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Micro versus macro consumption data: the cyclical properties of the consumer expenditure survey

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The Consumer Expenditure Survey (CEX) offers the most comprehensive consumption data at the consumer level for the United States. Several previous studies have shown a large gap between per-capita consumption from the CEX and the aggregate Personal Consumption Expenditure (PCE) series. While previous research has focused on consumption levels, we focus on the cyclical properties of consumption. We find that the cyclical properties of consumption expenditure data from the two sources are quantitatively very different. This result calls for caution when using CEX data for business cycle research.

Keywords: consumption; business cycles; Consumer Expenditure Survey; Personal Consumption Expenditure

JEL Classification: E01; E21; E32

I. Introduction

While representative agent models can be usefully calibrated or estimated with aggregate data, the need for more detailed micro datasets becomes apparent as the discipline increasingly resorts to heterogeneous agent models.[1] Consumption is, of course, a key variable, as it is one of the two variables from which agents who populate macroeconomic models regularly derive utility – the other being leisure. The Consumer Expenditure Survey (CEX) is the only source for micro-data on consumption with a breadth of coverage comparable to Personal Consumption Expenditure (PCE), the aggregate series on consumption commonly used in business cycle research. Competing surveys, such as the Consumer Population Survey (CPS) and the Panel Study of Income Dynamics (PSID), do not reach the breadth and level of detail in consumption included in the CEX.[2]

Macroeconomists have long been users of CEX micro-level data. Several strands of literature are notable clients of the CEX data. First, the CEX data are an indispensable source for studying consumption dynamics over the life cycle. The work by Attanasio *et al.* (1999) is an early example of this ongoing literature. Second, a continuing body of work including Souleles (1999) and Parker (1999) tests the Euler equation using the CEX data. Third, a more recent literature uses the CEX data to study the cross-sectional dispersions of consumption expenditure, how these dispersions evolved over time and how their evolution compares with that of income

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[1] On the trend towards heterogeneous agent models consider the statement by Heathcote *et al.* (2010), who write 'the expansion of business-cycle analysis to richer models with heterogeneous agents is at the forefront of the research program in quantitative macroeconomics', and also the survey on heterogeneous agent models by Heathcote *et al.* (2009). On the use of micro-data in macroeconomic research, consider the forceful case made by Browning *et al.* (1999) in their entry in the *Handbook of Macroeconomics*.

[2] For a description and discussion of the relative merits of the CEX, CPS and PSID, see Attanasio (1999).

inequalities. Examples in this literature include the work by Krueger and Perri (2006), as well as by Blundell *et al*. (2008), Primiceri and van Rens (2009) and Heathcote *et al*. (2010). Fourth, in business cycle research, CEX data was used by Klenow (1998) and, more recently, by Eusepi and Preston (2009) and López (2010).

Previous research has detected a gap in levels between CEX micro-data and PCE (see, e.g. Slesnick, 1992; Garner *et al*. 2006, and recent work by Heathcote *et al*., 2010). The finding is that per-capita consumption expenditure measured in the CEX is roughly half as large as PCE data and that the gap increases over time. This gap in levels does, however, not tell us anything about how deviations from trend in consumption measured from the CEX and the PCE compare.[3] We tackle this question in this article. Using consumption data from the CEX interview survey, we conduct the type of analysis which is familiar to macroeconomists from the influential work by Cooley and Prescott (1995) and which looks at the moments of log-deviations from trend of the variables of interest.

Studying the cyclical properties of consumption from the CEX is of particular importance if CEX data are to be used for business cycle research. If the cyclical properties of micro and macro consumption data do not line up, results from a dynamic general equilibrium model using micro-data from CEX and the long body of prior research using aggregate PCE data are not easily comparable.

II. Data and Methodology

The CEX and PCE

PCE measures the goods and services purchased by households and by Non-Profit Institutions Serving Households (NPISHs) who reside in the United States. PCE also includes purchases by US government civilian and military personnel stationed abroad, regardless of the duration of their assignments, and by US residents who are travelling or working abroad for 1 year or less. Travel expenditures by nonresidents are subtracted to compute a net value.

The CEX, on the other hand, is a survey which measures the goods and services purchased by households resident in the United States, and does not include expenses of NPISHs. The survey targets the civilian noninstitutionalized population, and therefore excludes government civilian and military personnel stationed abroad. Although it measures travel expenditures by residents, it evidently does not measure travel expenditures by nonresidents.

The CEX actually consists of two separate surveys: the Interview survey and the Diary survey. The survey we use, the Interview survey, is a rotating panel which interviews households with quarterly frequency. Household members are asked to recall expenditure on consumption items made over the previous 3 months. In addition to data on consumption expenditure, this survey offers complete information on socio-economic characteristics of households. In the smaller Diary survey, on the other hand, respondents are asked to fill a diary for two consecutive weeks. Data on some items, particularly food, are more detailed than in the Interview survey. A major drawback of the Diary survey is that it provides comprehensive consumption data starting only in 1986.

Due to differences in scope we are forced to exclude from our analysis the two functional categories present in PCE which cannot be measured with CEX data: *Final consumption expenditures of NPISH* and *Net Foreign Travel*. There is no need to exclude any other category beyond these two for our study. The CEX covers the definitions of the remaining PCE categories remarkably well. It does, for example, include a measure of imputed housing services, an important sub-item in *Housing and utilities*, which is included in PCE and the CEX despite not being an expenditure. Our aggregate consumption measures are then defined as follows. Using line numbers from National Income and Product Accounts (NIPA) Table 2.4.5U, we define durable goods as line 3 ('*Durable goods*') and nondurable goods as line 70 ('*Nondurable goods*'). Services are defined as line 149 ('*Household consumption expenditures* (*for services*)') minus line 327 ('*Net foreign travel*').[4]

Neither the CEX's own consumption classification nor the classification of nondurable consumption in Attanasio and Weber (1995) – which is a classification usually followed in the literature – are comparable to the definition of PCE in aggregate NIPA data. This problem spawned the pioneering work by Harris and Sabelhaus (2000), who created the CEX-NBER extracts for the period 1980:Q1–2003:Q2 by using the detailed expenditure files of the CEX and mapping each Universal Classification Code (UCC) into a functional category of consumption of a previous classification of the PCE. We conduct our study for the whole period for which CEX data are available, 1980:Q1–2010:Q4. Since the functional classification for PCE has changed over time (it experienced a substantive change in the 2009 comprehensive revision by the Bureau of Economic Analysis (BEA)), we cannot use the mapping by Harris and Sabelhaus (2000), or any other previous mapping. We redo the classification and map each UCC into its closest analogue in the functional classification of PCE data to obtain durable, nondurable and services consumption expenditure for each consumer unit in the sample. Our mapping from UCCs into PCE categories is provided in the Appendix.

Sample selection and data treatment

We follow the literature in dropping some households from the sample for data quality purposes. It is common to restrict the sample to consumer units satisfying certain consistency criteria. We focus on consumer units classified as complete income reporters with nonzero, nondurable consumption. Further, if a wage is reported, we require that the hourly wage is at least

[3] In fact, examples can be constructed in which there is a gap between PCE and the CEX but deviations from trend are identical. Consider, for example, two fictitious consumption time series $c_t^a = \exp(\gamma^a t)$ and $c_t^b = \exp(\gamma^b t)$ where $\gamma^a \neq \gamma^b$. There is a gap between the two series (which is increasing over time). However, the log of each series is a straight line. A trend extracted from a straight line (using either a linear trend specification or the Hodrick–Prescott (HP) filter) will just identify the trend with the straight line. Log-deviations from this trend are then exactly equal to zero for both time series and all relevant business cycle statistics coincide.

[4] Line 149, '*Household consumption expenditures* (*for services*)' already excludes '*Final consumption expenditures of NPISH*', measured in line 336. Lines 149 and 336 add up to line 148 in NIPA Table 2.4.5U ('*Services*').

Table 1. Summary statistics for the period 1980Q1–2010Q4

	GDP	CEX D	CEX ND	CEX S	PCE D	PCE ND	PCE S
Mean	53.32	1.80	4.60	9.65	3.67	8.79	24.31
SD	8.80	0.48	0.17	0.62	1.49	1.14	4.04
Relative SD	1.00	0.05	0.02	0.07	0.17	0.13	0.46
CV	0.16	0.26	0.04	0.06	0.41	0.13	0.17
Relative CV	1.00	1.60	0.23	0.39	2.47	0.79	1.01

Notes: Variables are in levels after seasonally adjusting. The first two rows are measured in thousands of constant 2005 dollars. The word 'relative' indicates that a value is measured relative to GDP. Abbreviations are D: durables, ND: nondurables, S: services; CV: coefficient of variation.

half of the minimum wage and that the consumer unit does not report positive labour income while working zero hours. As virtually all studies using the CEX over the whole period do, we consider only urban consumer units. The reason is that between 1981 and 1984 nonurban households were excluded from some of the interviews because of budget cuts.[5]

Before conducting the analysis, we transform the data into the form used in business cycle research. As is common practice in this line of research, data are rendered per-capita by dividing by a measure of working-age population: civilian noninstitutionalized population between the ages 16 and 64.[6] We deflate data with indexes from NIPA Table 1.1.9: *Implicit Price Deflators for Gross Domestic Product* to obtain chained-dollars of 2005 and seasonally adjust using the Census Bureau's Autoregressive Integrated Moving Average (ARIMA) X-11 procedure.

III. Results

Table 1 exhibits summary statistics for per-capita consumption expenditure from CEX and PCE data, as well as per-capita Gross Domestic Product (GDP). Consumption expenditure as measured from the CEX hovers around 50% of consumption expenditure in PCE for durables and nondurables, and around 40% for services. In the case of services, the shortfall of CEX data is the largest. This finding is, of course, not new. It is in line with the findings of previous research which was discussed in Section I. The gap between CEX and PCE data widens as time progresses for all three consumption categories. This can be best seen in Fig. 1(a–c).

The gap in levels is not by itself informative of the cyclical properties of data from the CEX and PCE. As discussed in Section I, the difference in levels, and the increasing gap, will show up in the trend which is fitted to the data, not in the deviations from trend. However, Fig. 1(a–c) already hint at the fact that deviations from trend are more volatile in the CEX than in data from PCE. The question about volatility is quantitatively taken up in Table 2, which exhibits variability measures for the cyclical component of the macroeconomic aggregates. The cyclical components for durable, nondurable and services consumption in CEX and PCE data are plotted in Fig. 1(d–f). As is usual in business cycle research, we measure the cyclical component as the log-deviation from a trend by running the data through a HP filter with a parameter value of 1600.

As documented by Table 2, the SD of the cyclical component of consumption expenditure is uniformly larger for CEX data. In fact, the cycle of nondurables and services is at least twice as volatile as in PCE data.

The last row of Table 2 computes a statistic frequently used in business cycle research: the SD of the cyclical component of consumption aggregates relative to the SD of the per-capita GDP cycle. It is remarkable that the volatility of the cycle of nondurable and services consumption is larger than GDP volatility. If we were to take the standpoint that consumption expenditure in the CEX is adequately measured, then we would conclude that agents are not succeeding in smoothing consumption.

To study the contemporaneous co-movement of variables, we compute correlations between consumption in CEX and PCE data. The upper half of Table 3 shows that, while the correlation in log-levels between the three consumption aggregates is high in PCE data, this is less true for the CEX. Also, in the case of CEX, the correlation of nondurable consumption with the other two aggregates is extremely low when compared to the PCE benchmark.

The lower half of Table 3 exhibits contemporaneous correlations for the cyclical components of the series. It shows that the consumption cycle in the CEX is badly correlated with the cycle measured with data from PCE. Again, we find that the correlation between the different CEX consumption categories is also lower than the correlation between PCE consumption categories for all variables involved. This result, which is also apparent from viewing the plots in Fig. 1, means that aggregated micro-data from the CEX give completely different information about the business cycle than aggregate PCE data.

In Table 4 we compute the correlations between GDP deviations from trend and lagged and forward deviations from trend of expenditure categories. Across the board, correlations are lower when CEX data rather than PCE data are employed. For example, the contemporaneous correlation of the consumption cycle (measured as nondurables and services) with

[5] For the absence of rural households in the CEX in selected years, see Citro and Michael (1995, p. 392) and the documentation file for the 1982–1983 data tapes. Rural data was discontinued in the third quarter of 1981 and then resumed in the first quarter of 1984. Leaving rural households in the sample could produce jumps that would be (incorrectly) interpreted as cyclical movements in consumption.

[6] We obtain these data from the Bureau of Labor Statistics (BLS) website (we compute quarterly averages of the difference between series LNU00000000 and series LNU00000097).

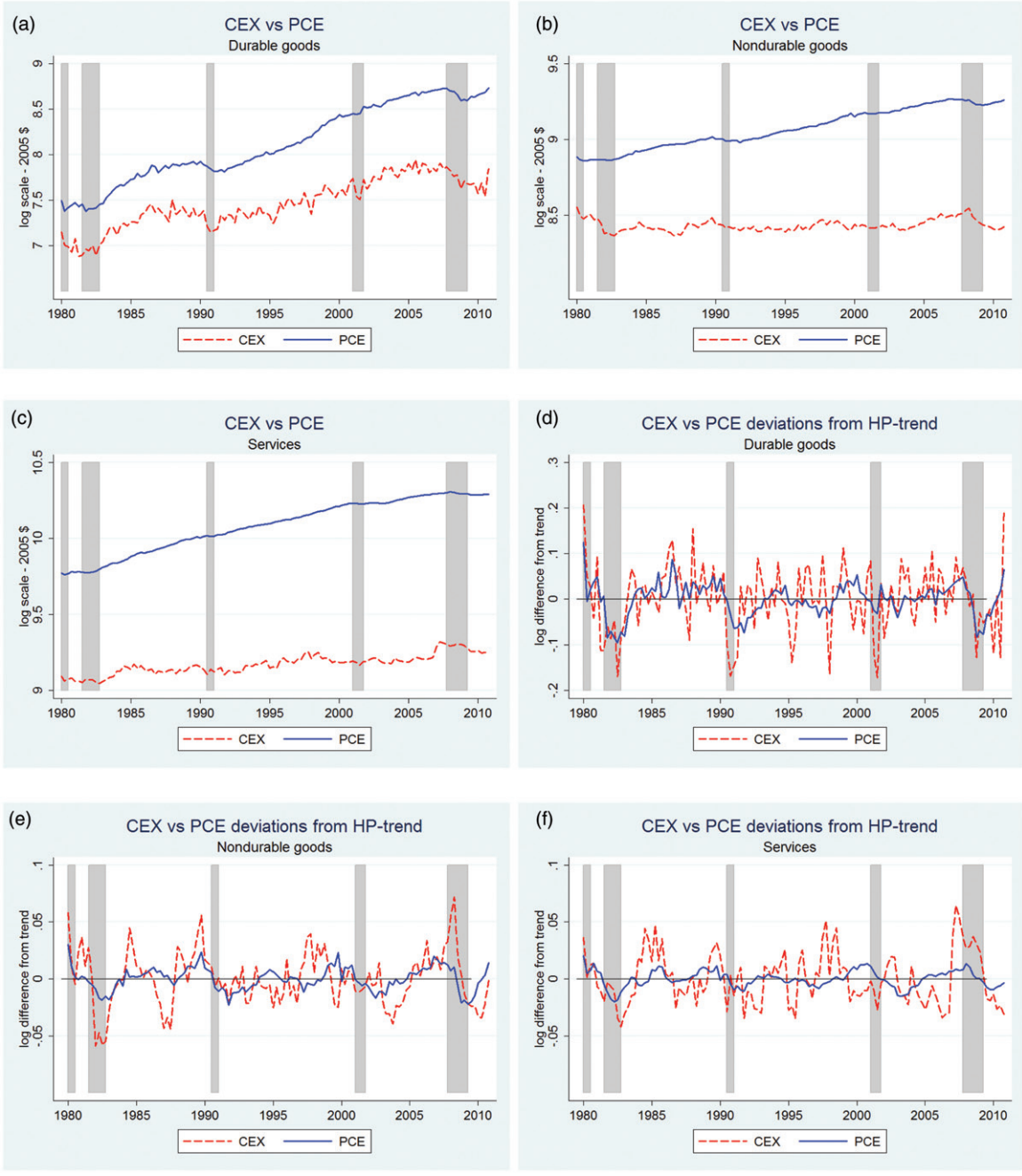

Fig. 1. (a)–(c) plot the logarithm of quarterly seasonally adjusted per-capita durable, nondurable and services consumption expenditure in the CEX survey and in PCE. (d)–(f) plot the cyclical component of per-capita durable, nondurable and services consumption expenditure in the CEX survey and in PCE. Data in these last figures are the logarithm of the seasonally adjusted series and has been filtered with the HP filter with parameter 1600. Shaded areas represent NBER-dated recessions

Table 2. Summary statistics for the period 1980Q1–2010Q4

	GDP	CEX D	CEX ND	CEX S	PCE D	PCE ND	PCE S
Mean	10.87	7.46	8.43	9.17	8.12	9.07	10.08
SD cycle	0.01	0.07	0.02	0.02	0.04	0.01	0.01
Relative SD cycle	1.00	5.43	1.78	1.68	2.71	0.75	0.55

Notes: Variables are in logs after seasonally adjusting. The last two rows refer to deviations from a HP trendline with smoothing factor 1600. The word 'relative' indicates that a value is measured relative to GDP. Abbreviations are D: durables, ND: nondurables, S: services.

Table 3. Correlation matrix for log levels and cycle for the period 1980Q1–2010Q4

	CEX D	CEX ND	CEX S	PCE D	PCE ND	PCE S
Log-levels						
CEX D	1.00					
CEX ND	0.29	1.00				
CEX S	0.82	0.38	1.00			
PCE D	0.95	0.29	0.87	1.00		
PCE ND	0.94	0.31	0.88	1.00	1.00	
PCE S	0.91	0.24	0.87	0.97	0.98	1.00
	CEX D	CEX ND	CEX S	PCE D	PCE ND	PCE S
Cycle						
CEX D	1.00					
CEX ND	0.29	1.00				
CEX S	0.21	0.55	1.00			
PCE D	0.53	0.44	0.25	1.00		
PCE ND	0.40	0.47	0.21	0.77	1.00	
PCE S	0.27	0.59	0.29	0.62	0.66	1.00

Notes: Data is seasonally adjusted before taking logs. The cycle is measured as log-deviations from a HP trend with smoothing factor 1600. Abbreviations are D: durables, ND: nondurables, S: services.

Table 4. Cross correlations between variables and GDP

	$t-5$	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$
CEX D	0.31	0.36	0.39	0.41	0.35	0.34	0.15	0.01	−0.10	−0.13	−0.22
CEX ND	−0.06	0.11	0.28	0.41	0.56	0.66	0.58	0.43	0.32	0.14	−0.00
CEX S	−0.04	0.07	0.15	0.22	0.29	0.33	0.33	0.32	0.27	0.18	0.06
CEX C	−0.05	0.10	0.22	0.32	0.43	0.49	0.47	0.40	0.32	0.19	0.04
PCE D	0.17	0.40	0.57	0.69	0.79	0.78	0.56	0.38	0.18	0.01	−0.15
PCE ND	0.13	0.33	0.50	0.64	0.73	0.83	0.72	0.55	0.37	0.19	−0.01
PCE S	0.05	0.30	0.47	0.60	0.70	0.74	0.65	0.56	0.46	0.31	0.19
PCE C	0.08	0.33	0.52	0.66	0.77	0.84	0.74	0.61	0.47	0.30	0.14

Notes: The variables are measured as quarterly lagged deviations from a HP trend with smoothing factor 1600. Quarterly data for the period 1980Q1–2010Q4. Abbreviations are D: durables, ND: nondurables, S: services, C: nondurables and services.

the GDP cycle is 0.49 in CEX data compared to 0.84 in aggregate data.

In addition to low cross-correlations, CEX cyclical measures also exhibit low autocorrelations. We display autocorrelations in Table 5 and again find that the CEX exhibits the lower values. Autocorrelations of the cyclical components in the CEX drop to zero quickly. In the case of PCE, autocorrelations do not drop as fast as the order of the lag is increased.

Summarizing, our main findings are that (1) CEX data exhibit a low correlation with PCE data, particularly in the case of nondurable and services consumption, (2) the consumption cycle is more volatile in the CEX than PCE, (in fact, CEX nondurables and services are more volatile than the GDP cycle), (3) CEX data are less autocorrelated and (4) the cyclical components in CEX data are less correlated with the GDP cycle at various different lags.

IV. Discussion and Conclusion

Micro evidence has been used in informing and evaluating dynamic general equilibrium models at least since the 1980s (cf. Prescott, 1986). The CEX, given its exhaustive information on consumption, provides, in principle, an ideal dataset to bridge the micro and macro literatures. However, we have found in this article that micro and macro measures of consumption do not exhibit the same cyclical properties. This discrepancy between the cyclical properties of CEX and PCE is particularly worrying if CEX data are to be used in research where the cyclical properties of data play a significant role. By highlighting the discrepancy between the cyclical properties of the CEX and the PCE, our article warns against the indiscriminate use of the CEX for this purpose.

There is a case to be made that some of the findings, in particular the greater variance in the CEX, are to be expected to some extent. Similar to all other surveys, the CEX will contain survey (sampling) variability. It is, however, not obvious that this increased cross-sectional variability necessarily translates into greater variability over time of deviations from a trend. The reason of the discrepancy between micro and macro data may also lie on the side of aggregate data. In the calculation of PCE, interpolation and forecasting methods are used. Personal consumption

Table 5. Autocorrelations

	CEX D	CEX ND	CEX S	CEX C	PCE D	PCE ND	PCE S	PCE C
$t-1$	0.19	0.71	0.63	0.70	0.69	0.80	0.85	0.86
$t-2$	0.15	0.47	0.42	0.51	0.56	0.65	0.69	0.72
$t-3$	0.09	0.29	0.23	0.33	0.40	0.49	0.52	0.58
$t-4$	−0.04	0.08	0.02	0.10	0.21	0.29	0.26	0.34
$t-5$	−0.09	−0.00	0.05	0.04	0.02	0.08	0.06	0.13

Notes: The variables are measured as quarterly deviations from a HP trend with smoothing factor 1600. Quarterly data for the period 1980Q1–2010Q4. Abbreviations are D: durables, ND: nondurables, S: services, C: nondurables and services.

expenditure on certain items is estimated using the residual method (by subtracting government purchases from total expenditure).

In our article, we do not extend judgement on which data source, the CEX or PCE, is the 'correct' measure of consumption expenditures, although some of the findings, such as the excessive volatility of consumption – which implies a failure of consumption smoothing by the average CEX consumer unit – will probably make some macroeconomists suspicious of the CEX. If, in fact, the cyclical properties of PCE data are preferred over those of CEX, then this leads to the next question: Is there a way of adjusting CEX data so that it is compatible with the cyclical properties of PCE?

At the time of writing, a generally accepted way of adjusting or improving CEX data was not available. We have identified two possible strategies in the literature which, although not specifically designed to align the cyclical properties of both data sources, have been proposed to correct for measurement error in the CEX. The first approach is to use complementary data sources to minimize measurement error in the CEX. Recent work in this direction includes Attanasio *et al*. (2004) and Battistin and Padula (2010), who attempt to resolve measurement error by using two different collection methods available in the CEX: the interview data, which is used in our study, and a diary of consumption available for some consumption items. The second approach relies on consumer theory and, in particular, budget constraints. Examples of this strategy include Parker *et al*. (2009) and Aguiar and Bils (2011), who use a demand system to correct for systematic measurement error in the CEX's expenditure data. Both approaches have proven useful in closing the gap between the CEX data and the aggregate consumption data. Whether they help in aligning micro and macro data on the cyclical dimension in a satisfactory way is still an open question that we leave for future research.

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Appendix: UCC Mapping

In this Appendix, we explain how consumption expenditures from the detailed expenditure files in the CEX can be aggregated to make them compatible with PCE (2009 revision).

The construction of an updated mapping between UCCs and PCE categories is a byproduct of this article. Since we expect our mapping to be useful for others, we present it at the highest possible level of detail, so that future researchers do not need to 'reinvent the wheel'. Rather than exhibiting a table that maps UCCs into the three major categories (durables, nondurables and services), we map them into sub-items of these categories. Sub-categories can then be collapsed into the major categories if desired by taking into account that major categories are composed of the following sub-categories (numbers in parentheses indicate line numbers in NIPA Table 2.4.5U):

Durable goods include *Motor vehicles and parts* (4), *Furnishings and durable household equipment* (21), *Recreational goods and vehicles* (36), *Other durable goods* (60).

Nondurable goods include *Food and beverages purchased for off-premises consumption* (71), *Clothing and footwear* (102), *Gasoline and other energy goods* (111) and *Other nondurable goods* (118).

Services include *Housing and Utilities* (150), *Health care* (168), *Transportation services* (186), *Recreation services* (205), *Food services and accommodations* (228), *Financial services and insurance* (246), *Communication* (275), *Education services* (284), *Professional and other services* (292), *Personal care and clothing services* (301), *Social services and religious activities* (309) and *Household Maintenance* (321).

Table A1. Classification of UCC codes into line numbers of NIPA Table 2.4.5U

Line No.	UCC
4	450110 450210 480110 480211 480213 480214 480215 490500 490501 490502 600141 600142
21	230117 230118 230131 230132 230133 230134 240111 240112 240113 240121 240122 240123 240211 240212 240213 240214 240221 240222 240223 240311 240312 240313 240321 240322 240323 290110 290120 290210 290310 290320 290410 290420 290430 290440 300111 300112 300211 300212 300221 300222 300311 300312 300321 300322 300331 300332 300411 300412 320110 320111 320120 320130 320150 320161 320162 320163 320210 320220 320230 320231 320233 320310 320320 320330 320340 320350 320360 320370 320410 320420 320511 320512 320521 320522 320611 320612 320613 320621 320622 320623 320631 320632 320633 320901 320902 320904 610120 690241 690242 690243 690244 690245 790690 990920 990930 990940
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