Volume Title: Improving the Measurement of Consumer Expenditures

Volume Author/Editor: Christopher D. Carroll, Thomas F. Crossley, and John Sabelhaus, editors

Series: Studies in Income and Wealth, volume 74

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-12665-X, 978-0-226-12665-4

Volume URL: http://www.nber.org/books/carr11-1

Conference Date: December 2-3, 2011

Publication Date: May 2015

Chapter Title: Constructing a PCE-Weighted Consumer Price Index

Chapter Author(s): Caitlin Blair

Chapter URL: http://www.nber.org/chapters/c12661

Chapter pages in book: (p. 53 – 74)

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# Constructing a PCE-Weighted Consumer Price Index

Caitlin Blair

## 2.1 Introduction

Consumer Expenditure Survey (CE) data are a source of frequent debate in the federal statistical community. Pundits have criticized the household survey with arguments ranging from population and item coverage bias to inaccurate reporting as disadvantages of using CE data.[1] However, alternatives to the Consumer Expenditure Survey are scarce, and CE data have many advantages, including scope and population specificity. A variety of agencies and statistical programs utilize CE data, but one of the most important uses of CE data is in the construction of weights for the US Consumer Price Index (CPI), produced by the Bureau of Labor Statistics (BLS). Reported expenditures in the CE survey are used to calculate the relative importance, or expenditure weight, of each item category in the index. In order for the CPI to be an accurate measure of price change, it is vital that the weight data are accurate and representative of the appropriate population. If there is a systemic bias in the CE weights, there could be a bias in the resulting CPI.

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This chapter was originally prepared for the NBER/CRIW conference on Improving the Measurement of Consumer Expenditures, December 2011. The author would like to thank Rob Cage, Sara Stanley, Josh Klick, Madeleine Saxton, Bill Passero, Ronald Johnson, Anya Stockburger, Charles Mason, and John Greenlees of the Bureau of Labor Statistics and Clinton McCully and Brent Moulton of the Bureau of Economic Analysis for their support and input on this project. The views expressed in this chapter are those of the author and do not necessarily represent the views of the Bureau of Labor Statistics or the Department of Labor. The author takes full responsibility for any errors. Please contact Anya Stockburger of the BLS (stockburger.anya@bls.gov) with any questions related to this chapter. For acknowledgments, sources of research support, and disclosure of the author's material financial relationships, if any, please see http://www.nber.org/chapters/c12661.ack.

1. Garner et al. (2006) provide a brief chronology of work comparing CE and PCE.

This chapter examines CPI weights using an alternate weighting scheme under current CPI methodology. This is done by comparing official 2005–2010 CPI index values with index values derived from secondary source weights. Creating these indexes and comparing them to the published CPI allows us to gain a better understanding of item representativeness and item response accuracy in the CE-sourced CPI aggregation weights. In this study, personal consumption expenditures (PCE) data from the Bureau of Economic Analysis are the secondary source. Ultimately, we find that an index weighted to PCE levels matches the urban Consumer Price Index (CPI-U) very closely in trend and magnitude but grows at an annualized rate that is about 0.1 percent lower than the CPI-U growth rate over the 2005–2010 period. An index weighted to PCE levels that is not adjusted for definitional differences has an annualized five-year growth rate that is 0.3 percent higher than the CPI-U rate.

## 2.2 Importance of CE in the CPI

One reason that CE data are currently used in CPI production is the level of item, geographic, and population disaggregation available from the survey. The CPI utilizes expenditure values for five distinct population subgroups, which are then combined to create a variety of indexes for specific populations such as "urban," "wage-earner," and "elderly." Detailed demographic data ranging from respondent age to housing tenure to Social Security recipiency status are collected in the CE survey and can be used in index research. In addition, CE data are collected for thirty-eight geographic zones known as index areas, which are the primary level of geographic index aggregation in the CPI. These subnational population and geographic distinctions are possible because in the CE, survey data are collected at the household rather than national level.

The CE collates expense reports for over 200 unique expenditure categories, which can then be used to construct category expenditure estimates. The survey is conducted continuously on a monthly basis, providing users the ability to derive monthly, quarterly, and annual expenditure estimates. In this regard, the CE survey is unique. It is currently the exclusive source of monthly and annual expenditure estimates as required by the CPI program to construct elementary item-area indexes for the CPI.[2]

The alternative source of consumer expenditure data in this report, the PCE component of the National Income and Product Accounts (NIPA), is produced by the Bureau of Economic Analysis (BEA). These data are based on a census of retail establishments conducted every five years and on a variety of other sources rather than on a single survey, and they are

2. The CPI methodology is explained in detail in the BLS *Handbook of Methods*, available at http://stats.bls.gov/opub/hom.

widely used as a measure of national consumption expenditures. This chapter examines the accuracy and reliability of CPI data by comparing the official CPI, based on CE expenditure weights, to experimental indexes based on PCE expenditure levels using a PCE/CE spending factor. Because the PCE data are national data and the CE data are available at a local-area level, the PCE/CE spending factor used in the chapter must be applied identically across all areas and population groups. The comparisons that follow discuss indexes created for the years 2005–2010.

Two alternative indexes were constructed for the analysis. The first of these indexes, called PCE-UNADJ, uses PCE expenditure levels with CPI item definitions without adjusting PCE data for coverage differences (for example, the inclusion of expenditures for rural households) or conceptual differences (for example, PCE's inclusion of employer-provided health insurance). The second index, called PCE-ADJ, uses PCE expenditure levels adjusted for CPI item definitions, coverage, and concepts. A PCE alternate-weighting scheme is also useful in providing a check of the two data sources against each other. Both PCE and CE measure consumer expenditures, but they do so with very different approaches.

### 2.3 Data and Hybrid Index Design

Previous work has studied weighting bias, deflator differences, and expenditure ratios between PCE and CE to stimulate discussion and methodological improvement. This chapter builds upon that body of work by reconstructing CPI aggregation weights using PCE expenditure levels and item definitions to create hybrid indexes. These hybrid indexes use CPI index methodology and CE expenditure data to construct weights as the CPI does; however, CPI expenditures in the hybrid index aggregation weights are multiplied by factors that adjust them to PCE expenditure levels. The following pages discuss the realities of creating such PCE-calibrated CPIs using current CPI methodology and describe both results and drawbacks of such work. Designing a PCE-calibrated CPI is especially valuable to the current discussion of CE design, as it gives us a better idea of whether CE item response is both accurate and representative.[3] The similarity of the CPI-U and PCE-calibrated indexes and item-relative importances provides insight into CE accuracy.

To create PCE-calibrated indexes, a concordance between CPI and PCE item classifications is required. With this concordance, PCE expenditures are approximately matched to CPI item classifications and used to adjust the CPI expenditure weights to the levels where they would be if the CE reported absolute expenditures at the same level as PCE. This constitutes the PCE scope index in this study: an index that is calibrated to PCE expenditure

3. For a description of the current CE redesign project, see http://www.bls.gov/cex/geminiproject.htm.

levels in the CPI goods and services categories that correspond to PCE categories. The PCE scope index is referred to as PCE-UNADJ in this chapter.

The other created index goes one step further and tries to account for the fact that some PCE categories match CPI categories in concept but not in expenditure definition; in this index, factors derived from secondary source data are used to adjust PCE expenditures to match CPI definitions in categories where the two data sources differ. For example, both PCE and CPI measure eggs and milk expenditures in the same way, but they measure medical expenditures differently. The CPI only uses out-of-pocket consumer spending for medical goods and services, including insurance premiums, whereas PCE includes all expenditures made both by and on behalf of consumers for medical goods and services, taking into account additional expenditures such as employer and government contributions. Therefore, this index includes a factor that adjusts PCE medical expenditures to include out-of-pocket payments only. This index is referred to as PCE-ADJ for the purposes of this chapter. The methodology section below elaborates on this process.

### 2.3.1 Previous Consumer Expenditure Data Comparisons

Numerous authors have undertaken important research into the comparison of PCE and CPI data on consumer expenditures to examine the quality and accuracy of CE. This previous work delves further into potential causes of bias and error between PCE and CE. Lebow and Rudd (2003) approached the issue of weighting bias in the CPI after the 1990s brought about tremendous change in CPI methodology.[4] They constructed a set of PCE weights to compare to CPI weights in the same time period by performing a variety of adjustments to PCE data and then aggregating the weights. They excluded out-of-scope items, adjusted medical, housing, and education expenditures to more closely align with CPI values, and they attempted to adjust for population differences between the two data sources using a factor.

Fixler and Jaditz (2002) compared the CPI and the PCE deflator, the BEA's price index computed from PCE data, to derive the magnitude of index difference attributable in 1992–1997 to each type of major difference: formulaic, conceptual, and implementation related.[5] They focused on what they called an "accounting" solution that attempted to adjust for each of the major differences and calculate its ratio of the index discrepancies; Fixler and Jaditz did not try to examine weighting or pricing issues directly.

McCully, Moyer, and Stewart (2007) built on work like that by Fixler and Jaditz to expand the time period addressed forward to 2007 and calculated formula, scope, weight, and "other" effects, such as seasonal adjustment, that cause fundamental differences between the deflator and the CPI.[6]

4. See Lebow and Rudd (2003).
5. See Fixler and Jaditz (2002).
6. For more information see McCully, Moyer, and Stewart (2007).

Garner et al. (2006) have produced a variety of papers in which they construct and update expenditure category ratios between PCE and CE data.[7] Those authors constructed ratios for both comparable and noncomparable goods and services categories, taking care to examine each category in their paper and explain the caveats to the comparison and provide some reasons why ratios differ from one. Many other authors, including Clark (2003), Triplett (1978, 1981), and others have also examined the PCE and CPI; the work of the authors mentioned above adds to the debate about differences between the two subjects.

All of the papers discussed above bring to light a variety of fundamental issues in attempting to relate PCE and CE or CPI data. Garner et al. (2006) explain data collection methodology differences between the two. The CE obtains its data through a series of diary and interview surveys of consumers. In contrast, PCE data come from a variety of data sources, but are primarily derived from the quinquennial Economic Census, with data from trade and industry surveys to supplement in the off years (or nonbenchmark years).

Many authors speak of the item-scope differences between the two surveys. As McCully, Moyer, and Stewart (2007) explain, CPI includes out-of-pocket consumer expenditures and PCE includes purchases both by and on behalf of consumers. Two big conceptual differences discussed by Fixler and Jaditz (2002) are population and implementation at the component level. In most cases, they argue, CE data should be a subset of PCE data. The PCE includes expenditures by military personnel and third-party payers, such as employers, that CE does not allow. However, CE and CPI go outside of the bounds of PCE in some areas. The PCE does not include items that it considers coercive, such as vehicle registration and licensing, which are included in both CE and the Consumer Price Index. The PCE also does not include CPI and CE items such as lawn mowers and garden tractors, household maintenance and repairs, and fishing and hunting licenses.

There are even differences in definition between items that match each other in the two indexes, such as apparel and food. In many cases, PCE and CPI categories will be a perfect match, except that the item classification results in CPI arranging items in a way that is slightly different from how it is done in PCE. For example, CPI and PCE apparel categories concord perfectly, except that CPI includes wallets, umbrellas, and purses in apparel under accessories. The PCE includes these items not in apparel, but in luggage. Some of this structure knowledge comes from concordance research conducted as a collaborative effort between the CE, CPI, and PCE offices at the Bureau of Labor Statistics and Bureau of Economic Analysis.[8]

7. See Garner et al. (2006).

8. E-mails and concordance discussions with Clinton McCully (BEA), William Passero (BLS), Thesia Garner (BLS), and Rob Cage (BLS), 2011.

Garner et al. (2006) note that previous studies have shown that although underreporting in CE and diminished representativeness or respondent accuracy may be a cause for the difference between PCE and CE results, the magnitude of PCE revisions indicates that there are potential estimation issues coming from those data as well. Issues may also arise in the way that PCE uses a variety of data sources. The general consensus among authors who studied both PCE and CE data was that one could not be chosen as the whole source of bias and difference between the two, and all agreed that there was further work to be done.

### 2.3.2 Index Methodology

There are two experimental indexes in this study: an index that is PCE-calibrated using PCE valuation of consumption (PCE-UNADJ) and an index that is PCE-calibrated using CPI valuation of consumption (PCE-ADJ). The PCE-UNADJ is created in the following manner:

1. A CPI entry level item[9] (ELI) to PCE series code[10] concordance is created with input from the Bureau of Labor Statistics and the Bureau of Economic Analysis. This is because the CPI uses a proprietary classification system that does not align perfectly with the PCE system: there are many goods and services that are classified in general categories in one system and in disaggregated categories in the other system. There are also goods and services that have different definitions between PCE and CPI and no clear match between their PCE and CPI classification codes. In the concordance, ELIs are assigned to the lowest-level-matching PCE series code publicly available. Although this is sometimes a perfect match, sometimes multiple ELIs matched to one broad PCE code, and sometimes an ELI had to be split between multiple PCE codes in the concordance. Using this concordance, all ELIs are broken down into one of three categories: out of PCE scope, one PCE series code per ELI, and multiple PCE series codes per ELI. One example of an ELI that falls outside the scope of PCE is TF011 (see table 2.1).

The CPI apparel demonstrates an example of the other two types of ELIs, ELIs that match to exactly one PCE series code and ELIs that must be split between multiple PCE series codes (see table 2.2).

The ELI AA021 maps into only one PCE series code, DMBCRC. The AA022, however, maps mostly into DMBCRC but also maps in part to

9. More information on ELIs can be found in the BLS *Handbook of Methods*, chapter 17 (http://stats.bls.gov/opub/hom): "Within each item stratum, one or more substrata, called entry-level items (ELIs), are defined. There are a total of 305 ELIs, which are the ultimate sampling units for items as selected by the BLS national office. They represent the level of item definition from which data collectors begin item sampling within each sample outlet."

10. The PCE series code names and definitions can be found in National Income and Product Accounts (NIPA) Underlying Detail Table 2.4.5U "Personal Consumption Expenditures by Type of Product." Further information about the PCE series structure is available in the NIPA Handbook at http://www.bea.gov/national/pdf/NIPAchapters1–9.pdf.

**Table 2.1** **Out-of-scope ELI example**

| ELI | ELI description | PCE series code | PCE description | Allocation ratio |
|---|---|---|---|---|
| TF011 | State vehicle registration and driver's license | n/a | n/a | 0.00 |

**Table 2.2** **In-scope ELI examples**

| ELI | ELI description | PCE series code | PCE description | Allocation ratio |
|---|---|---|---|---|
| AA021 | Men's underwear, hosiery, and nightwear | DMBCRC | Men's and boys' clothing | 1.00 |
| AA022 | Men's accessories | DMBCRC | Men's and boys' clothing | 0.93 |
| AA022 | Men's accessories | DLUGRC | Luggage and similar personal items | 0.07 |

DLUGRC. This is because CPI includes wallets and umbrellas in apparel, whereas PCE includes those items in luggage.[11]

2. Allocation ratios are assigned to each ELI-PCE code combination so that all ratios for an ELI summed to one.[12] All ELIs that matched perfectly to one PCE code, regardless of the number of ELIs per PCE code, receive a value of "1" as in the example above for ELI AA021. The ELIs that are not included in the scope of PCE are given a value of "0," as shown above in the TF011 example.[13] All other ELIs are divided into their component PCE series codes using underlying CE expenditure data at the observation level. For most ELIs, this means using data at the CE diary survey level. For the few split ELIs that are only available in the interview portion of CE, an even split ratio is provided for all PCE codes that mapped to the ELI. This is the case in two education ELIs and one other goods and services ELI. In the apparel example above, a scan of all 2003–2008 AA022 diary data

11. The ELI-to-PCE-series-code concordance can be viewed on the CPI website at http://www.bls.gov/cpi/cpipceconcd.pdf.

12. If the ELI did not completely map to PCE, that is, part of but not the entire ELI was out of PCE scope, then the ratios for that ELI would sum to the percentage of ELI expenditures that were within scope for both CE and PCE. For example, the ratios for EE031, "other information services," sum to approximately .98 because a small web services component of that ELI does not map to PCE at all.

13. In some cases, it may be possible to find expenditure data in the National Income and Product Accounts that corresponds to these goods and services. However, this study makes no attempt to supplement PCE expenditure data with secondary source data in such a manner to account for item categories included in the CPI but excluded from PCE. A similar procedure could be implemented in a later version of this chapter.

shows that 7 percent of all AA022 expenditures were wallets and umbrellas, whereas 93 percent of AA022 consists of other accessories. Therefore, the AA022 allocation ratios are 0.93 for DMBCRC and 0.07 for DLUGRC.

3. The ratios are multiplied by CE expenditure data and then summed by PCE code assignment to create a set of total CPI expenditures by PCE code for each year in the period.

4. Using NIPA underlying table 2.4.5U "Personal Consumption Expenditures by Type of Product"[14] and the CPI expenditure data from step number 3, PCE/CPI factors are created for each PCE series code. For example, in a PCE category where PCE reported $200 of expenditures and CE reported $100 of expenditures, the PCE/CPI factor would be two.

5. The factor is applied to expenditure data and then applied to the CE microlevel data to recalibrate CPI aggregation weights to PCE values for the 2003–2008 period. For example, an ELI that matched one-to-one in definition with a PCE series code would have a recalibration factor of one. If PCE reported $200 in expenditures for that PCE code and CPI reported $100 in expenditures for that PCE code, then the factor would be two as in step number 4. Because of the perfect definition match, the PCE calibration for this ELI would simply apply a factor of two to the microlevel data.

6. The adjustments in step number 5 are made for each ELI at the reported CPI expense level. The resulting adjusted costs are then weighted and summed to the elementary CPI item-area category level, annualized for the 2003–2004, 2005–2006, and 2007–2008 expenditure reference periods, and converted into aggregation weights.

7. The new aggregation weights are used to create indexes for 2005–2010 using standard CPI-U methodology.

Because two market basket structure changes have taken place in the CPI over the past few years, the aggregation weights are adjusted depending on the market basket structure used in that year. The final result of this work is a set of annualized biennial expenditure weights by CPI item-area category that are used to create PCE-UNADJ using CPI index aggregation methods. That is, the indexes presented here all employ the same formula and biennial weight update process used in the CPI-U, whereas the PCE indexes published by the BEA use quarterly weights and a Fisher ideal index formula.

An important difference between the CE and PCE weights is that the former are calculated and implemented in the CPI at the item-area level. For example, the CPI employs "apple" category weights for thirty-eight geographic areas and matches them to thirty-eight corresponding area-level basic price indexes. In contrast, PCE weights and indexes exist only at the national level. This chapter uses elementary item-area prices and adjusted weights. Due to data availability, we assume that the PCE/CPI expenditure ratio is uniform across

14. http://www.bea.gov/national/nipaweb.

US areas and create the calibration factors and PCE-ADJ adjustment factors at a national level to apply them to the local thirty-eight-area CPI data.

To create PCE-ADJ, the original recalibration factors are modified by secondary source data to create a new set of factors that not only reflect differences in item definition, but also reflect differences in expenditure definition. The CPI apparel example above is a difference in item definition: CPI wallets and umbrellas are listed in clothing accessories, whereas PCE wallets and umbrellas are included in luggage; the ratios for both PCE-UNADJ and PCE-ADJ are created so that the wallet and umbrella value from CPI apparel is recalibrated by PCE luggage expenditures. An expenditure definition difference can be seen in CPI education: CPI higher education tuition reflects only out-of-pocket payments, whereas PCE higher education tuition reflects all payments—out-of-pocket and third party; the expenditure factor must be adjusted by a constant that represents the average US out-of-pocket spending on college tuition as a percentage of total US spending on college tuition. After this proportion adjustment is made, the process aligns perfectly with the process used to create PCE-UNADJ in steps 4–7 above.

In this project, a variety of adjustments are made to differentiate PCE-ADJ from PCE-UNADJ, or to adjust PCE categories with different expenditure definitions to fit CPI expenditure definitions. In many cases, this adjustment removes third-party payments from PCE expenditure data. Table 2.3 contains the adjustments and affected ELIs.

For PCE-ADJ, student tuition and board expenditures from PCE-UNADJ are adjusted to exclude third-party payments such as grants using National Center for Education Statistics data on total and out-of-pocket costs of college for American students.[15] Medical expenditures that typically include some insurance payment component are adjusted to exclude third-party payments made by employers, government, and others using data from the Agency for Healthcare Research and Quality's Medical Expenditure Panel Survey (2008).[16] Utilities, rent, homeowners' insurance, financial services fees, vehicle insurance, and vehicle maintenance and repair are adjusted using the CE-PCE ratios in Garner et al. (2006) to fit PCE levels.

The homeowners' insurance ratio of 8 is an approximation from the text of the paper rather than an official ratio, and it is used because homeowners' insurance is included in a large-scope ratio of "other household operations" that has a value closer to 1.03. The ratios from Garner et al. (2006) are not ideal for such an index because they include other factors beyond expenditure difference such as item under- or overreporting.[17] However, in these cases,

15. The National Center for Education Statistics (NCES) data used is derived from tables 1 and 2 in Wei (2010).

16. The MEPS data comes from the Agency for Healthcare and Research Quality (2008).

17. The goal of this chapter is to produce broad-level PCE/CE ratios to shed a critical light on how the two have changed over the years. These ratios may differ from one for a variety of reasons other than differences in the way category consumer expenditures are measured.

**Table 2.3 PCE-ADJ adjustments by ELI**

| ELI(s) | CPI description | PCE code(s) | PCE description | Adjustment factor | Data source |
|---|---|---|---|---|---|
| All "EB" ELIs | Tuition, other school fees, and child care | All | All | 0.59 | NCES[a] |
| FV051 | Board, catered events, and other food away from home | DMSLRC | Meals at schools | 0.59 | NCES |
| GD051 | Checking accounts and other bank services | DFEERC | Financial service charges and fees | 0.08 | GJPPV[b] |
| HA011 | Rent of primary residence | All | All | 0.98 | GJPPV |
| HD011 | Tenants' and household insurance | All | All | 8.00 | GJPPV |
| HF011 | Electricity | All | All | 1.02 | GJPPV |
| HF021 | Utility (piped) gas service | All | All | 0.86 | GJPPV |
| HG011 | Residential water and sewage service | All | All | 0.69 | GJPPV |
| MA011 and MF011 | Prescription drugs | All | All | 0.17 | AHRQ[c] |
| MA090 and MG090 | Unsampled rent or repair of medical equipment | DOMORC | All other professional medical services | 0.17 | AHRQ |
| All "MC" ELIs | Professional medical services | All | All | 0.17 | AHRQ |
| All "MD" ELIs except MD031 | Hospital and related services | All | All | 0.17 | AHRQ |
| All "ME" ELIs | Health insurance | All | All | 0.17 | AHRQ |
| MB023 and MG013 | Supportive and convalescent medical equipment | All | All | 0.17 | AHRQ |
| All "TD" ELIs | Motor vehicle maintenance and repair | All | All | 0.67 | GJPPV |
| TE011 | Motor vehicle insurance | All | All | 2.11 | GJPPV |

[a] NCES refers to the National Center for Education Statistics publication "What Is the Price of College? Total, Net, and Out-of-Pocket Prices in 2007–2008" (Wei 2010).

[b] GJPPV refers to Garner et al. (2006).

[c] AHRQ refers to the Agency for Healthcare Research and Quality's Medical Expenditure Panel Survey (2008).

quality national data that separated item costs by the expenditure type needed are unavailable.

## 2.4 Results

### 2.4.1 Item Representation

In the 2007–2008 annualized weights (which correspond to the 2010 index values), the mean item stratum PCE-UNADJ-to-CPI-U expenditure ratio is 1.65—this is a simplified approximation of the ratio that was applied to CE data in step number 3 to create weights for PCE-UNADJ and PCE-ADJ. The mean item stratum PCE-ADJ-to-CPI-U expenditure ratio for the same time period is 1.51. It aligns well with the final expenditure totals: at $9.3 trillion, the 2010 final weighted PCE-UNADJ expenditure total was slightly less than twice the CPI-U expenditure total of approximately $5.1 trillion. In contrast, the 2010 final weighted PCE-ADJ expenditure total of $7.5 trillion was 1.46 times the CPI-U total—these expenditure totals correspond with the 2007–2008 annualized weights.

Tables 2.4 and 2.5 show more detail for the items with the highest and lowest CPI-U/PCE-ADJ ratios—this is the inverse of the PCE-ADJ-to-CPI-U ratio discussed previously. These cases in which the adjusted PCE expenditure value differs most from the CPI value can be indicative of item representation issues or of areas where the PCE-ADJ secondary source adjustments could be more finely tuned. "Child care and nursery school," as seen leading table 2.4, is an excellent example of this. Babysitting, a person-to-person component of child care, frequently involves payments between individuals and is therefore more likely to be represented in the CPI. For the purposes of this chapter, child care in one's home has been removed from the ratio allocations to account for this definition difference because that is the lowest accurate level at which the child care and nursery school data can be disaggregated to remove babysitting. However, not all in-home child care is considered to be babysitting, which may be the cause behind the high ratio seen below.

Table 2.5 lists item strata with the lowest CPI-U/PCE-ADJ expenditure ratio—this is equivalent to the highest PCE-ADJ/CPI-U expenditure ratio. Item strata that consistently have much higher PCE-ADJ expenditure levels than CPI-U expenditure levels include "floor coverings," "other video equipment," and "technical and business school tuition and fees." In table 2.4, there are multiple notable medical-item strata, which is indicative of the possibility that the broadly applied medical-expenditure adjustment used in PCE-ADJ may not be a perfect fit for all medical expense categories.

Figures 2.1 and 2.2 show scatterplots of the CPI-U and PCE-ADJ expenditure values for each item stratum, with rent and a few other large expenditures such as tuition and vehicles excluded in figure 2.2 so that all other

**Table 2.4** **Top five CPI-U/PCE-ADJ expenditure ratio maximums**

| Item | Item description | 2005 ratio | Item | Item description | 2007 ratio | Item | Item description | 2009 ratio |
|---|---|---|---|---|---|---|---|---|
| SEEB03 | Child care and nursery school | 4.155 | SEEB03 | Child care and nursery school | 4.556 | SEEB03 | Child care and nursery school | 4.182 |
| SEMC03 | Eyeglasses and eye care | 2.529 | SEMC03 | Eyeglasses and eye care | 2.820 | SEMC03 | Eyeglasses and eye care | 2.708 |
| SEMC02 | Dental services | 2.006 | SEHE02 | Other household fuels | 2.450 | SEHE02 | Other household fuels | 2.640 |
| SEHE02 | Other household fuels | 1.806 | SEMC02 | Dental services | 2.112 | SEMC02 | Dental services | 1.986 |
| SEHB02 | Other lodging away from home including hotels and motels | 1.763 | SEHB02 | Other lodging away from home including hotels and motels | 1.623 | SEME03 | Health maintenance plans | 1.509 |

**Table 2.5** **Bottom five CPI-U/PCE-ADJ expenditure ratio minimums**

| Item | Item description | 2005 ratio | Item | Item description | 2007 ratio | Item | Item description | 2009 ratio |
|---|---|---|---|---|---|---|---|---|
| SEGD01 | Legal services | 0.136 | SEFW02 | Distilled spirits at home | 0.136 | SEEE02 | Computer software and accessories | 0.131 |
| SEEE02 | Computer software and accessories | 0.133 | SEEE02 | Computer software and accessories | 0.117 | SEFW02 | Distilled spirits at home | 0.131 |
| SEEB04 | Technical and business school tuition and fees | 0.132 | SEMD03 | Care of invalids and elderly at home | 0.112 | SEHH01 | Floor coverings | 0.117 |
| SERA03 | Other video equipment | 0.128 | SERA03 | Other video equipment | 0.099 | SEEB04 | Technical and business school tuition and fees | 0.087 |
| SEHH01 | Floor coverings | 0.100 | SEHH01 | Floor coverings | 0.090 | SERA03 | Other video equipment | 0.087 |

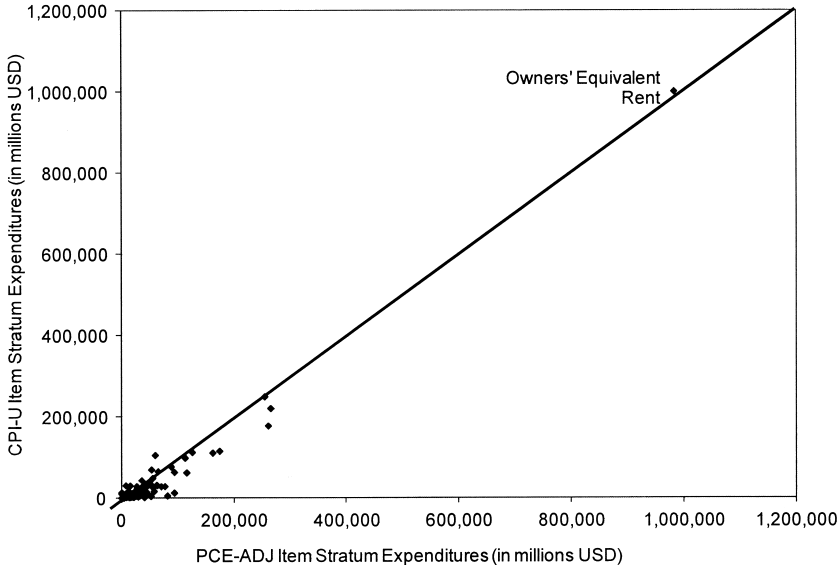


**Fig. 2.1 Scatterplot of CPI-U and PCE-ADJ elementary item stratum expenditure estimates, 2005.12**

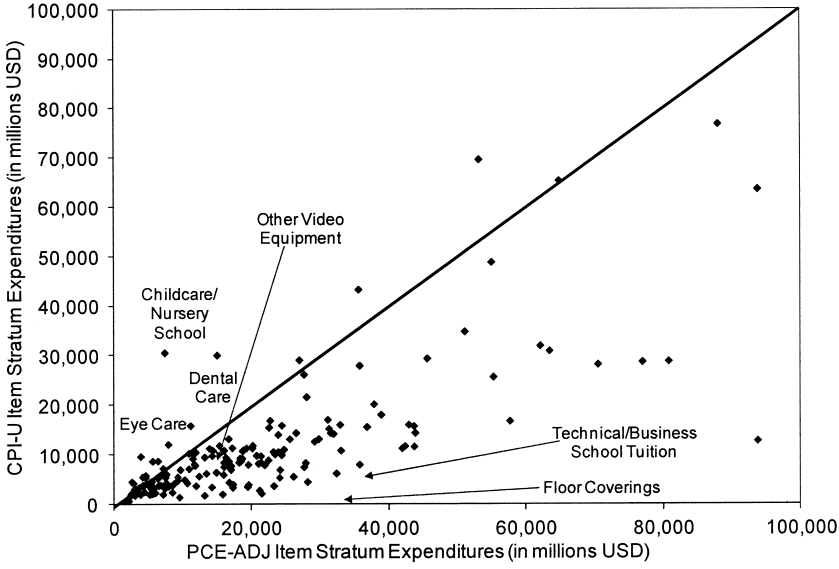


**Fig. 2.2 Scatterplot of CPI-U and PCE-ADJ elementary item stratum expenditure estimates, 2005.12 (OER, tuition, and other large expenditures excluded)**

**Table 2.6 December 2005 item relation importances**

| Consumption category | CPI-U (%) | PCE-calibrated indexes: PCE-UNADJ (%) | PCE-calibrated indexes: PCE-ADJ (%) |
|---|---|---|---|
| Food and beverages | 15.1 | 13.8 | 17.0 |
| Food at home | 8.0 | 7.1 | 8.7 |
| Food away from home | 6.0 | 4.9 | 6.0 |
| Alcoholic beverages | 1.1 | 1.8 | 2.3 |
| Housing | 42.4 | 26.5 | 32.9 |
| Rent | 5.8 | 3.4 | 4.1 |
| Owner's equivalent rent | 23.4 | 12.9 | 15.9 |
| Other housing | 13.1 | 10.2 | 12.9 |
| Apparel | 3.8 | 4.5 | 5.5 |
| Medical care | 6.2 | 22.3 | 5.0 |
| Transportation | 17.4 | 13.9 | 17.3 |
| Motor vehicles | 7.9 | 5.3 | 6.5 |
| Gasoline | 4.2 | 3.4 | 4.3 |
| Other transportation | 5.4 | 5.2 | 6.5 |
| Education and communication | 6.0 | 5.4 | 6.7 |
| Recreation | 5.6 | 6.8 | 8.4 |
| Tobacco | 0.7 | 1.0 | 1.2 |
| Other goods and services | 2.8 | 5.8 | 6.0 |
| | 100.0 | 100.0 | 100.0 |

item trends may be more easily examined. From these scatterplots, it is easy to see that the expenditure levels used to calculate the PCE-ADJ and CPI-U are similar, because their ratio lies along the 45° line. In other words, after secondary source adjustment to CPI definitions, these items have roughly the same absolute expenditure value in both CE and PCE.

In both figures, a 1:1 ratio line illustrates item stratum expenditure level trends; items below the line have a higher PCE-ADJ expenditure level than CPI-U expenditure level, while items above the line have a higher CPI-U expenditure level than PCE-ADJ expenditure level. A majority of the 211-item strata fall below the line, which indicates, as expected due to the PCE weight adjustments, that overall expenditure levels for most items are higher in the PCE-calibrated CPI-U than in the published CPI-U.

Table 2.6 shows item-category relative importances for the three indexes using December 2005 weights. As expected, there are large differences in medical relative importances between PCE-UNADJ and PCE-ADJ and small differences in these relative importances between the CPI and PCE-ADJ. Shelter relative importances are very different between both PCE indexes and the CPI-U, not because of dramatic differences between the two data sources in housing expenditure levels, but rather because of total expenditure differences in other categories (such as medical care). In other words, although the budget share of housing is smaller using PCE data than

CE data, both PCE and CE agree on how much is spent total on shelter—the share itself changes because other goods and services increase their proportions of total spending in the PCE indexes.

It is also important to note that some items show larger differences between the CPI-U and PCE-ADJ, which could be indicative of an item representation issue in CE. Four categories that are commonly cited as being underrepresented in CE due to respondent behavior are apparel, other goods, tobacco, and alcohol. The evidence from this study supports the expectation that those four categories might have lower CE representation than PCE representation. Tobacco and alcohol, which are believed to be underreported because of their sensitive nature, also have a significantly smaller relative importance in the CPI-U than in PCE-ADJ index. Apparel and other goods may be underreported in CE because of proxy reporting: if only one member reports expenditures for the entire household, they may be more aware of family food, housing, and education purchases than of the clothing and other personal goods purchases made by all household members.[18] Both of those categories also have significantly higher relative importance values in both PCE-calibrated indexes than they do in the CPI-U.

The PCE-UNADJ relative importances are slightly different. Because medical care is measured so differently between the two sources (CE and PCE) and therefore carries a large adjustment in this study, medical care makes up almost a quarter of PCE-UNADJ, but makes up only 5 percent of the CPI-U and PCE-ADJ. In accordance with the other adjustments made to create PCE-ADJ, the PCE-UNADJ transportation and housing categories have lower relative importances than the corresponding CPI-U and PCE-ADJ categories, while PCE-UNADJ education is a bit higher. Slight variations exist in some of the other item categories such as recreation and other goods. This merits further investigation; it is possible that there could be a significant difference in item representation in one of those categories as well.

### 2.4.2 Index Levels and Change

When the PCE-calibrated indexes and the CPI-U are compared between 2005 and 2010, it is clear how closely the published CPI-U and PCE-ADJ track each other. As shown in figure 2.1, the CPI-U tends to be slightly higher than PCE-ADJ. However, overall the PCE-ADJ five-year annualized growth rate is 0.071 percent lower than the CPI-U five-year annualized growth rate. In contrast, the PCE-UNADJ five-year annualized growth rate is 0.338 percent higher than the CPI-U five-year annualized growth rate.

Lebow and Rudd (2003), constructing an index similar to PCE-ADJ, concluded that the CPI has an upward bias of approximately 0.1 percent per

18. Garner et al. (2006) provide an in-depth discussion of underreporting in the context of PCE/CE ratios in their paper.

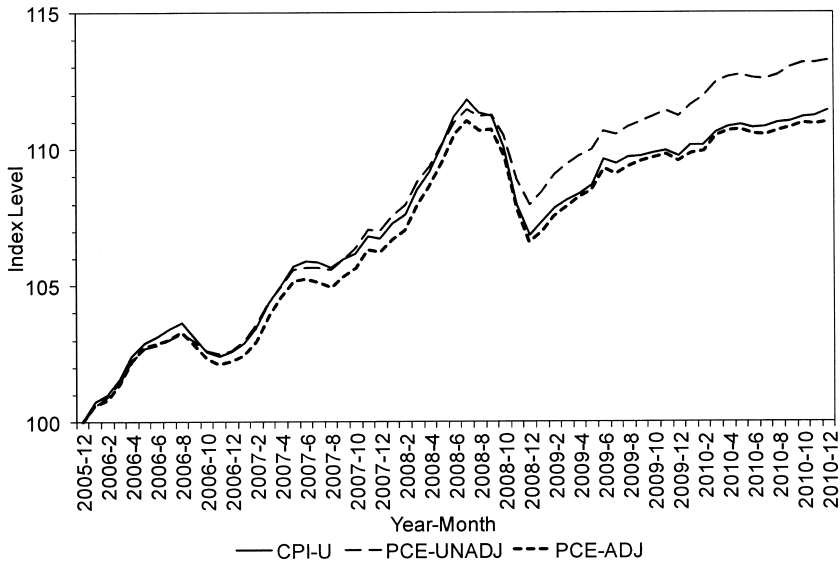


**Fig. 2.3 CPI-U and PCE-calibrated index comparisons**

year due to inaccurate weights. Their conclusion was based on comparison of indexes using CE and PCE weights over the 1987–2001 period, with those weights computed at the twenty-four-item level. This chapter, using a later time period and a more detailed weight and index decomposition, shows a difference of 0.071 percent, which is of the same magnitude as Lebow and Rudd's results, but slightly lower.

Figure 2.3 demonstrates the shape and direction of the indexes. As previously noted, both indexes containing the CPI definitions (CPI-U and PCE-ADJ) exhibit similar rates of change and rise more slowly than the index that uses PCE expenditure valuation (PCE-UNADJ). The fact that the CPI-U and PCE-ADJ indexes exhibit similar rates of change is logical because their expenditure definitions match in two large categories: medical expenses and education.

Figure 2.3 also shows that the PCE-UNADJ index has risen more quickly than the CPI-U and PCE-ADJ indexes. The PCE-UNADJ index series diverges from the CPI-U and PCE-ADJ index series after October 2008 due to the larger weight given to medical care and education items. From October 2008 to the end of the study period, the all-items CPI-U index increased 1.20 percent while the medical care and education CPI-U indexes increased 7.16 percent and 8.93 percent, respectively. Combined, these categories contribute to a larger rate of inflation for the PCE-UNADJ series compared to the CPI-U and PCE-ADJ series.

Most items in the CPI-U and PCE-ADJ indexes have similar relative importances between the two indexes, with one notable exception. Shelter,

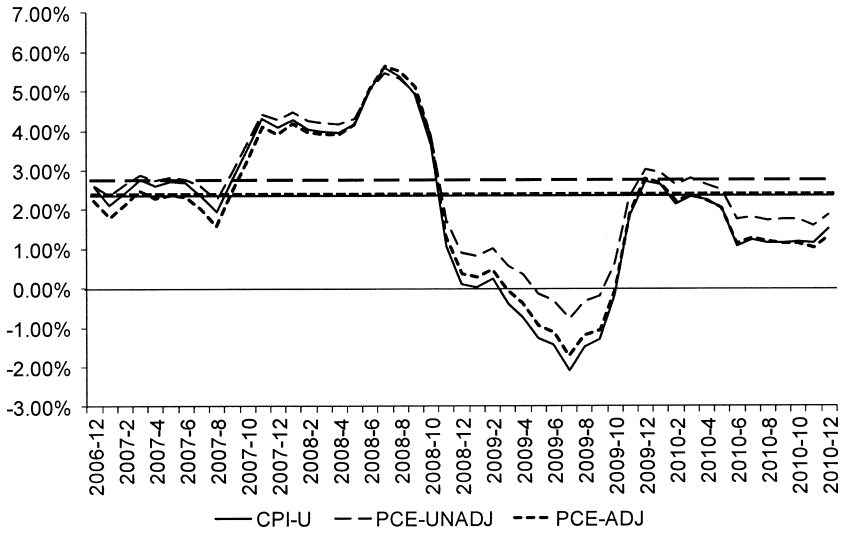


**Fig. 2.4 CPI-U and PCE-calibrated twelve-month index change comparisons**

the category that has a relative importance almost 10 percentage points higher in the CPI-U than in the PCE-ADJ, might be expected to be the reason that the PCE-ADJ diverges from the CPI-U for most of the time between 2005 and 2010.[19] The shelter CPI-U index increased 0.46 percent from October 2008 through December 2010—a price change lower than the all-items index change. Between October 2008 and December 2010, the average monthly shelter-only CPI-U index change differed from the average monthly CPI-U index change for all items by a mere 0.010 percent. A look at 1998–2010 CPI-U data reveals that the two average monthly CPI-U index change values differed by only 0.015 percent (with the all-items index increasing slightly more rapidly than the shelter-only index) between the two indexes. Despite the difference in weights, shelter price change is more similar to the rest of the CPI than education and medical services, and so it has a lower impact on the experimental index results than the latter two items.

Figure 2.4 shows the twelve-month index change values for each of the three indexes. While the 2006–2010 average twelve-month index change for the CPI-U is approximately 2.013 percent, that value is 0.003 percent lower for PCE-ADJ and 0.441 percent higher for the PCE-UNADJ index. However, the difference between CPI-U and PCE-ADJ twelve-month index change ranges from 0.371 to –0.373 over the 2006–2010 period.

19. Section 4.1 includes a discussion of why shelter-relative importances differ between PCE-ADJ and CPI-U.

### 2.4.3 Caveats

As mentioned above, there are a variety of ways in which it is nearly impossible to create a perfect PCE-calibrated CPI due to differences in the nature of the data. Although secondary source data make the ratio estimates for education and medical expenses more useful, they are applied broadly in the creation of PCE-ADJ rather than disaggregated down to the item level. It is unlikely that the ratio of medical expenditures paid out-of-pocket by consumers will be identical for the purchase medical specialist services and prescription drugs or primary care doctor visits. It is also possible that the proportions of education expenditures for public and private universities are different between the CPI and the NCES survey from which the tuition ratio is derived. There may be ratios other than those created by Garner et al. (2006) in which the nonconsumer portion of the ratio can be removed in aggregation, although they are difficult to find in secondary sources.

In addition, the populations covered by the aggregate CPI-U and PCE data are very different. The CPI-U data cover urban, nonmilitary, noninstitutional households, whereas PCE data cover domestic consumers including third parties that make purchases on behalf of consumers. The PCE does not include domestic consumers who have been and will be in the country for less than one year.

Across all time periods, the total expenditure values for items HA01 and HC01—the two major CPI shelter categories—are nearly identical for the CPI-U and its PCE-calibrated counterparts. As shown in figure 2.1, owners' equivalent rent falls extremely close to the CPI-U/PCE-ADJ=1 line in 2005. However, the relative importance of housing in the CPI-U is higher than the relative importance of housing in both PCE-UNADJ and PCE-ADJ because CE expenditure levels in housing more closely match PCE expenditure levels than expenditure levels in other item categories do; in many item categories outside of housing, CE expenditure levels are lower than PCE expenditure levels.

Other small discrepancies may arise in specifics of the concordance and in the scope of the two consumption data sets; PCE and CPI both contain items that are out-of-scope in the other consumption data. To produce the two indexes above, four ELIs from the three-market basket structures used had to be removed altogether because they are considered out of scope in PCE and therefore have no expenditure value. Vehicle registration and license fees are seen as coercive and not included in PCE, while gardening and lawn services and inside home maintenance and repair are not included in PCE because they are considered intermediate expenditures of homeowners. Some additional portions of CPI items, such as hunting and fishing licenses, are excluded from PCE. In such cases, the portion of the ELI that is not used in PCE was removed, causing these ELI proportions to sum to less than one. There is also the potential for item definition differences that

were not addressed in the concordance used for this study. This is because CE uses survey data, and item definition interpretations can vary from respondent to respondent. For example, PCE disaggregates the CPI "souvenirs" universal classification code (UCC) out to categories that describe the individual components. Guidebooks and programs are included in books, postcards are included in stationery, and T-shirts are a part of apparel. However, determining this disaggregation in the CPI can be nearly impossible because some respondents simply write "$20 souvenirs" rather than "$15 T-shirt, $5 postcards" in the diary portion of the survey.

Finally, an unsolved methodological debate arose during this project that involves the way in which PCE-CPI expenditure ratios were calculated for ELIs that had to be split between PCE codes. Data are PCE calibrated by fitting CPI expenditures into PCE series categories, but the data must then be mapped back into CPI items (one level above ELIs) to construct expenditure weights as CE data are in CPI production. For the purposes of this chapter, data are mapped into the item categories corresponding to the ELIs from which their CPI expenditures originally came. However, a future improvement to this methodology would be to identify the CPI items that best match where the PCE expenditures map so that CPI price quotes are functionally "moved" into the categories that best fit the PCE calibration rather than staying in their original item categories.

### 2.5 Future Research

The PCE and CE data have been compared for years at the Bureau of Labor Statistics and in the broader federal community.[20] There is still much work to do, however. If anything, this chapter illustrates the need for further analysis in this area. The PCE-calibrated price indexes constructed here explore only a few of the many possibilities that exist in bringing current CPI data closer to the data used in PCE. Although some of these possibilities seem infeasible currently, there is always the hope that more light will be shed on them in future efforts.

One area in which methodological improvements could be made is in population matching. The CE and CPI populations differ from the PCE population, which is a problem rooted in the way the data are collected. The PCE data come primarily from the production side as part of the National Income and Product Accounts and are typically the result of equations that remove all nonconsumer use allocations from the total purchase value of a good or service to create a personal consumption value. The CE (and therefore CPI) data are collected directly from the consumer, a practice that allows for more population-limiting specificity. These data are limited to nonmilitary, noninstitutionalized households and, in the case of the CPI-U,

20. See Lebow and Rudd (2003) or Fixler and Jaditz (2002) for examples of this.

can be further limited to exclude consumption by rural households. Finding a method by which to more closely match the CPI population to the PCE population would allow for more accurate use of PCE weights in an alternate CPI.

Further study into the historical differences between the CPI-U and an index similar to PCE-ADJ would also be very useful. Being able to see ten or more years of comparative data instead of five would help researchers better understand the differences and how they have changed with time and item-structure updates in both the CPI and PCE. The CPI has undergone two item-structure changes in the past few years, and PCE has moved from one benchmark year period to the next. These changes could potentially have a large effect on the data, but also help us more easily identify bias and data inaccuracies as they change from structure to structure or period to period.

A larger-scale update to the methodology used in this chapter lies in the items themselves. Although this concording exercise focuses on the weight side of the Consumer Price Index, it would be beneficial to create a hybrid CPI that matches PCE definitions for both weighting and pricing. Similarly, a set of hybrid indexes created using concorded UCCs rather than concorded ELIs could create a more accurate comparison by fine-tuning the good- and service-level comparisons. The UCC structure can also change, and the methodology used here only focused on item- and ELI-structure changes when determining allocation ratios.

Finally, there are a few ways in which data from the Consumer Price Index can be used to create a more accurate representation of a PCE-calibrated index. An index could be constructed by modifying the level of aggregation in the CPI. A CPI aggregated to the major group (apparel, education and communication, food, other goods, housing, medical, recreation, transportation) level would remove many definitional discrepancies between PCE and CPI, allowing us to focus on the largest differences. Going in the opposite direction, more detailed concording research could be done to break data down for classification at the individual-observation level, causing each data point in the CPI or PCE data to be intentionally mapped to its correct ELI or PCE series code. This would mean the creation of a "true" PCE-UNADJ or PCE-ADJ, but would also involve mapping both NIPA and CPI data to underlying categories.

## 2.6 Conclusion

This chapter contrasts current BLS Consumer Price Index values with the values derived from PCE-calibrated Consumer Price Indexes adjusted to PCE and CPI good and service definitions. Ultimately, the results indicate that adjusting PCE weights to CPI expenditure definitions yields an index (PCE-ADJ) that closely tracks the CPI-U. However, there are also strong differences between the two indexes, particularly once results are disaggre-

gated to the item level. We see differences in item-relative importance in the apparel, alcohol, and tobacco categories that may be indicative of an item representativeness issue in those categories in the CE survey. Overall, the PCE-UNADJ annualized growth rate over five years is 0.338 percent higher than that of the CPI-U, while the PCE-ADJ annualized growth rate over five years is 0.071 percent lower than that of the CPI-U.

As shown above, there is still a lot of ground to cover in order for this work to accurately represent the two indexes. Some aspects may be more difficult to correct in future work, such as adjustments for population and scope differences between PCE and CPI, while others may provide an excellent opportunity for further research, such as more detailed item concording using further disaggregated data from both the BLS and the BEA. The closer these indexes come to accurately representing the real CPI and a real PCE-valued CPI, the more useful they are in examining the representativeness of CE survey data. Finding that PCE and CE have similar item-level outcomes may be useful in future survey design to reduce respondent burden or allow for detailed data-quality checks. Large differences would indicate that it may be time to reexamine the motivations and methodology in the two consumer expenditure data sets. Although, when using this index data, we cannot show whether match issues are due to CE bias or PCE methods, the above results and future work will help us to better determine how to continue refining our data collection and aggregation methods.

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