads to a lag in index publication. For example, if one wanted to calculate inflation for May, and it takes a few months to collect and assemble expenditure data, one would need to wait until well after May to finish producing the index value.

Given the differences in the construction and output of these two inflation metrics, it is fair to ask whether one of them is better. The Federal Reserve, for example, primarily uses the PCE for its monetary policy and economic outlook analyses. Does that indicate the PCE is more accurate or reliable? In a word, no. When the Fed switched to using the PCE, they gave three justifications, which highlight its advantages: the PCE index, because it reduces substitution bias, more accurately captured consumer behavior; the PCE data—to the best of BEA's ability—are revised in their entirety to reflect methodological changes when they happen; and the scope of the PCE was broader and thus captured more of the economy.<sup>5</sup> To address the first concern, the BLS began producing a new index, known as the chained-CPI, which employs a Tornqvist index formula. The Tornqvist formula, similar to the Fisher Ideal formula, mitigates substitution bias, but has a lag in production as well. Furthermore, some users prefer the CPI's earlier release. Per the second comment, while the revision process may be beneficial for the Fed's data analysis, other users prefer the CPI's data precisely because it is static and generally not revisable.<sup>6</sup> On the last point, while it is true that the PCE captures the price changes for a wider swath of the economy, some users prefer the CPI because it narrowly targets the inflation being felt by consumers specifically. Both indexes have users who prefer various other components of their respective methodologies.<sup>7</sup> In fact, while the Federal Reserve primarily uses the PCE, it monitors the CPI as well in order to get a multifaceted view of inflation. Thus, neither is objectively better, and both serve useful purposes, answering different questions.

With both indexes providing useful, yet different, insights into the economy, many have sought to identify the cause of the divergence between the two. As mentioned, there are a variety of differences in both the goal and construction of the CPI and the PCE. Those

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<sup>4</sup> For more on substitution bias, see the Boskin Commission Report. This report studied the impact of the CPI on government programs, and potential improvements to the CPI. Written in plain language, it gives a clear review of the challenges of inflation estimation, including accounting for substitution bias. Boskin, Michael J., E. Dulberger, R. Gordon, Z. Griliches, and D. Jorgenson, "Toward A More Accurate Measure Of The Cost Of Living," Social Security Administration, accessed July 12, 2017, <https://www.ssa.gov/history/reports/boskinrpt.html#cpi1>.

<sup>5</sup> "Monetary Policy and the Economic Outlook," The Federal Reserve Boards, accessed July 12, 2017, <https://www.federalreserve.gov/boarddocs/hh/2000/February/ReportSection1.htm>.

<sup>6</sup> CPI is only revised for seasonal adjustments. Because it is not frequently revised, it is better for indexing payments and prices in contracts.

Todd E. Clark, "A comparison of the CPI and the PCE Price Index," *Economic Review* (1999): 15-29.

<sup>7</sup> Ibid

individual differences contribute varying amounts to the total difference between the two indexes. The causes of the difference between CPI and PCE are typically organized into four effects: scope effects, weight effects, formula effects, and other effects.

The formula effect is a result of CPI using the Laspeyres index formula and PCE using the Fisher-Ideal index formula. The Laspeyres formula holds the weight of each item constant, while the Fisher-Ideal formula allows the weights to fluctuate. This means that if the price of an item changes, the weight in a Laspeyres index will stay fixed even if people start buying substitute items as a reaction to higher prices; meanwhile, the weight in a Fisher Ideal index would change to reflect consumers' substitutions into or away from comparable items. This means that CPI inflation is typically higher than PCE inflation, because it does not capture people purchasing relatively cheaper substitutes for items when prices change.<sup>8</sup>

The scope effect is a result of the different population and expenditure definitions that the BLS and the BEA use when defining what should be included in the CPI and the PCE, respectively. As mentioned, the scope of each index is determined differently, reflecting the goal of each index. CPI considers only urban out-of-pocket expenditures, while PCE considers out-of-pocket expenditures by, and on behalf of, both urban and rural consumers.<sup>9</sup>

The weight effect has several components, and is slightly more complicated. The weight effect is the result of the difference in sourcing for the expenditure data used to weight the price changes in the indexes. The CPI uses CE data that relies on consumers to report what they bought, whereas the PCE uses NIPA's Personal Consumption Expenditure data to determine what businesses sold to consumers. The surveys not only differ in who the respondents are, but also in terms of sample size and data integrity. There are also weight effects within the scope effect and formula effect. The difference in scope means that different weights are attributed to some items not by virtue of the survey methodology differences, but because the PCE includes some expenditures—such as those made on behalf of consumers or by rural consumers—that the CPI does not include. For example, employer-provided insurance contributes nothing to the CPI weight for healthcare. The formula effect also has a weight effect, in that the two indexes use formulas that utilize the weight data differently: one keeps the weights fixed, while the other allows them to vary.<sup>10</sup>

The other effects are those not resulting from formula, scope, or weight differences, and comprise a myriad of other differences between the two, most notably the difference in price sourcing. Most prices in the PCE are the same as the prices in the CPI, but the BEA also utilizes price data from other sources for certain items. There are also differences in each index's seasonal adjustment methodology.<sup>11</sup>

The above differences are well documented—many papers detail the differences between the CPI and the PCE, and debate their respective benefits and flaws. In addition to qualitative analysis on the subject, several authors have sought to quantify the contribution each of the effects has on the total gap between the PCE and the CPI. Some of the original

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<sup>8</sup> McCully, Clinton P., Brian C. Moyer, and Kenneth J. Stewart, "Comparing the Consumer Price Index and the Personal Consumption Expenditures Price Index," *Survey of Current Business*, November 2007: 26–33.

<sup>9</sup> Ibid

<sup>10</sup> Ibid

<sup>11</sup> Ibid

work on the subject is still produced by the BEA on a monthly basis.<sup>12</sup> The work in this paper builds on work previously done by Caitlin Blair of the BLS. Her work uses PCE's weight data, in what is otherwise a CPI index, to show the weight effect. She also adjusted those results to try to match the CPI scope to remove the scope effect and the scope-related weight effect. Using the CPI formula also removes the formula-related weight effects.<sup>13</sup>

Throughout the literature there are four categories of items that are persistently mentioned because of their impact on the difference between the CPI and the PCE: healthcare, housing, education, and “vices” like alcohol and tobacco. These items are some of the most affected by the differing methodologies mentioned above. Healthcare is weighted substantially more in PCE because PCE includes third party expenditures made on behalf of consumers. Employer-provided health insurance and government health programs are excluded from the CPI, but they are included in the PCE. As a result, housing—which in the CPI is by far the highest weighted—becomes less heavily weighted, with healthcare spending displacing some of the percentage of total spending that housing represents. Housing differences also exist as a result of methodological and definitional differences, especially when it comes to owner-occupied housing. Similar to healthcare, a lot of education spending is done by third parties, such as the government and non-profits, on behalf of consumers, through public education, financial aid, and student loans, thus created a marked difference between the surveys. There are also methodological differences in how CPI's CE survey and PCE capture private education spending, with CE only using out-of-pocket costs, and PCE approximating spending by looking at private school operating expenses. The difference in “vices” is a function of reporting. Respondents in the Consumer Expenditure Survey may not want to admit how much they spend on alcohol and tobacco; however, the business respondents in the Personal Consumption Expenditure survey have no fear of opprobrium in admitting how much of those products they sell. Therefore, such goods are usually more heavily weighted in PCE.<sup>14</sup>

### 3. Methodology

In order to investigate the impact of the weight effect—primarily driven by the different sources for expenditure data—on indexes, PCE expenditure data were allocated to CPI items to create PCE-weighted CPI indexes. They are PCE-weighted CPI indexes because aside from the weights, all the other methodology is the same as in typical CPI index construction. If all the components of the indexes are the same except the weights, the difference between the indexes can approximate the difference caused by the weights. This was done twice: once changing only the weight data source, and once adjusting the expenditures for scope as well to account for scope-related weight effects. Because both the unadjusted and adjusted indexes use the CPI Laspeyres index formula, they both

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<sup>12</sup> “Table 9.1U. Reconciliation of Percent Change in the CPI with Percent Change in the PCE Price Index”, Bureau of Economic Analysis, accessed July 12, 2017, <https://www.bea.gov/iTable/iTable.cfm?reqid=12&step=3&isuri=1&1203=75#reqid=12&step=3&isuri=1&1203=2075>.

<sup>13</sup> Caitlin Blair, “Constructing A PCE-Weighted Consumer Price Index,” *National Bureau of Economic Research Working Papers* 19582 (2013): 1-26.

<sup>14</sup> Garner, Thesia L., G. Janini, W. Passero, L. Paszkiewicz, and M. Vandemia, “The CE and the PCE: a comparison,” *Monthly Labor Review* (2006): 20-46.

account for formula-related weight effects. This work was done by following the methodology set out by Caitlin Blair.<sup>15</sup>

The first step was to create a concordance, or bridge, between the CPI and PCE item classification systems. To do this, every CPI item—technically CPI sub-items called Entry-Level Items (ELIs)—was mapped to a corresponding PCE category. In most cases, ELIs matched one-to-one with PCE categories; however, in some cases, they matched to multiple PCE categories, or did not map to a PCE category at all.<sup>16</sup> When there were multiple PCE categories for a given ELI, the ELI was split between them. When available, Consumer Expenditure Survey data from sub-categories of the ELIs were used to create a split factor. If the ELI's subcategories did not conform to PCE categories, then raw survey data could be used to split a given subcategory to isolate expenditures on specific purchases that matched the PCE categories. If that also failed, a split ratio was created based on BEA's Input-Output (IO) data. IO data are BEA estimates of total spending on components of the economy, many of which have direct matches with PCE categories.<sup>17</sup>

Some examples help illustrate this system. The ELI Men's Suits matches one-to-one with the PCE category Men's and Boys' Clothing. No splits are required. The ELI Ham had to be split between two PCE categories, as canned ham is categorized differently from other pork in the PCE. Luckily, this ELI has two subcategories: one containing non-canned ham, which maps to Pork, while the other, with canned ham, maps to Other Meats. Thus, Ham was split using a ratio of the expenditures of these two subcategories, as they matched with their respective PCE categories. Such ratios are known as allocation ratios, because they allocate CPI expenditures to PCE categories.

Other ELIs were more difficult. The ELI Men's Accessories needed to be split between two PCE categories. The CPI includes wallets and umbrellas in this ELI, along with all other accessories. In the PCE, however, wallets and umbrellas are in the Luggage and Similar Personal Items category, with all other accessories being placed in the Men's and Boys' Clothing category. Unfortunately, wallets and umbrellas are mixed with other accessories in the same ELI subcategory. To resolve this, survey data were queried to determine how much expenditure data referenced wallets and umbrellas. The results were used to create ratios allocating expenditures between the two PCE categories. If there were no survey data to determine such a split, an alternative data source, the IO tables, were used to approximate total spending on the PCE categories in question. The total spending figures provided data to create a ratio. For example, there were no CPI data to determine how to split expenditures between the PCE categories for local and long-distance phone calls. Therefore, IO data on national spending on those two categories were used to create a ratio. The aforementioned examples can be seen in table one below.

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<sup>15</sup> For a detailed description of the methodology used here, see Caitlin Blair's work.

Caitlin Blair, "Constructing A PCE-Weighted Consumer Price Index," *National Bureau of Economic Research Working Papers* 19582 (2013): 1-26.

<sup>16</sup> Only one item did not map, "State registration and driver's license". This is because the PCE does not include taxes, and these fees are treated as taxes, as they are mandatory, and law dictates their purchase.

<sup>17</sup> The use of IO table data marks the only difference with Caitlin Blair's methodology, which in these uncommon cases simply split the expenditure data evenly, for example 50/50 between two PCE categories.

**Table 1:** Examples of Allocation Ratios in CPI-to-PCE Mapping

CPI ELI	PCE Category	Allocation Ratio
Men's Suits	Men's and Boys' Clothing	1.00
Men's Accessories	Men's and Boys' Clothing	0.93
Men's Accessories	Luggage and Similar Personal Items	0.07
Ham	Pork	0.97
Ham	Other Meats	0.03
Residential Telephone, VOIP	Local Phone Calls	0.67
Residential Telephone, VOIP	Long-Distance Phone Calls	0.33

Once this mapping was done, CPI expenditures were mapped to PCE categories, either directly or allocated by the splits described above. Around 50 of the roughly 300 ELIs required splits, while the remaining 250 mapped directly. After the expenditures had been mapped to PCE categories, a PCE-to-CPI factor was calculated. For example, if \$2 million in CPI expenditures mapped to a PCE category that had \$5 million in PCE expenditures, the factor would be 2.5. This factor was the ratio of PCE expenditures to CPI expenditures for each PCE category. In a case where the factor was 2.5, that would mean for that PCE category, the PCE estimates that consumers spend two and a half times the amount the CPI estimates consumers spent. These factors were then multiplied by the CPI expenditures for every CPI-ELI-PCE-category combination to approximate PCE expenditures for the ELIs. Those results were then consolidated by ELI, thus creating PCE-weighted CPI ELIs. Using the above examples, first consider Men's Suits. The PCE-to-CPI factor for Men's and Boys' Clothing were multiplied by CPI expenditures on Men's Suits, thus creating an approximation of PCE spending on the CPI ELI Men's Suits. For Ham, the three percent of Ham expenditures that mapped to Other Meats were multiplied by the PCE-to-CPI factor for Other Meats, while the other 97 percent were multiplied by the factor for Pork. The subcomponents of Ham were then summed together. This process was repeated for all ELIs, and the results were then used to construct the weights for index creation.

As mentioned earlier, constructing an index requires combining weights and prices with an index formula. Once the PCE weights had been assigned to the CPI items, CPI prices were combined with PCE-weighted CPI items using the Laspeyres formula that CPI uses in index calculation. This created a CPI index with PCE weights, and also PCE scope, because the PCE expenditure data used for weights include expenditures by rural households and by third parties.

Using PCE expenditure data for weights captures the weight effect and the scope-related weight effect, because the PCE expenditure data include third party spending and rural household spending. In order to further isolate the weight effect—resulting from the survey difference—the PCE expenditures were further transformed. To remove scope-related weight effects, the scope differences were adjusted by factors to create a proxy for the CPI scope. These factors were determined using research into the proportion of various expenditures that are out-of-pocket. For example, according to data from the Medical Expenditure Panel Survey conducted by the Agency for Healthcare Research and Quality,

only twelve percent of expenditures on healthcare for Americans are out-of-pocket.<sup>18</sup> Therefore, some medical PCE expenditures are multiplied by a factor of 0.12 to get the scope-adjusted PCE expenditures, to approximate the out-of-pocket costs. These adjustments account for the difference caused by third-party spending, but cannot account for the population definition difference.<sup>19</sup> Thus, there were two weights: one that approximated the weight effects alone (adjusted for scope), and the other, which approximated the weight effect and the scope-related weight effect (unadjusted for scope). The two sets of weights created with these expenditure data were used to create indexes; furthermore, they were used to identify which items drove differences with CPI. Because all the indexes used a Laspeyres formula, there were no formula-driven weight effects.

The aforementioned weights served two purposes. They were used to create indexes to show the effect these components have on inflation rates. They were also used to create ratios of the weights across methodologies. To do so, relative importance was used instead of the raw weight. Relative importance is the percentage of the total spending that an item makes up, and thus it can have more meaning than a dollar expenditure value. In other words, the ratio of the expenditures on eggs in CPI and PCE is not relevant because of methodological differences; however, the ratio of the percentages of total spending eggs make up are comparable. The spending on eggs could be one million dollars and two million dollars, respectively, yet both could make up 1% of consumer spending because of the different totals in the respective surveys. The ratios of relative importance showed which PCE weights were dramatically different from CPI's. If a ratio was 0.5, for example, then the PCE weight for that item is half the weight for CPI. Of note is that, at this point in the analysis, ELIs are no longer used, and instead CPI items are used. ELIs are the subcomponents of items, and items are the lowest level at which CPI data are published.

Finally, the indexes were used to analyze their impact on Social Security outlays. The goal was to demonstrate how significant the factors that make up inflation indexes are, given their influence on other indicators.

#### 4. Results

For the most part, the relative importance values of items using CPI's CE-derived weights and those using PCE-derived weights are similar. In the scatterplots seen in figures one and two, one can see that the relative importance values for most items cluster around a line with a slope of one, indicating that they are similar in both survey sources. The relative importance is the percentage of expenditures a given item contributes to the total, which is more comparable than the dollar expenditure value.<sup>20</sup> The similarities between relative importance values for most items held true in both the case where the weights were adjusted for scope and the case where they were unadjusted for scope.

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<sup>18</sup> "Medical Expenditure Panel Survey," Agency for Healthcare Research and Quality, accessed July 12, 2017

[https://meps.ahrq.gov/data\\_stats/quick\\_tables\\_results.jsp?component=1&subcomponent=0&tableSeries=1&year=-1&SearchMethod=1&Action=Search](https://meps.ahrq.gov/data_stats/quick_tables_results.jsp?component=1&subcomponent=0&tableSeries=1&year=-1&SearchMethod=1&Action=Search).

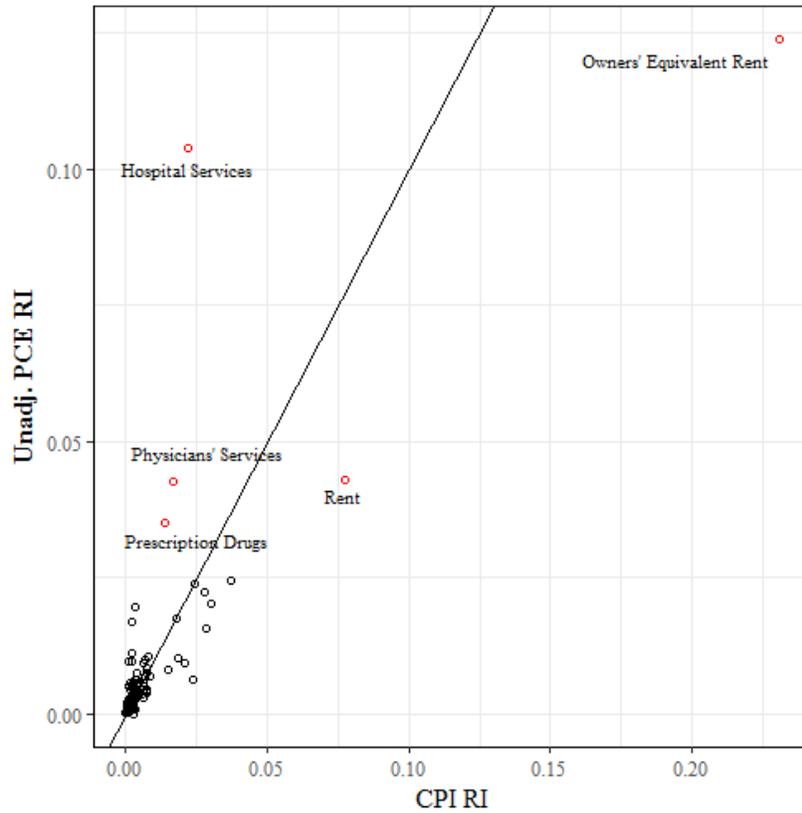
<sup>19</sup> A full list of all these factors and their sources is presented in Caitlin Blair's work. The only factor that had more recent data available, and was thus updated, was the MEPS medical adjustment factor, which went from 0.17 to 0.12.

<sup>20</sup> This is also known as budget share as it reflects the share the item comprises of a consumer's budget.

If the relative importance of an item is the same using both systems, they have no impact on the weight effect. Because the inflation data for the item is the same in both systems, if the weight is the same, the item will contribute the same amount of inflation in either index. Using an oversimplified example, if inflation in shoes is 10%, and shoes make up 1% of spending in both indexes, then shoes will contribute 1/10<sup>th</sup> of 1% to both indexes—thus not contributing to the difference. Therefore, it is the items with differences in their relative importance between weight systems that drive the weight effect. Looking at scatterplots illustrates which items are different.

However, having different weights alone is not enough to add to the weight effect. The inflation of the item, or a group of items, which is discussed later, must be different from the inflation in the rest of the market basket. If bread has a weight of 2% in one system, and 4% in the other, but bread inflation is the same as the other 98% and 96% of the indexes respectively, it will also not contribute to the weight effect. An item's weight must be different between the two expenditure data sources *and* the inflation of that item must be different from the rest of the index. Because of the nature of a weighted average, if an item has small relative importances in both systems, and a small difference, there would need to be significant inflation to contribute meaningfully to the weight effect. Items with large relative importance, and large differences, require less inflation to impact the weight effect, and thereby contribute to the difference between indexes. With this in mind, consider figures one and two below.

Figure one shows that using the unadjusted PCE weights, healthcare and housing items had some of the widest discrepancies in relative importance, as predicted by the literature. The most egregious violator of the apparent parity between systems—seen in the top right—is a housing item, Owners' Equivalent Rent. The smattering of items away from the line signifying equality are medical care items. They are substantially different because the PCE's expenditures include spending on healthcare on behalf of consumers, not just spending done directly by consumers, such as by governments and employers. The other items mentioned in the literature, education and vice items, while different, were not among the most appreciably different.



**Figure 1:** Relationship between CPI and PCE Relative Importance (Unadjusted)

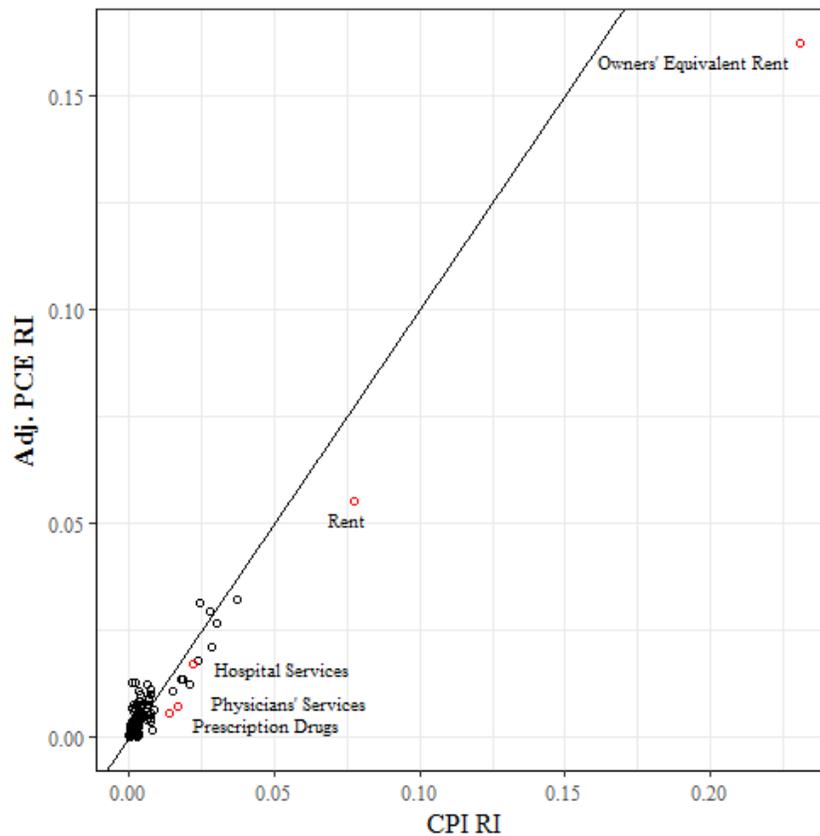
Table two shows the ten items with the largest absolute difference in relative importance between the CPI weights and the unadjusted PCE weights. Using absolute value determines the ten greatest differences regardless of whether CPI is greater than unadjusted PCE or unadjusted PCE is greater than CPI. While the items are listed from largest to smallest by absolute value, the signs are included to highlight which weight source is higher. The noteworthy items from the scatterplot are the seen in the table.

**Table 2:** Top Ten Largest Total Differences between CPI and Unadjusted PCE Relative Importance

Item	Item description	CPI	- Unadj. PCE	= Difference
HC01	Owners' equivalent rent of primary residence	23.12%	12.39%	10.73%
MD01	Hospital services	2.19%	10.40%	-8.21%
HA01	Rent of primary residence	7.73%	4.30%	3.44%
MC01	Physicians' services	1.68%	4.27%	-2.59%
MF01	Prescription drugs and medical supplies	1.38%	3.51%	-2.13%
TE01	Motor vehicle insurance	2.38%	0.64%	1.74%
MC04	Services by other medical professionals	0.31%	1.96%	-1.64%
MD02	Nursing homes and adult daycare	0.19%	1.68%	-1.49%
TA01	New vehicles	3.74%	2.44%	1.30%
HF01	Electricity	2.83%	1.58%	1.25%

Not included in the scatterplot, but included in the table, is motor vehicle insurance. This is likely a result of differences in definition between the CE and PCE surveys on classifying insurance. While CE only collects the premiums paid by consumers for insurance, PCE takes the difference between premiums collected and the losses that are reimbursed. In other words, with car insurance, CE does not take into account any money a consumer receives in the wake of an accident while PCE does. Thus, the CPI relative importance is much higher than in PCE.<sup>21</sup>

Figure two compares the relative importance data once the PCE weights were adjusted for CPI scope. One can see that while housing items remain substantially different between the systems, the medical items do not. Once they were modified to reflect only out-of-pocket spending, they were more in line with CPI's estimates, and thus wound up closer to the line indicating equality. Again, the education and vice items, while different, were not among the most different.



**Figure 2:** Relationship between CPI and PCE Relative Importance (Adjusted)

Table three is similar to table two: it shows the largest ten differences between CPI and adjusted PCE relative importance. The differences for all items on both lists are reduced, as a result of the scope adjustment. One change is that MD03, “Care of Invalids and Elderly at Home,” now appears on the list. On the prior list, MD03’s difference was not enough to

<sup>21</sup> Garner, Thesia I., G. Janini, W. Passero, L. Paszkiewicz, and M. Vandemia, “The CE and the PCE: a comparison,” *Monthly Labor Review* (2006): 20-46.

make the list, but once the other items had been reduced, it became one of the largest. This is because MD03 is the only medical item not adjusted for scope, as those expenses are usually not covered by insurance from employers or government programs. While some employers offer long-term care insurance that would cover such costs, they are in the minority.<sup>22</sup> Medicare, the most likely government program to cover such expenditures, only covers home healthcare in specific circumstances; therefore, it would be difficult to isolate how much of such expenditures are out-of-pocket as opposed to paid by the government.<sup>23</sup> Used cars and trucks also appear on the list in table three. There are significant methodological differences between used cars and trucks calculations in the two surveys. CE includes house-to-house sales in addition to business-to-household spending directly reported in the survey; meanwhile, PCE approximates used car spending by combining money spent on cars that are trade-ins, purchases of cars from the business sector such as rental companies, and the scrap value of scrapped cars. Given these differences, it is no surprise the estimations of relative importance differ.<sup>24</sup> Meanwhile, Motor Vehicle Insurance fell off the list, as it was also one of the items that was scope-adjusted to take into account definitional differences.

**Table 3:** Top Ten Largest Total Differences between CPI and Adjusted PCE Relative Importance

Item	Item description	CPI	- Adj. PCE	= Difference
HC01	Owners' equivalent rent of primary residence	23.12%	16.21%	6.90%
HA01	Rent of primary residence	7.73%	5.51%	2.22%
MD03	Care of invalids and elderly at home	0.08%	1.26%	-1.18%
GD01	Legal services	0.24%	1.26%	-1.02%
MC01	Physicians' services	1.68%	0.69%	0.99%
TA02	Used cars and trucks	2.10%	1.24%	0.86%
MF01	Prescription drugs and medical supplies	1.38%	0.57%	0.81%
HF01	Electricity	2.83%	2.12%	0.72%
HD01	Tenants' and household insurance	0.35%	1.05%	-0.70%
FV02	Limited service meals and snacks	2.45%	3.12%	-0.67%

Of note is that in the scatterplots and tables, as well as the histograms and tables that follow, only 184 of the 211 CPI market basket items are included. The CPI market basket contains 26 “unsampled” items. These items are not priced directly in stores, but are instead imputed from other prices. They represent miscellaneous items not captured elsewhere by more specific items, an example being “unsampled boys’ apparel”, which includes all boys’ apparel not specified elsewhere. Such items have their prices imputed, and their expenditure data are based on a very small sample. Their small relative importance makes them less relevant and the low sample leads to high volatility; therefore, they were removed to lower the “noise” and to provide a clearer look at the other items. One of the 211 items,

<sup>22</sup> According to the BLS Employee Benefits Survey, as of March 2016, 17% of employers offered long-term care insurance. This can be seen in Table 42.

<sup>23</sup> “Table 42. Health-related benefits: Access, private industry workers, March 2016,” Bureau of Labor Statistics, accessed July 19, 2017 <https://www.bls.gov/ncs/ebs/benefits/2016/ownership/private/table42a.pdf>.

<sup>24</sup> “Medicare & Home Health Care,” Department of Health and Human Services, Accessed July 19, 2017 <https://www.medicare.gov/Pubs/pdf/10969-Medicare-and-Home-Health-Care.pdf>.

<sup>24</sup> Garner, Thesia L., G. Janini, W. Passero, L. Paszkiewicz, and M. Vandemia, “The CE and the PCE: a comparison,” *Monthly Labor Review* (2006): 20-46.

State Registration and Driver's Licenses, is removed because it is out of PCE scope, and was thus excluded from analysis.

In the scatterplots, one can see that most items have a small relative importance: very few items contribute more than 1% to consumer spending. Because they have very small relative importance in both systems, only inflation significantly different relative to the other items could drive a meaningful difference between the indexes. Meanwhile, the items most divergent in relative importance also had the highest relative importance. This means inflation in these items—different from the rest of their indexes—would drive differences between the indexes, as their differences are, effectively, heavily weighted.

The scatterplots and tables above show the items that have a large total difference. In other words, it highlights the items with the largest difference in percentage point, such as how the scope-adjusted PCE rent relative importance was 2.22 percentage points lower than the CPI relative importance. Another way to look at the difference in relative importance between the weights is to look at the proportional difference. Not just how much bigger one is in percentage points, but what percent difference there is. \$10,000 is \$9,000 more than \$1,000, and is ten times larger; \$20,000 is \$10,000 more than \$10,000, but is only two times bigger. The total difference in the latter is larger, but the proportional difference in the former is larger. The metric one chooses determines which items are the “most different” so it can be helpful to consider both.

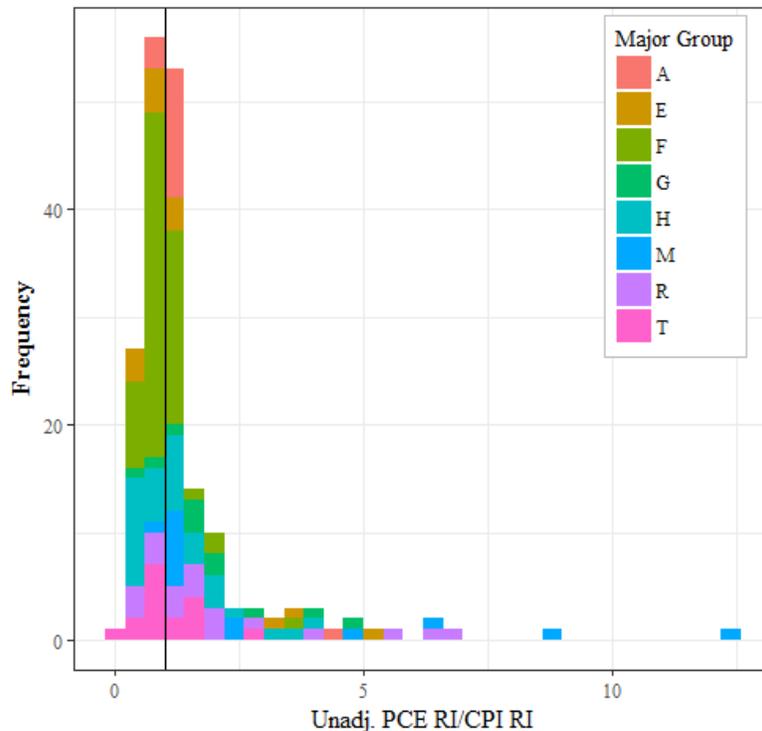
To determine which weights were the most significantly different proportionally, ratios of the relative importance values were created. A ratio was created by dividing the PCE relative importance by the CPI relative importance. A ratio of one indicates that the two are equivalent: using either PCE or CPI expenditures, the item makes up the same percentage of total consumer spending (for the math inclined,  $X\% / X\% = 1$ ). Once the ratios were created, they were plotted as a histogram. This shows the distribution of the proportional differences between PCE and CPI weights. The distributions in the following histograms show most of the ratios are around one, highlighted by a line. The items where the ratio does not equal one are those that differ—proportionally—across weight systems, and thus could potentially be driving the weight effect. The height of a bar indicates how many items have a ratio in a range.

The graphs can be slightly deceiving. The farther an item is from the line that indicates a ratio of one, the more proportionally different it is between systems; however, this is shown asymmetrically. A ratio of five, meaning the PCE relative importance is five times that of its CPI counterpart, looks far from the line. A ratio of 0.2, which means CPI is five times its PCE counterpart, doesn't look as far away. Tables were created to take this into account, looking at the top ten proportional differences regardless of which weight source is the numerator.

The histograms are color coded by “major group.” There are eight CPI major groups, which are composed of the items in the CPI market basket, and they reflect categories of items. The eight major groups are apparel, education and communication, food and beverages, other goods and services, housing, medical care, recreation, and transportation (represented in the legends in figures three and four as A, E, F, G, H, M, R, and T respectively). This was done to identify broader patterns across the distribution of items. Each bar of the

histogram represents the number of items with ratios in a range, and the bars are then colored proportionally based on how many of those items are in each group.

Figure three shows the distribution of the proportional differences between unadjusted PCE weights and CPI weights. One sees that most ratios are either just over one or just under one. This indicates that for the most part, the relative importance of the items are proportionally similar to one another. Based on the group coloring, one can see that of the items that have ratios close to one, most belong to a few categories, with food, apparel, and transportation making up a bulk of them. Not only that, but those columns represent a majority of the aforementioned major groups' items—they have few outliers. Looking at the ratios far from one, that items in the housing and medical care major groups diverge is not surprising; however, the prevalence of recreation items was not expected based on the literature. The recreation items are not likely to have a meaningful impact on the difference in the indexes because, although they have strikingly different proportional relative importance values, their weights are so small that they do not have a large impact.



**Figure 3:** Distribution of Unadjusted PCE to CPI Relative Importance Ratio

Similar to the tables accompanying the scatterplots, table four shows the top ten proportional differences between the relative importances by weight source. No CPI relative importance was proportionally higher than PCE to qualify for the list. As one would expect, four of the top ten are medical care items. This is the result of the PCE expenditures, and thus the relative importances, including spending on medical care by third parties, such as government and employers. The two most important housing items, rent and owners' equivalent rent, while very different in percentage point terms, were not proportionally different enough to make the list. CPI's rent and owners' equivalent rent have almost twice the relative importance of the unadjusted PCE, but that was not a large enough proportional difference. The non-medical care items have very small relative

importance in the CPI, but, while not large, are significantly larger in the unadjusted PCE weights. As mentioned earlier, this means that they probably contribute little to the weight effect. Because they were not mentioned in the literature, their presence warrants an explanation.<sup>25</sup> One commonly bought item that should not suffer sample size issues that appears on the list is Computer Software and Accessories. A potential explanation for this is many people may buy computers, software, and accessories for home businesses, and PCE has a harder time distinguishing that. While the CE survey specifically asks respondents to not include business expenses, if people buy such goods from consumer outlets, PCE would not have a way of distinguishing between personal and business expenditures.

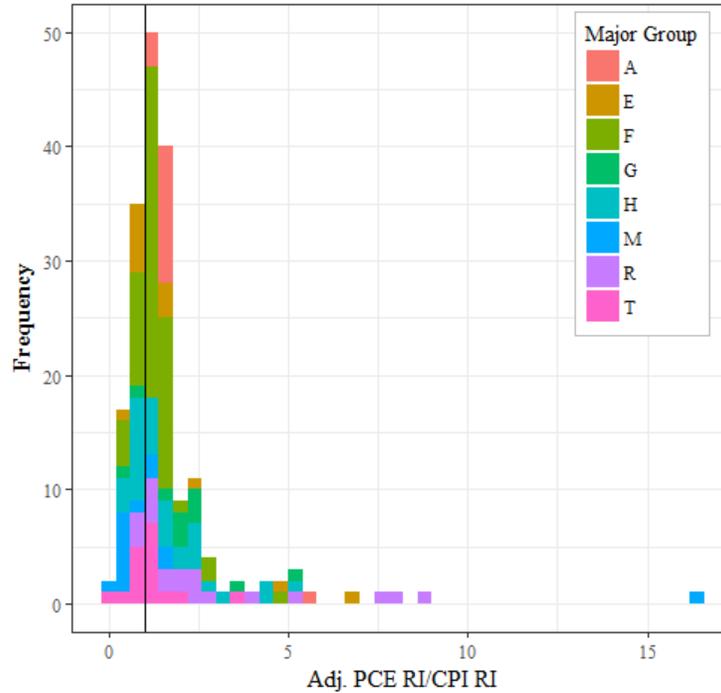
**Table 4:** Top Ten Largest Proportional Differences between CPI and Unadjusted PCE Relative Importance

Item	Item description	Unadj. PCE	CPI	Ratio
MD03	Care of invalids and elderly at home	0.96%	0.08%	12.4
MD02	Nursing homes and adult day care	1.68%	0.19%	8.8
RA03	Other video equipment	0.18%	0.03%	6.9
RA06	Audio discs, tapes and other media	0.15%	0.02%	6.2
MC04	Services by other medical professionals	1.96%	0.31%	6.2
RG01	Newspapers and periodicals	0.50%	0.09%	5.8
EE02	Computer software and accessories	0.50%	0.10%	5.2
GD05	Financial services	1.13%	0.23%	5.0
MD01	Hospital services	10.40%	2.19%	4.7
AG02	Jewelry	0.57%	0.13%	4.3

Figure four shows similar results as figure three, in that food, apparel, and transportation items remain close to the proportion of one. As with the scatterplots, many of the outliers fall away as the medical items become adjusted for the scope difference.

<sup>25</sup> One item, legal services, is mentioned briefly in a paper by Thesia Garner, et al. She attributes the difference to either recall bias, to be discussed shortly, or being similar to a vice item, in that people don't want to admit they were in legal trouble.

Garner, Thesia I., G. Janini, W. Passero, L. Paszkiewicz, and M. Vandemia, "The CE and the PCE: a comparison," *Monthly Labor Review* (2006): 20-46.



**Figure 4:** Distribution of Adjusted PCE to CPI Relative Importance Ratio

In table five, one can see the top ten ratios of scope-adjusted PCE to CPI relative importance. All the medical items have fallen away except MD03, “care of invalids and elderly at home.” As mentioned, MD03 is the only medical item not adjusted for scope, as those expenses are not often covered by employers or government programs. The MD03 ratios for the unadjusted and adjusted PCE are similar because there has been no adjustment to the PCE expenditures, unlike the other medical items. The ratio increases using the adjusted weights, as the total expenditure—relative importance of an item is that item’s expenditure over the total—has been decreased, reflecting the removal of third party spending. The item with the star, MC03, is the only item for which the CPI relative importance is greater than the PCE relative importance, and the 6.3 ratio is actually CPI divided by the adjusted PCE relative importance (the inverse of the ratio used for the rest). How did a medical item become significantly larger for CPI after the adjustment? The best explanation has to do with the nature of the medical care scope adjustment. All medical items, besides MD03, are reduced by the same factor. According to the Agency for Healthcare Research and Quality, 12% of medical expenses are covered out-of-pocket, so all medical expenditures are reduced to 12% of the reported rate in PCE to adjust for CPI’s out-of-pocket scope requirement. However, it is unlikely that all medical expenditures are equally reimbursed through insurance and government programs. It could be that third parties pay much less for eyeglasses and eye care, and so the PCE expenditures are being over-adjusted. Unfortunately, there is not an effective tool for determining the proportions of medical expenditures that are reimbursed at a more granular level. The non-medical items are familiar from table four, and are primarily recreation items. Again, this was an unexpected discrepancy.

**Table 5:** Top Ten Largest Proportional Differences between CPI and Adjusted PCE Relative Importance

Item	Item description	Adj. PCE	/ CPI	Ratio
MD03	Care of invalids and elderly at home	1.26%	0.08%	16.2
RA03	Other video equipment	0.23%	0.03%	9.0
RA06	Audio discs, tapes and other media	0.20%	0.02%	8.2
RG01	Newspapers and periodicals	0.66%	0.09%	7.6
EE02	Computer software and accessories	0.65%	0.10%	6.7
MC03	Eyeglasses and eye care	0.05%	0.32%	6.3*
AG02	Jewelry	0.74%	0.13%	5.6
RG02	Recreational books	0.35%	0.07%	5.2
GD01	Legal services	1.26%	0.24%	5.2
HL03	Dishes and flatware	0.28%	0.05%	5.1

How did the non-medical items in tables four and five diverge so much proportionally in their relative importances across systems? There are no scope-related reasons these items should diverge, hence many appear on both the list of items where there were scope adjustments and the list where there were not. There are no reasons a CE respondent should be unwilling to admit to purchasing such items. The most probable justification is survey methodology. It is likely that these items are simply underreported in CE compared with PCE. Data for CE are collected from individuals in two surveys: one called the Diary and the other called the Interview. The Diary survey attempts to capture frequent purchases such as food and household cleaning products. Survey respondents fill out a diary of all of their expenditures for two one-week periods. The Interview is meant to capture larger expenditures, such as cars and large household appliances. Respondents are asked if they have purchased various goods, and are given a three-month recall period, as these goods are purchased infrequently.<sup>26</sup> Respondents participate in these surveys to the best of their ability and do so voluntarily.

PCE's data are from multiple business surveys. The primary one is the comprehensive Economic Census, which is conducted every five years, and where participation is mandatory—not responding is a finable offense.<sup>27</sup> To supplement the Economic Census in between the five-year periods, PCE uses data from a number of other business surveys, including the Annual Survey of Manufactures, the Annual Wholesale Trade Survey, the Service Annual Surveys, the Annual Wholesale Trade Survey, and the Annual Retail Trade Survey.<sup>28</sup>

Given the difference in the construction of these surveys, it is plausible that there could be survey-related implications. In 2015, the Consumer Expenditure Survey sample had 23,574 Interview and 11,841 Diary survey valid respondents, with response rates of 64% and 58%, respectively.<sup>29</sup> Meanwhile, the Economic Census has over four million

<sup>26</sup> Garner, Thesia I., G. Janini, W. Passero, L. Paszkiewicz, and M. Vandemia, "The CE and the PCE: a comparison," *Monthly Labor Review* (2006): 20-46.

<sup>27</sup> "FAQ," United States Census Bureau, accessed July 20, 2017, [https://www.census.gov/programs-surveys/economic-census/about/faq.html#par\\_textimage\\_6](https://www.census.gov/programs-surveys/economic-census/about/faq.html#par_textimage_6).

<sup>28</sup> Ibid.

<sup>29</sup> "2015 Response Rates Interview Survey and Diary Survey Consumer Expenditure Public Use Data," Bureau of Labor Statistics, access July 20, 2017, <https://www.bls.gov/cex/pumd/2015/csxresponserates.pdf>.

respondents, including small, medium, and large businesses, and involves coordination with over 1,000 trade associations.<sup>30</sup> Because participation in the Economic Census is mandated by law, it is easier to obtain a higher response rate. The response rate for the Economic Census in 2012 was 84%.<sup>31</sup>

There are a number of reasons to believe the PCE may be more accurate in approximating the relative importances of the items on the lists that have small relative importances in the CPI. First, the larger sample size means there should be less volatility and more accuracy. Some of the listed items are not bought very often, so, with a small sample size, it may be hard to collect expenditure data on purchases of recreational books, for example. But because so many book businesses are surveyed in the PCE, the data are likely to be more representative. Second, due to the nature of a voluntary survey versus a mandatory census, CE likely has more non-response bias.<sup>32</sup> Those who take part in the survey do so voluntarily, and so there may be characteristics of those who respond that are different from the population as a whole. Because participation in the Economic Census is mandatory, there shouldn't be a similar non-response bias. Last, there is recall bias. CE respondents respond to the best of their ability. But people make mistakes when trying to recall expenditures, and they don't always remember things correctly.<sup>33</sup> While CE respondents are encouraged to consult records, consumers often do not keep meticulous records of all their spending. Companies, on the other hand, have very detailed sales data and are able to consult these records for more accurate responses.

Looking at items is not the only way to investigate these differences. Many of the items with the large proportional differences have such small relative importances that it is unlikely they would impact the weight effect. This is true of many of the items in the market basket. Therefore, it may be more helpful to look at larger categories of items to see if patterns appear, so that small samples or anomolous outcomes in certain items do not distract from larger trends. Furthermore, many items with small relative importance have plenty of sample, but simply are not large enough to make an impact. The CPI major groups were used as categories to remove some of the noise of the large number of small relative importance items. In figure five, one can see how healthcare and housing stand out.

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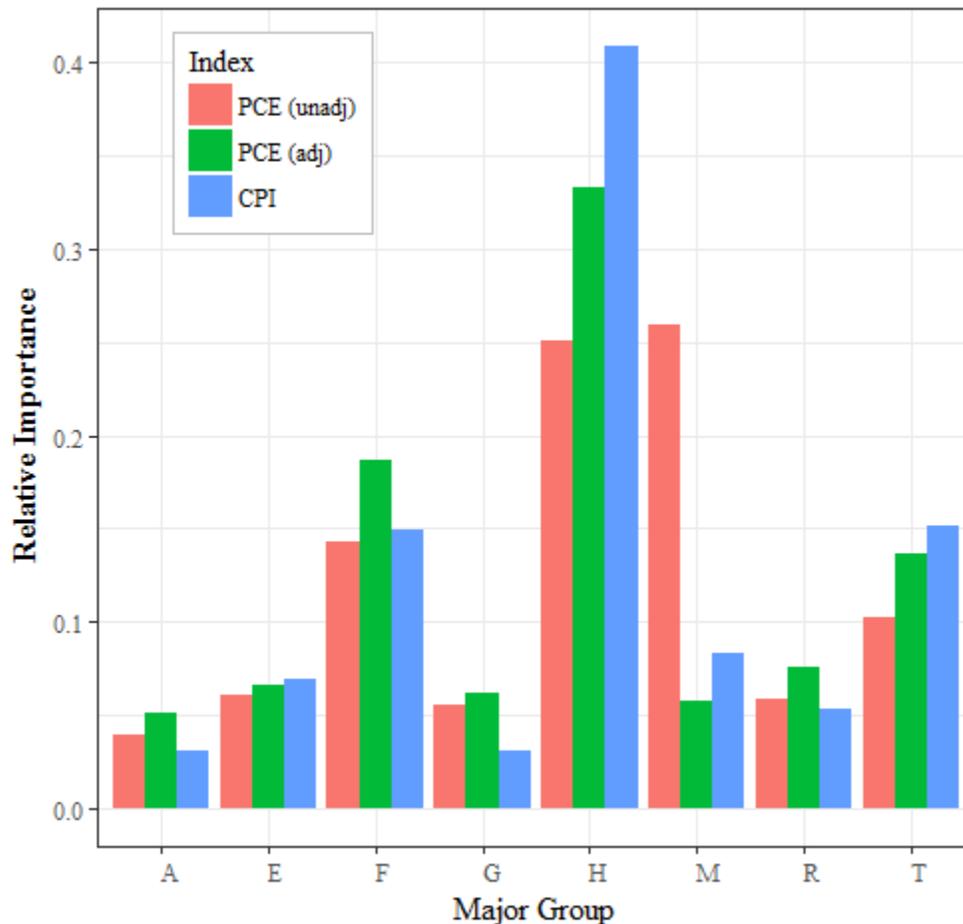
<sup>30</sup> "About the Economic Census," United States Census Bureau, accessed July 12, 2017 <https://www.census.gov/programs-surveys/economic-census/about.html>.

<sup>31</sup> "Part B – Collections of Information Employing Statistical Methods," Department of Commerce, accessed July 20, 2017 [ftp://ftp.census.gov/about/cic/2014-03\\_brady.pdf](ftp://ftp.census.gov/about/cic/2014-03_brady.pdf).

<sup>32</sup> The Office of Management and Budget requires household and establishment surveys with response rates under 80%, like the Consumer Expenditure Survey, to undergo reviews for non-response bias. A 2009 paper found that while CE had non-response issues, the bias wasn't meaningful—albeit response rates have slid further since then.

"Assessing Nonresponse Bias in the Consumer Expenditure Interview Survey," Bureau of Labor Statistics, accessed July 20, 2017 <https://www.bls.gov/osmr/pdf/st090220.pdf>.

<sup>33</sup> McCully, Clinton P., Brian C. Moyer, and Kenneth J. Stewart. (2007). "A Reconciliation Between the Consumer Price Index and the Personal Consumption Expenditures Price Index," mimeo, Bureau of Economic Analysis and Bureau of Labor Statistics, September 2007.



**Figure 5:** Relative Importance by Major Group

The data seen in figure five is summarized in detail in table six.

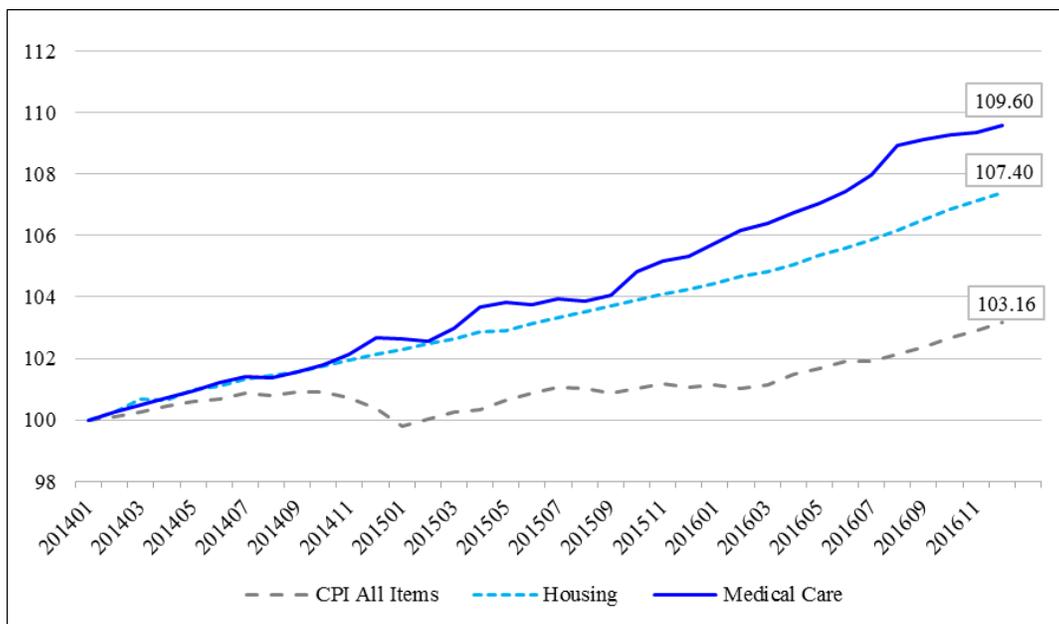
**Table 6:** Relative Importance by Major Group

Major Group	PCE (Unadj)	PCE (Adj)	CPI
Apparel (A)	3.91%	5.12%	3.07%
Education and Communication (E)	6.09%	6.58%	7.00%
Food and Beverages (F)	14.33%	18.66%	14.97%
Other Goods and Services (G)	5.61%	6.24%	3.06%
Housing (H)	25.08%	33.32%	40.87%
Medical Care (M)	25.93%	5.82%	8.37%
Recreation (R)	5.83%	7.63%	5.38%
Transportation (T)	10.29%	13.69%	15.11%

One can see that the differences are most dramatic in housing and medical care, as predicted by the literature. Surprisingly, food shows a difference at the major group level, even though the individual items did not appear to have substantial differences. Meanwhile, recreation doesn't show a dramatic difference at the major group level, despite some of the individual items being notably different.

To see how this affects price indexes, it is helpful to look at how prices have moved for the groups with significant differences. As mentioned earlier, if the relative importance of a major group is the same across indexes, it will not contribute to the weight effect, as the impact on the respective indexes will be the same. The more they differ, however, the more the inflation in that major group—or lack thereof—contributes to the weight effect between the indexes, as the inflation is being weighted differently. This is amplified the larger the relative importance of a major group or item is, as a greater weight is given to the difference. For example, if there is a large difference in the weight of the apparel major group, which, seen above in figure five, has a low relative importance, the impact will be minimal. The more relative importance of a major group or item, the more consequential a difference becomes. If a weight difference exists, for it to have an impact the inflation for an item or major group must differ from the rest of the items. If housing, for example, has a different weight across indexes, but housing inflation matches inflation for the rest of the market basket, there will be no impact.

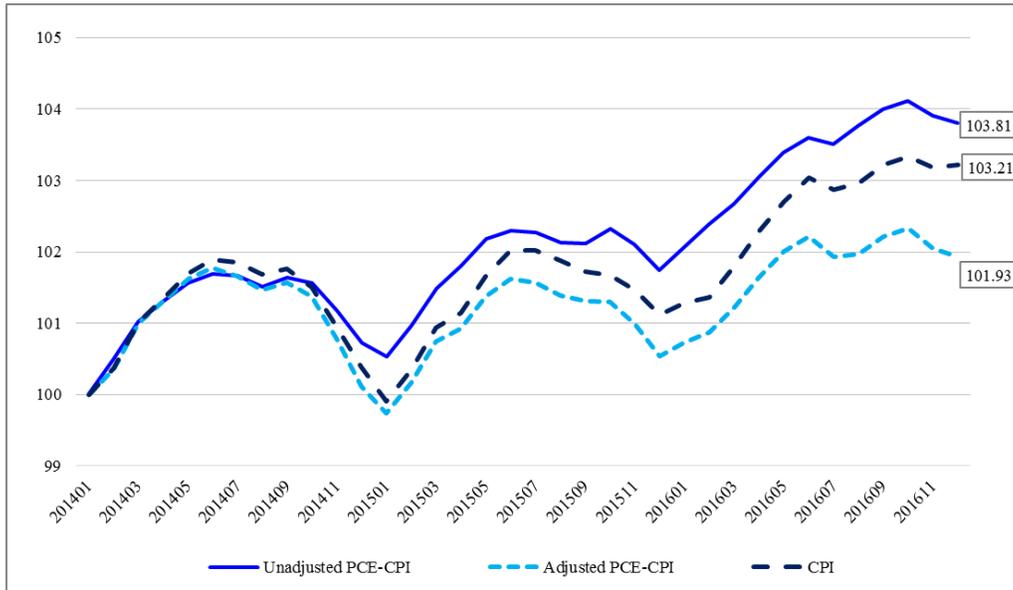
In this case, the major groups with the largest relative importance are also the ones with the largest weight differences across price indexes. In addition, the inflation in these major groups differed from inflation in the market basket. To see how the inflation in housing and medical care affect the indexes, because of the differences in weight, see figure six below showing price change in the two major groups over the time period in question compared with inflation of the all-items index. Because of the inflation in these major groups, given their difference in weights between indexes, there is a material impact on the indexes' differences.



**Figure 6:** Housing, Medical Care, and All-Items Inflation over Time

In figure seven below, one can see the end result: the differences in indexes as a result of the weights. The difference in the indexes is modest, with the unadjusted PCE index registering inflation a little under 1% more than the CPI, and the adjusted PCE index a little

over 1% less than the CPI. Over the three-year period investigated, the CPI and both PCE-weighted CPIs generally move in the same pattern. The non-seasonally adjusted CPI registered inflation of 3.21%; the PCE-weighted index adjusted for scope registered inflation of 1.93%; and the PCE-weighted index that was not adjusted registered inflation of 3.81%.<sup>34</sup> A potential explanation for why the unadjusted PCE-weighted index saw the highest inflation is that it gave the most weight to medical care, which as one can see in figure six, had substantially higher inflation than the all items market basket.



**Figure 7:** CPI, Adjusted-PCE CPI, Unadjusted-PCE CPI from 2014-2016

Figure seven shows the trend in inflation over the time period of this analysis. Sometimes it can be helpful to compare the total inflation over a period to the annualized rate. In table seven below, one can see the exact figures for the inflation over each period by index, as well as the annual rate of inflation for each. Both in total, and annualized, the differences in inflation appear small, differing by less than a percent in all but one case.

**Table 7:** Inflation of Indices over Time

	Inflation Over Period	Annualized Inflation
Unadjusted PCE	3.81%	1.25%
Adjusted PCE	1.93%	0.64%
CPI	3.21%	1.06%

### 5. Implications

While the differences mentioned above might seem small, they can have a significant impact. Inflation is a widely used economic indicator: in business, it is used in business forecasting and when setting inflation-adjusted wage contracts; in government, it is used for public policy analysis and inflation-adjusting government benefits; in academia, it is used for research in a variety of fields, not only on its own, but when adjusting other

<sup>34</sup> The non-seasonally adjusted CPI was used for comparison, as the PCE-weighted indexes were not seasonally adjusted.

economic indicators. Inflation being a key economic indicator that informs policy decisions, especially at the Federal Reserve, means it has far-reaching impact. Therefore, it needs to be as accurate as possible. A tenth of a percent of a trillion dollars is a billion dollars, so being off by even small amounts when adjusting multi-trillion-dollar quantities can have major consequences.

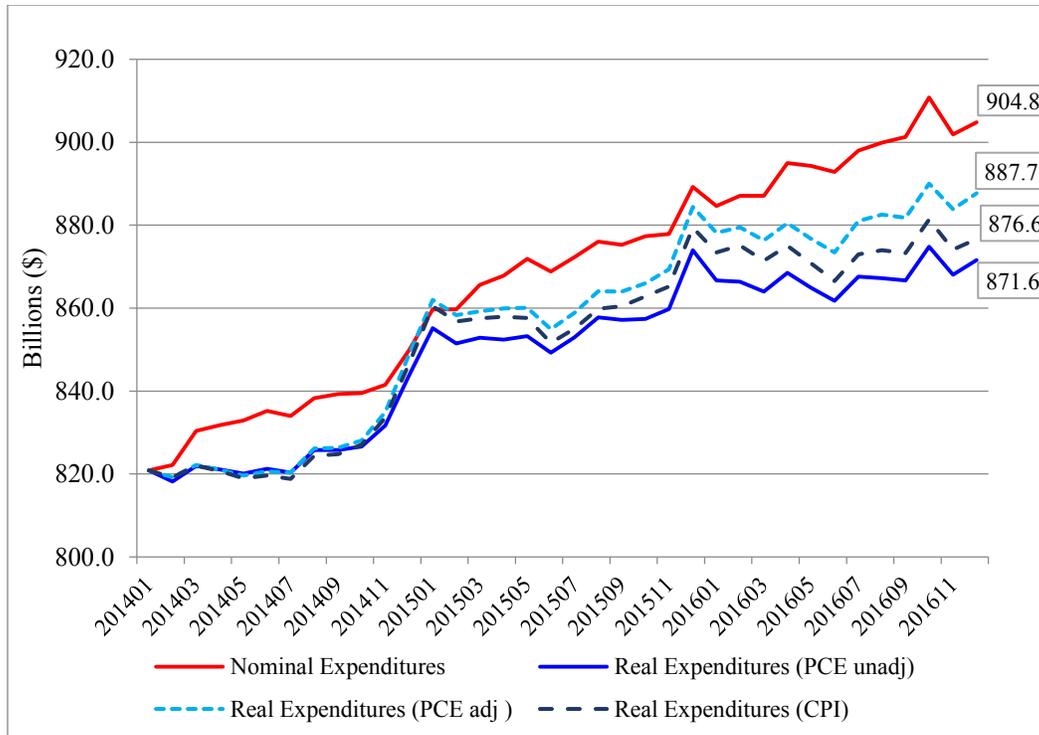
To demonstrate this, the three inflation indexes (the CPI and both PCE-adjusted CPIs) are used to evaluate the real value of Social Security payments over the period in question.<sup>35</sup> In chart eight below shows the impact different inflation methodology can have, even in a short period of time, on inflation-adjusted expenditures. The inflation-adjusted social security expenditures vary by billions of dollars, depending on the index used for adjustment. The scope-adjusted PCE-weighted index leads to real social security spending roughly \$10 billion over that when using CPI, while the unadjusted PCE-weighted index leads to real expenditures \$5 billion less than when the CPI is used..

This example is not simply a thought exercise. The \$910 billion spent on social security benefits in 2016 was almost a quarter of all federal government spending, and represented almost five percent of U.S. GDP.<sup>36</sup> How quickly this spending grows is of paramount importance for the government's fiscal outlook. Not only that, but for social security recipients, making sure that their payments are accurately indexed to inflation has implications for their quality of life. If payments do not keep up with rising costs of living, they will see a decrease in quality of life.

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<sup>35</sup> "Personal current transfer receipts: Government social benefits to persons: Social Security," St. Louis Federal Reserve, accessed July 13, 2017 <https://fred.stlouisfed.org/series/W823RC1>.

<sup>36</sup> "The Federal Budget in 2016," Congressional Budget Office, accessed July 30, 2017 <https://www.cbo.gov/sites/default/files/115th-congress-2017-2018/graphic/52408-budgetoverall.pdf>.

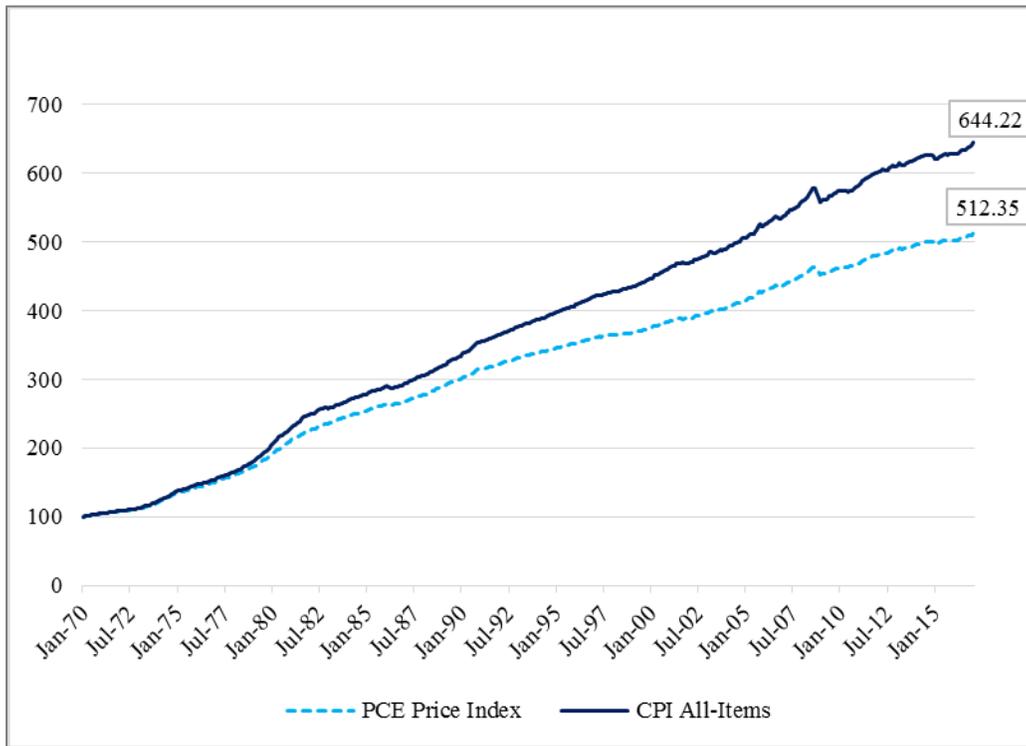


**Figure 8:** Annualized Social Security Spending, Adjusted for Inflation

Social security expenditures are not the only federal outlays that are inflation-related. The Treasury Department issues Treasury Inflation-Indexed Securities (TIPS), of which there are over \$550 billion outstanding. Determining the most appropriate inflation index to use—currently it is CPI—and calculating that index in the most accurate way possible has implications for both government spending and investors.<sup>37</sup>

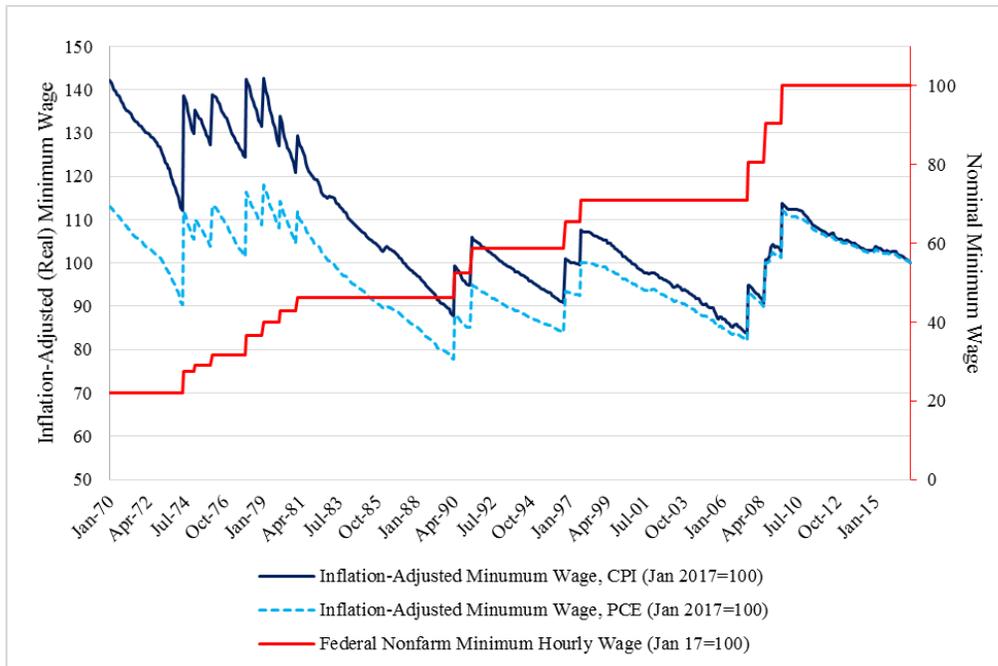
This research focused on only two of the differences between CPI and PCE, the scope and weight. Figure eight above shows the difference in outcome that results from adjusting only these two factors, while otherwise retaining CPI methodology. As one saw, these differences alone led to outlays billions of dollars apart after over only three years. However, the official PCE and CPI indexes have many more differences, including their formulas, revision processes, and population-related scope differences that couldn't be accounted for in this analysis that push them apart. To fully appreciate the difference between CPI and PCE, it is worth looking at the two indexes in their published forms, rather than focusing on the a few isolated differences. The spread between the two becomes especially dramatic over a longer period of time. To see how stark the impact of all these differences is, it helps to see both indexes over a longer period of time. In figure nine, one can see CPI and PCE from 1970 to 2017. One can see that they are dramatically different, for all reasons mentions: their scope, their weight source, their formula, and all the other differences. The implications of choosing one over the other—for either public or private sector purposes—becomes evident. In the almost-50 years in the time series, CPI inflation is over 100 percentage points higher than PCE inflation.

<sup>37</sup> "Treasury Inflation Indexed Securities," Department of Treasury, accessed July 30, 2017 <https://www.treasury.gov/resource-center/fin-mkts/Pages/tips.aspx>.



**Figure 9:** CPI and PCE from 1970-2017

This dramatic difference over long periods of time is consequential. Consider the debate about adjusting the minimum wage: if the minimum wage were indexed to inflation, what would be the most appropriate index? There is likely a compelling case for either, but it cannot be stressed enough how the choice would affect those paying and receiving the minimum wage. In figure ten below, there are three indexes: one is the minimum wage, one is the minimum wage adjusted with CPI, and the other adjusted with PCE. They have all been rebased so that 2017 is 100, as using dollar amounts when showing differences between real and nominal growth can be disorienting. The nominal minimum wage, tracked on the right axis, has risen by over 400% (from \$1.60 to \$7.25). The real minimum wages, however, show that \$1.60 in 1970 actually bought more than \$7.25 today. The question is, how much more? Using CPI, the data suggest that purchasing power from the minimum wage has fallen almost 30%. PCE data, meanwhile, suggest that purchasing power has only fallen 10%. Given the significant difference the choice of index would have, it is important to understand what causes the differences, and when it is the appropriate time to use each.



**Figure 10:** Minimum Wage from 1970-2017 Adjusted and Unadjusted for Inflation

## 6. Summary and Future Work

This paper focused on how weights impact the difference between the CPI and PCE indexes, especially the contribution of the source for expenditure weighting data. It looked into the weight differences as a result of different survey sources and scope, and how those affected particular items and groups of items. This was followed by a discussion of why this matters, given inflation's impact on other economic data as well as spending both in the public and private sector. But much was not covered.

One important piece of work to be done is the potential creation of a framework to determine when it is most appropriate to use PCE or CPI. Both indexes measure inflation, but do so very differently, both in technical construction and defining what inflation is. In some cases, PCE is superior, such as when a long time series is necessary for academic analysis, because PCE revises all its data when there are methodology changes, thereby creating consistency. On the other hand, the timeliness of CPI, which is produced monthly for the preceding month, makes it superior when it is necessary to be expeditious. When one wants to measure consumer product inflation in the economy as a whole, PCE is superior as it contains spending on consumer goods whomever the buyer is; meanwhile, CPI is better when determining the inflation consumers are feeling, because of its narrower out-of-pocket scope. These broad guidelines, however, could be formalized into a framework that determined when to use each index based on their comparative advantages and disadvantages.

Broadening the scope of this research, one could look into the implications of the choice to use PCE versus CPI, without the limited scope of considering only one of the four effects set out in the literature. A discussion of whether the appropriate indexes are being used where there is inflation adjustment would be valuable, and would benefit from a quantification of how things would change if there was a switch.

Another project is to resolve why these results do not match the results of the reconciliation research produced by BEA comparing PCE and CPI. The work done here and the original research by Caitlin Blair produced different approximations of the weight and scope effects from the BEA work. There is an opportunity to determine what is driving this discrepancy. One potential cause is the order of the deconstruction of the effects. Another is the methodology used to quantify the effects. Ideally, if one system is more accurate, that system should be used in future research.

Probing further into the research presented here, one could try to isolate the direct index contribution to the weight effect from each item. Many of the items that had the largest proportional differences in relative importance also had some of the smallest relative importances. This means that, while different, the impact was minor: a large difference in the weights for “audio discs, tapes, and other media” has minimal impact. The difference in the relative importances for housing items, however, will likely impact the weight the most. Their proportional difference wasn’t as significant, although the total difference was large. Creating some sort of impact factor by which to evaluate all items could identify which items warrant more investigation. Another option would be to limit analysis to the items with large total differences, or which met a floor in terms of relative importance—perhaps only items that constitute over 1% of consumer spending.

The current theory as to why some proportional differences are so dramatic—because of sample size and quality in the respective surveys—deserves more analysis. A comparison of the sample sizes by item, analysis into how sample size affects volatility in expenditure estimates, or investigation of non-response bias would be beneficial in understanding the discrepancies discovered in this research.

Another avenue of research is to look into perceptions of inflation, and how they are affected by the items that constitute major differences between CPI and PCE. It seems plausible that people’s perceptions of inflation would more closely match CPI, as it only includes out-of-pocket spending. However, consumers are being shielded from the impact of inflation in certain areas because so much of the cost is covered by third parties. If employers pay the lion’s share of consumer health insurance premiums, and all consumers spend on medical service is a co-pay, they may not experience as much inflation as there is in the overall economy. Over 80% of healthcare spending is not out-of-pocket. Moreover, healthcare inflation has recently been more rapid than inflation for other market basket items. Thus, consumers may perceive less inflation than they actually experience. Employers pass on increases to their cost of health insurance premiums cost to employees, by either increasing the amount deducted from paychecks, or by not offering raises. Thus, severity of the impact of rising healthcare costs remains mostly hidden from consumers, but it affects them nonetheless.

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