## Calculating State Weights for the Consumer Expenditure Survey November 2017

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**Abstract**
The Consumer Expenditure Survey (CE) is designed to produce unbiased estimates of expenditures made by U.S. households at both the national and regional levels, but not at the state level. However, there is an increasing demand for state-level expenditure estimates and re-designing the survey to produce unbiased state-level estimates in all 50 states would be prohibitively expensive. This paper presents an experimental approach to calculating weights for selected states with a sufficient representation in the CE survey so that users can use the weights to calculate unbiased expenditure estimates for their research projects. The approach was first tested in New Jersey because in the sample design based on the 2000 Census, every county in the state was in CE's sample. New Jersey's sample was reduced by dropping counties, and expenditure estimates were calculated using both the full and reduced samples. There were no statistical difference in the expenditure estimates, indicating a successful approach. Then the approach was extended to Florida and California and again there were no statistical differences, so the state weighting algorithm was successful in all three test states.

**Key words: base weights, stratification, Census tracts, constrained clustering, Consumer Expenditure Survey, sampling**

### 1. Introduction

The Consumer Expenditure Survey (CE) is a nationwide household survey which collects data on the expenditures made, income earned, and taxes paid by American households. The CE Survey consists of two independent surveys: the CE Interview Survey and the CE Diary Survey. The CE Interview Survey collects detailed expenditure data on large expenditures such as property, automobiles and major appliances; and on recurring expenditures such as rent, utilities, and insurance premiums. Conversely, the CE Diary Survey collects detailed expenditure data on small, frequently purchased items such as food and apparel. Both surveys share the same sample design.

CE data are used in a variety of ways. The Consumer Price Index (CPI) is the primary customer of the CE Survey and CPI uses the data to select new "market baskets" of goods and services for the index, to determine the relative importance of its components, and to derive cost weights for the baskets. The Internal Revenue Service (IRS) and the Supplemental Poverty Measure (SPM) are also customers of the CE Survey. The IRS uses CE's data to derive sales tax tables for taxpayers to use in the itemized deductions section of their tax returns. The SPM, which is an additional and not the official poverty measure, uses CE's data to derive poverty thresholds based on the amount of money consumers report spending on a basic set of goods that includes food, clothing, shelter, and utilities, and a small additional amount to allow for other needs.

CE uses a two-stage sample design to select a sample of households from the civilian non-institutional population.[1] In the first stage, single counties or groups of adjacent counties are assigned to Primary

[1] The civilian noninstitutional population covers approximately 98 percent of the U.S. population and includes people living in houses, condominiums, and apartments, as well as people living in group quarters such as college dormitories or boarding houses. However, it excludes the non-civilian and institutional portions of the population, such as military personnel living on base, nursing home residents, and prison inmates.

Sampling Units (PSUs) and a representative sample of PSUs is selected for the survey. In the second stage of the sample design, a representative sample of addresses is selected by systematic random sampling within each PSU.

CE redesigns its survey after every decennial census to reflect population changes, and to improve both coverage and sample selection procedures. CE has 91 PSUs in its sample which are distributed across the United States. Some of the PSUs are large metropolitan areas and are included in every design, whereas the other PSUs may enter and leave the sample with a design change after a decennial census. Some states may not have a PSU or only one or more rural PSUs, while other states such as New Jersey, may have every county in the sample. The sampling weights for each household are calibrated to national and regional population totals, but not state population totals. This means that the expenditure estimates are statistically valid at the national and regional levels, but not at the state level.

One approach to providing state-level estimates is for CE to calculate estimates for major expenditure categories for all 50 states, including the states without PSUs, and publish the tables. Another approach is to calculate weights for select states with PSUs that continue regardless of sample design changes and provide the user with weights so that they can produce expenditure estimates for their research projects. The latter approach was selected. The objective is to develop a state weighting algorithm for calculating respondent weights at the state level which parallels current procedures for estimating respondent weights at the national and regional levels. The state-level weights will be put on a separate public database so that the state weights can be merged with CE's Public Use Microdata (PUMD) files, allowing researchers to calculate state expenditure estimates for their projects.

New Jersey was selected as a test state because every county was included in a sampled PSU in Design 2000, the sample design based on the 2000 Census. Every county in New Jersey was included in either the New York or Philadelphia PSU. Therefore, expenditure data was available in every county of New Jersey, allowing for the calculation of the state's "true" expenditures. In Design 2010, the sample design based on the 2010 Census, five counties were dropped from the sample design. In this experiment, data from the sampled New Jersey counties in the 2010 Census were retained in the 2000 database and the state expenditures re-calculated. Thus, Design 2000 was treated as "truth" and Design 2010 was treated as an experiment, allowing a comparison of expenditure estimates from every county in the state with expenditure estimates from a subset of the counties. The estimates from the two designs were found not to be statistically different and found to be similar to estimates from CE's Philadelphia and New York Metropolitan Statistical Areas (MSAs). CE's large urban PSUs are also referred to as MSAs. Also, CE and the American Community Survey (ACS) ask similar questions for two expenditure categories, Electricity and natural gas and Rented dwellings. The ratio of the CE to ACS estimates at the national level were almost identical to the state level estimates, indicating that the New Jersey estimates were of the same quality as the national estimates.

This experimental technique for calculating state weights and expenditure estimates was then applied to Florida and California where only a subset of the counties in the state are included in sampled PSUs. The state expenditure estimates for Florida and California also compared favorably to expenditure estimates from state MSAs and for the two expenditure categories from the ACS. In conclusion, the results from the three states indicate that the technique for computing state weights is promising.

## 2. Overview of CE's Sample Design

It is important to understand CE's national sample design and weighting because the calculation of state weights is a modification of the national procedures (Neiman et al., 2015).

### 2.1 First Stage Sample Design

There are three major tasks in the first stage of a multi-stage stratified sample design: defining PSUs, stratifying PSUs, and selecting PSUs (Murphy 2008).

In the first stage, all 3,143 counties in the United States are assigned to PSUs. Urban PSUs are defined by the U.S. Office of Management and Budget (OMB) by assigning counties surrounding an urban core to geographic entities called Core Based Statistical Areas (CBSAs) where the assignment is based on each county's degree of economic and social integration to the urban core as measured by commuting patterns. There are two types of CBSAs: metropolitan CBSAs which are CBSAs that have an urban core with more than 50,000 people, and micropolitan CBSAs which are CBSAs that have an urban core with 10,000 to 50,000 people. All other counties are rural, and OMB does not group rural counties into small clusters of adjacent counties. CE defines its own rural PSUs using an adjacency matrix and zero-one integer linear programming (King 2012). In general, rural PSUs have their state's identity suppressed on CE's PUMD file because they have fewer than 100,000 people and there is a risk of identifying individual respondents. As a result, in most states, rural PSUs cannot be used for their state estimates.

After defining PSUs, each PSU is assigned to a stratification cluster based on its size-class and Census Region or Division. The primary objective of PSU stratification is to minimize the between-PSU component of sampling variance (Murphy 2008). In other words, the PSUs within each stratification cluster should be as homogenous as possible with respect to the survey variable, expenditures, but there should be variability between the stratification clusters. Also, within each Census Region or Division, each stratification cluster should have approximately the same population to minimize variance. This is a constrained clustering problem and is solved using heuristic algorithms. In Design 2010 a new heuristic stratification algorithm was developed which uses k-means clustering and zero-one integer linear programming (King et al., 2011). In Design 2010, four clustering variables were used: median household property value, median household income, latitude, and longitude. Median household income and median household property value correlate with expenditures and are calculated for each PSU from five-year ACS estimates.

After stratification, one PSU is selected to represent the PSUs in the stratification cluster with probability proportional to size. Very large metropolitan PSUs are assigned to their own stratum and are selected with probability of one. Consequently, these PSUs are referred to as self-representing. In Design 2010, self-representing PSUs have populations greater than 2.5 million people, whereas in Design 2000, the population cut-off was 2.7 million. The remaining PSUs are non-self-representing. The smaller metropolitan and micropolitan PSUs are stratified together in Design 2010, but stratified separately in Design 2000.

### 2.2 Second Stage Sample Design

After selecting the PSUs, a representative sample of addresses within each PSU is selected using systematic random sampling. The interest is in consumer units (CUs), [2] which are groups of people in households who pool their incomes to make joint expenditure decisions, but since there is usually one consumer unit per household and one household per address, the terms "address," "household," and "consumer unit" are often used interchangeably.

The first step of selecting a sample of addresses within each PSU is determining the survey's nationwide sample size and allocating it to the sample PSUs. CE's budget allows 12,000 addresses to be selected per year for the Interview Survey and 12,000 addresses per year for the Diary Survey. The objective of the allocation process is to allocate the 12,000 addresses to the 91 sampled PSUs such that the variance of CE's

[2] Consumer units include families; groups of unrelated people who live together and pool their incomes to make joint expenditure decisions; and single persons who live alone or with other individuals but who are financially independent of the other individuals.

most important statistic, the average annualized expenditure per consumer unit nationwide on all items, is minimized (Neiman et al., 2015). This objective is accomplished by allocating the nationwide sample to individual PSUs proportional to the number of people they represent, i.e., their stratum's population. After the sample has been allocated, a representative sample of addresses within each PSU is selected with systematic random sampling, where the within PSU sampling interval for each PSU is the number of addresses on the sampling frame in the PSU divided by the number of sample addresses allocated to the PSU.

## 3. Weighting for CE's Survey and State Weights

After drawing a representative sample of addresses in every PSU, each CU is assigned a base weight, which is the number of addresses in the population represented by the selected CU. The base weight is adjusted for subsampling in the field, noninterviews, and finally calibrated to known population totals.

### 3.1 Base Weights for the National Estimates

CE has a two-stage sample design which is reflected in the base weights. For Design 2000, the base weights are defined as:

$$\text{Base Weight} = \frac{1}{\text{Probability of Selecting PSU}} \times \left(2 \times \text{Within PSU Sampling Interval}\right)$$

where

$$\text{Probability of Selecting PSU} = \frac{\text{PSU Population}}{\text{Stratification Cluster Population}}$$

The probability of selection is calculated in the first stage of the sample design after the PSUs have been stratified and selected. The within PSU sampling interval is from the second sampling stage and is multiplied by two because a single sample is drawn for the combined Diary and Interview Survey with the sampled addresses alternately assigned to the Diary and Interview Survey. Beginning in 2018, the factor "2" will no longer be required since the sample of addresses will be drawn separately.

### 3.2 Base Weights for the State Estimates

The base weights for the state estimates are calculated similar to the national estimates. The primary difference is that. U.S. Census tracts replace PSUs for determining the probability of selection. Census tracts are small contiguous areas within a county or county equivalent that are relatively permanent from census to census. Ideally, Census tracts are approximately 4,000 people but can range from 1,200 to 8,000 people. Census tracts vary in geographical size, depending on population density, and range from a few blocks in densely populated areas to hundreds of square miles in sparsely populated areas.

Census tracts for a state are stratified using the same procedure for stratifying PSUs. For state estimates, the number of clusters is set to five, corresponding to the number of income quintiles. Only two clustering variables are used for state estimates: median household property value and median household income, which correlate with expenditures and are calculated for each Census tract from five-year ACS estimates. Latitude and longitude are not used as clustering variables for state-level estimates.

The same "within PSU sampling interval" is used for both state and national estimates, hence for the state weights, the base weights are calculated for each stratum as:

$$\text{State Base Weight} = \left(\frac{\text{Sum of the Tract Populations in State in a Stratum}}{\text{Sum of CE's Tract Populations in a Stratum}}\right) x$$

$$(\text{Within PSU Sampling Interval})$$

**3.3 Weighting Control Factor**

The weighting control factor adjusts for subsampling in the field, which occurs when a data collector visits a particular address and discovers multiple housing unit where only one housing unit was expected. The weighting control factor is generally 1.0, since subsampling is infrequent.

**3.4 Noninterview Adjustment**

The noninterview adjustment factor adjusts for interviews that cannot be conducted in occupied housing units due to a consumer's refusal to participate in the survey or the inability to contact anyone at the housing unit in spite of repeated attempts. For the national estimates, the sample CUs are partitioned into cells and an initial noninterview adjustment factor is calculated for each cell using a cell weighting procedure, where the cells are defined by five variables: the month in which the data was collected, the region of the U.S., the average adjusted gross income in the CU's zip code, the consumer unit size, and the number of contact attempts made by interviewers. The initial noninterview adjustment factor is calculated for each cell, but when there is an insufficient number of CUs in a cell, the factor is adjusted using a hierarchical cell collapsing procedure where cells are collapsed together using two of the five cell-defining variables: the consumer unit size and the number of contact attempts made by interviewers. Cells are not collapsed by month, the four regions of the U.S. (Northeast, Midwest, South, and West), or the three income groups (bottom 10%, middle 80%, and top 10%) which are formed using the average adjusted gross income in the CU's zip code according to a publicly available database from the IRS.

For state estimates, the noninterview adjustment is also calculated for each CU using the cell weighting procedure along with the hierarchical cell collapsing procedure. However, the procedure is run at the state level instead of at the regional level and run quarterly instead of monthly. The state's sample size is too small for monthly processing. A surrogate variable, ACS's median household income for each CU's Census tract replaced the average adjusted gross income in the CU's zip code.

**3.5 Calibration**

The final weight adjustment is calibration which adjusts the STAGE1WTs of the respondent CUs to sum to 24 "known" population totals to account for frame undercoverage. STAGE1WT is the product of the base weight x weighting control factor x noninterview adjustment factor. CE uses Lagrange multipliers to select the weights that minimize the amount of change made to the STAGE1WTs so that the calibrated weights multiplied by the number of CU members in each of the 24 demographic groups sum to the 24 population totals. The 24 population totals are from the Current Population Survey (CPS) and are: the total number of households in the U.S.; the total number of homeowning households in the U.S.; the total number of people in the four regions of the U.S.; the total number of people in the urban areas of those four regions; and the total number of people in 14 age x race categories. The population totals are updated every quarter from CPS.

At the state level, the same procedure is used, except only 9 "known" population totals are used in the Lagrange multiplier algorithm: the total number of households in the state; the total number of homeowning households in the state and the total number of people in 7 age categories. In most states, there is an insufficient number of black people in the sample for the calibration algorithm to converge, especially in the Diary Survey, which is the reason the 14 age x race categories were reduced to 7 age categories. On occasion, there was also an insufficient number of people in the 75+ age category, and when that occurred the 65-74 and 75+ age categories were combined into a single 65+ age category.

There are infinitely many set of weights that sum to the 24 (or 9) “known” population totals. The algorithm sets limits on the amount the STAGE1WTs can change, between 0.5 and 4, and the final weights are the product of the STAGE1WT x calibration factor.

## 4. Variance

Both the expenditure means and variances are calculated using the final weights from calibration using complete interviews. CE has a complex sample design and for the national estimates, balanced repeated replication (BRR) is used to generate an unbiased estimate of the sampling variance for expenditure means. CE assigns its PSUs to 43 rows of a Hadamard matrix, which are balanced by population, and the CUs within each stratum are randomly assigned to one of two half samples. For the state estimates, it is not possible to assign Census tracts to rows on a Hadamard matrix, so the jackknife, another method for estimating variances in a complex sample design, is applied (Valliant et al., 2013).

In applying the jackknife, one unit is deleted within a stratification cluster at a time. A unit is a county tract combination. Census tracts are unique within a county, but their codes may be duplicated in other counties so it is useful to create a new variable, CTY_TRACT, by concatenating county and tract. Some CTY_TRACTs are void of CUs and these are not used in the jackknife. Other CTY_TRACTs have one or more CUs, usually less than twelve. In the jackknife, each CTY_TRACT, i, is deleted one-at-a-time within a stratification cluster, h. Let $n_h$ be the number of CTY_TRACTs in cluster h. All CUs in the deleted CTY_TRACT have their state weights set to zero. The other $(n_h - 1)$ CTY_TRACTs in stratification cluster h have their state weights multiplied by $n_h/(n_h - 1)$ to represent the full stratification cluster. CUs in other stratification clusters retain their original state weight. Each deletion is a replicate, $\hat{\theta}_{(hi)}$ ,with a mean expenditure estimate for each of the over 800 expenditure categories and there is a replicate for each CTY_TRACT. The mean for the full sample is $\hat{\theta}$. The variance for each expenditure category is calculated using the following formula.

$$V(\hat{\theta}) = \sum_{h=1}^{5} \frac{n_h - 1}{n_h} \sum_{i=1}^{n_h} \left( \hat{\theta}_{(hi)} - \hat{\theta} \right)^2$$

## 5. State Estimates-Data

Five quarters of data from the Interview Survey and four quarters of data from the Diary Survey are required to calculate one-year estimates of consumer expenditures. Respondents for the Interview Survey are queried about their expenditures over a three-month period and interviews conducted in the first quarter of a year have expenditures from the previous year; therefore, five quarters of data are required to capture all expenditures that occurred in a single calendar year. Respondents for the Diary Survey are queried about their expenditures for the current week and there is no overlap for the previous year. Interview and Diary data from 2013 and quarter 1 of 2014 were selected for this project. Design 2010 was not implemented until 2015, so the data for this project uses Design 2000.

Other required variables include Census tract population, median household income and median household property value. The source of these variables is the 5-year, 2010-2014, estimates from the ACS.

## 6. State Estimates–New Jersey

New Jersey was selected as a test state because in Design 2000, every county was in a sampled PSU: either the Philadelphia or New York PSU. Therefore, expenditure data was available in every county of New Jersey, allowing for the calculation of the state's "true" expenditures. In Design 2010, three counties in southern New Jersey in the Philadelphia PSU (Atlantic, Cumberland, and Cape May) and two counties in the northern New Jersey in the New York PSU (Warren and Mercer) were dropped. Using the same data from Design 2000, data from the sampled New Jersey counties in the 2010 Census were retained, re-weighted, and a new set of state weights calculated. An evaluation of the differences between Design 2000 and Design 2010 expenditures gives an indication of the procedure's effectiveness when extended to other states where a smaller portion of the population is sampled.

Each Census tract in New Jersey was assigned to one of five stratification clusters using a heuristic stratification algorithm and two clustering variables from five-year ACS estimates: median household property value and median household income. These two clustering variables correlate with expenditures and are an indication of wealth. It is helpful to examine the distribution of wealth, as indicated by the mapping of the 2,010 Census tracts in New Jersey by stratification cluster, Figure 1. The varying geographic size of the clusters is evident in Figure 1. Smaller Census tracts in geographic size represent denser populations. The population is denser and more affluent in Northern New Jersey. Approximately 76% of the CUs in New Jersey are in the New York PSU. Consequently, the expenditure estimates are closer to New York than Philadelphia.

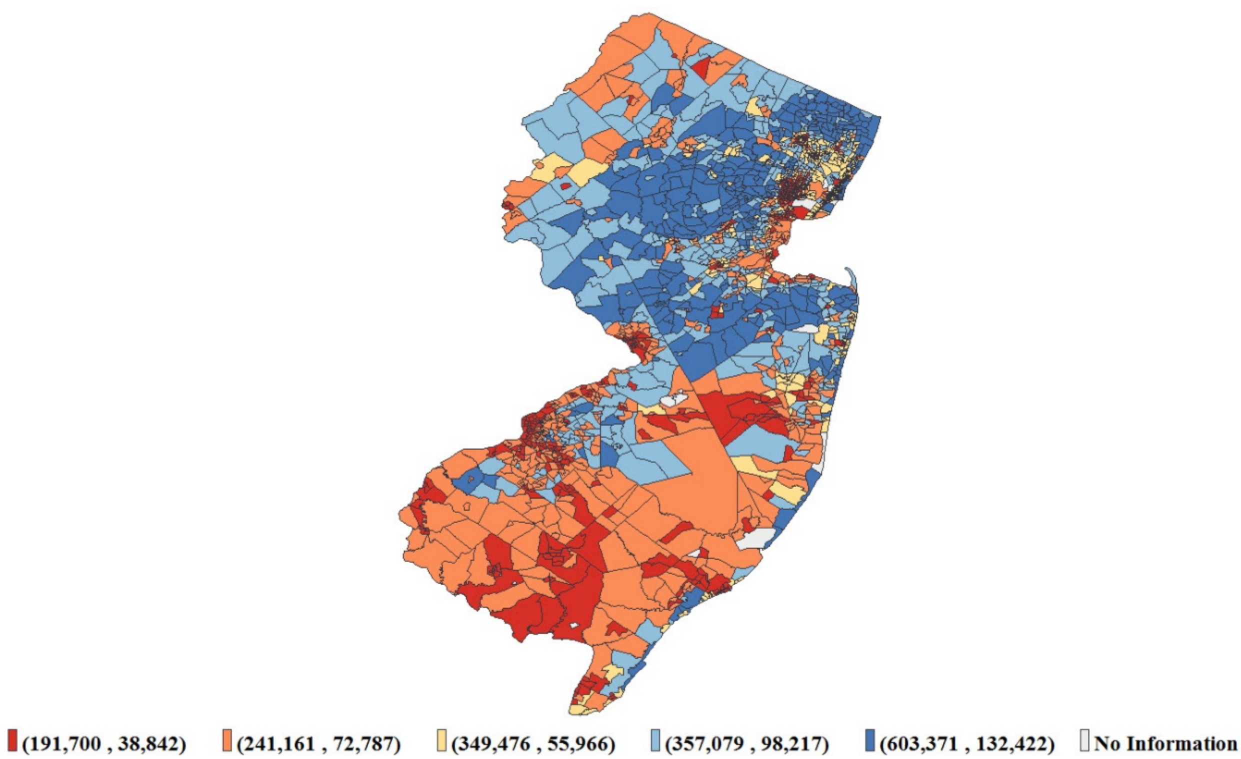


Figure 1. The Census tracts in New Jersey are mapped by their cluster stratification assignment and the cluster centers are provided below the map. The first coordinate is the median household property value and the second coordinate is median household income. The clusters are ordered in increasing median household property value. The higher median household property value and income tracts predominate in Northern New Jersey. The tract size indicates population density.

For both designs, New Jersey state-level expenditure estimates and their corresponding standard errors (SEs)and coefficient of variations (CVs) for 2013 are given in Table 1. Also, MSA-level expenditure estimates for 2013-2014 for the Philadelphia and New York MSAs are provided in the table for comparison. Currently, CE plans to publish state level estimates for New Jersey using one year of data, but currently publishes MSA-level expenditure estimates every year using two years of data.

From Table 1, both designs have similar mean expenditures. For Average annual expenditures, the difference between the two designs is $112 for a $65,000 expenditure. Housing, Transportation, and Food are major expenditure categories and the difference in the two designs are: $11, $59, and $107, respectively. In general, as expected, the standard errors increase with the reduced sample size in Design 2010, but the difference in SEs are small. The difference in SEs between the two designs for Average annual expenditures, Housing, Transportation, and Food are: $254, $23, $116, and $32, respectively. Another method of comparison, which accounts for the magnitude of the expenditures, is coefficient of variation, which is the ratio of the SE to the mean. For both designs, the CVs are of the same magnitude. For Average annual expenditures, the CV is 3.70% for Design 2000 and 4.08% for Design 2010. The coefficient of variation is highest for Education, a highly variable expense, since not all CU's have education expenses. These statistics indicate that the expenditure estimates from the reduced sample, Design 2010, are as reliable as the expenditure estimates from the full sample, Design 2000.

Also from Table 1, it is evident that CE's Design 2000 and 2010 estimated state expenditure means are closer to the means for the New York MSA than to the means for Philadelphia MSA. An exception is Transportation, which is closer to the Philadelphia MSA. Although, the Philadelphia and New York MSAs include counties outside of New Jersey, the closeness of CE's mean expenditure estimates to the MSAs mean expenditure estimates provides confidence that the state weighting algorithm is working correctly.

Another approach to evaluating the procedure for calculating state weights is to compare CE's expenditure estimates to those from other government surveys, which ask questions on a subset of topics covered by the CE Survey. CE is always interested in how the estimates from other surveys compare with CE's estimates. CE compared two of its expenditure categories, Electricity and natural gas and Rented dwellings, with the data in ACS's PUMD files. The comparison was made for the New Jersey estimates as well as for the national estimates. It is difficult to compare the estimates from two surveys due to conceptual differences in the questions, as well as differences in their target populations, sample designs, and interviewing procedures.

A comparison of the two surveys' estimates for two expenditure categories, Electricity and natural gas and Rented dwellings, is presented in Table 2. CE's Design 2000 expenditure estimates are lower than the ACS's expenditure estimates. For Electricity and natural gas, the CE/ACS ratio for the nation and New Jersey are 0.86 and 0.87, respectively. However, for Rented dwellings, the CE/ACS ratio is lower for the nation than for New Jersey, 0.79 and 0.87. The CE/ACS ratios are similar for Design 2010. Since, the CE/ACS ratios for New Jersey are as high as the CE/ACS ratios for the nation, this indicates that the New Jersey estimates are of equal quality as that for the nation and that the state weighting algorithm is working correctly.

In summary, several approaches were taken to evaluating the state expenditure estimates for New Jersey. Design 2000, with expenditure data from CUs in all counties, was compared to Design 2010, with expenditure data from CUs in a subset of the counties. Design 2000 and Design 2010 means and SEs were close to each other and the CVs were of the same magnitude as well. Because the New Jersey population is denser and more affluent in the portion of the state in the New York PSU, the New Jersey estimates are closer to the New York MSA estimates, as expected. Finally, the CE/ACS ratios for New Jersey were of equal quality as the national estimates. These results indicate that the state weighting algorithm will be effective in states where only a subset of the state's counties is included in the survey.

Table 1. New Jersey State means, SEs, CVs, and Philadelphia and New York MSA means for primary expenditure categories

| | CE's Estimated State Expenditures for 2013 | | | | Coefficient of Variation | | CE's MSA Tables for 2013-2014 | |
|---|---|---|---|---|---|---|---|---|
| | Design 2000 | | Design 2010 | | Design | Design | Philadelphia | New York |
| Expenditure Category | Mean ($) | SE ($) | Mean ($) | SE ($) | 2000 (%) | 2010 (%) | Mean ($) | Mean ($) |
| Average annual expenditures | 65,165 | 2,408 | 65,277 | 2,662 | 3.70 | 4.08 | 57,907 | 63,193 |
| Food | 7,842 | 524 | 7,735 | 556 | 6.68 | 7.19 | 7,263 | 7,329 |
| Alcoholic beverages | 588 | 90 | 589 | 104 | 15.40 | 17.73 | 636 | 541 |
| Housing | 25,064 | 850 | 25,074 | 827 | 3.39 | 3.30 | 20,475 | 25,046 |
| Apparel and services | 2,600 | 379 | 2,631 | 399 | 14.59 | 15.15 | 2,193 | 2,334 |
| Transportation | 9,177 | 790 | 9,118 | 906 | 8.61 | 9.93 | 9,500 | 8,442 |
| Healthcare | 3,857 | 228 | 3,945 | 260 | 5.92 | 6.59 | 4,386 | 3,937 |
| Entertainment | 2,584 | 197 | 2,491 | 191 | 7.61 | 7.66 | 2,730 | 2,597 |
| Personal care products and services | 778 | 80 | 747 | 82 | 10.22 | 10.99 | 676 | 748 |
| Reading | 110 | 23 | 108 | 23 | 20.91 | 21.52 | 105 | 100 |
| Education | 3,238 | 1,063 | 3,502 | 1,366 | 32.84 | 39.01 | 2,003 | 2,575 |
| Tobacco products and smoking supplies | 289 | 45 | 277 | 44 | 15.62 | 16.03 | 343 | 230 |
| Miscellaneous | 547 | 83 | 527 | 89 | 15.26 | 16.86 | 561 | 652 |
| Cash contributions | 1,543 | 205 | 1,505 | 230 | 13.30 | 15.28 | 1,237 | 1,669 |
| Personal insurance and pensions | 6,950 | 469 | 7,030 | 487 | 6.74 | 6.93 | 5,800 | 6,993 |

Table 2. CE and ACS comparison of New Jersey Design 2000 expenditures

| | National | | | New Jersey | | |
|---|---|---|---|---|---|---|
| Expenditure Category | CE ($) | ACS ($) | CE/ACS ($) | CE ($) | ACS ($) | CE/ACS ($) |
| Electricity and Natural Gas | 1,814.16 | 2,117.00 | 0.86 | 2,308.24 | 2,667.57 | 0.87 |
| Rented Dwellings | 3,323.61 | 4,220.06 | 0.79 | 4,507.20 | 5,167.57 | 0.87 |

## 7. State Estimates–Florida

Florida provides a different scenario to test the state weighting algorithm because it has both self-representing and non-self-representing PSUs. In Design 2010, PSUs are self-representing if they have more than 2.5 million people, so Miami and Tampa are self-representing PSUs and the other PSUs in the state are non-self-representing. By contrast, in Design 2000 the self-representing threshold was 2.7 million people, so Miami was the only self-representing PSU and the other PSUs in the state (including Tampa) were non-self-representing.

Self-representing PSUs have larger within-PSU sampling intervals than non-self-representing PSUs, which has an impact on the state base weight, see Section 3.2. The first factor in the base weight equation is calculated at the state and not at an individual PSU level. Consequently, the base weights are higher for self-representing PSUs than for non-self-representing PSUs, but the number of interviews in a non-self-representing PSUs is approximately the same as in a self-representing PSU. Thus, in the state estimates, households in self-representing PSUs have more weight than households in non-self-representing PSUs.

The stratification cluster algorithm uses zero-one integer linear programming in which the number of decision variables is equal to the number of stratification clusters (five) times the number of Census tracts. Thus, Florida has 4,245 Census tracts, and 21,225 decision variables whereas, New Jersey had 2,010 Census Tracts and 10,050 decision variables. It was important to test the stratification cluster algorithm, a vital component of the state weighting algorithm, on a problem of this size. The zero-one integer linear programming component solved the assignment problem and the mapping of Census tracts by stratification cluster.is shown in Figure 2. The cluster centers are provided below the map. The first coordinate is the median household property value and the second coordinate is median household income.

Table 3 shows both the state expenditure means and SEs for Florida and the MSA means for Miami. The state means and Miami MSA means are of the same magnitude, but in general, the state expenditures are slightly higher. However, residents in Miami spend more on Housing, Personal care products and services, and Education than the state average.

The difference between the state expenditures and Miami expenditures is not unexpected. Approximately 22% of the Florida CUs are from the Miami PSU, so the state is not dominated by Miami. Also, Miami is not an affluent metropolitan area. In 2010-2014, income after taxes in Miami ($48,310), which affects expenditures, is lower than the regional income after taxes for the South ($53,566) and for the United States ($57,364) (Dotson).

The CE and ACS comparison for two Florida expenditure categories, Electricity and natural gas and Rented dwellings, are presented in Table 4. For Electricity and natural gas, the CE/ACS Florida ratio is 0.88, which is slightly higher than the national CE/ACS ratio of 0.86. For Rented dwellings, the Florida CE/ACS ratio is 0.85 which is higher than the national CE/ACS ratio of 0.79. As with New Jersey, the state CE/ACS ratios are as good or better than the national CE/ACS ratios indicating that the state weighting algorithm is effective.

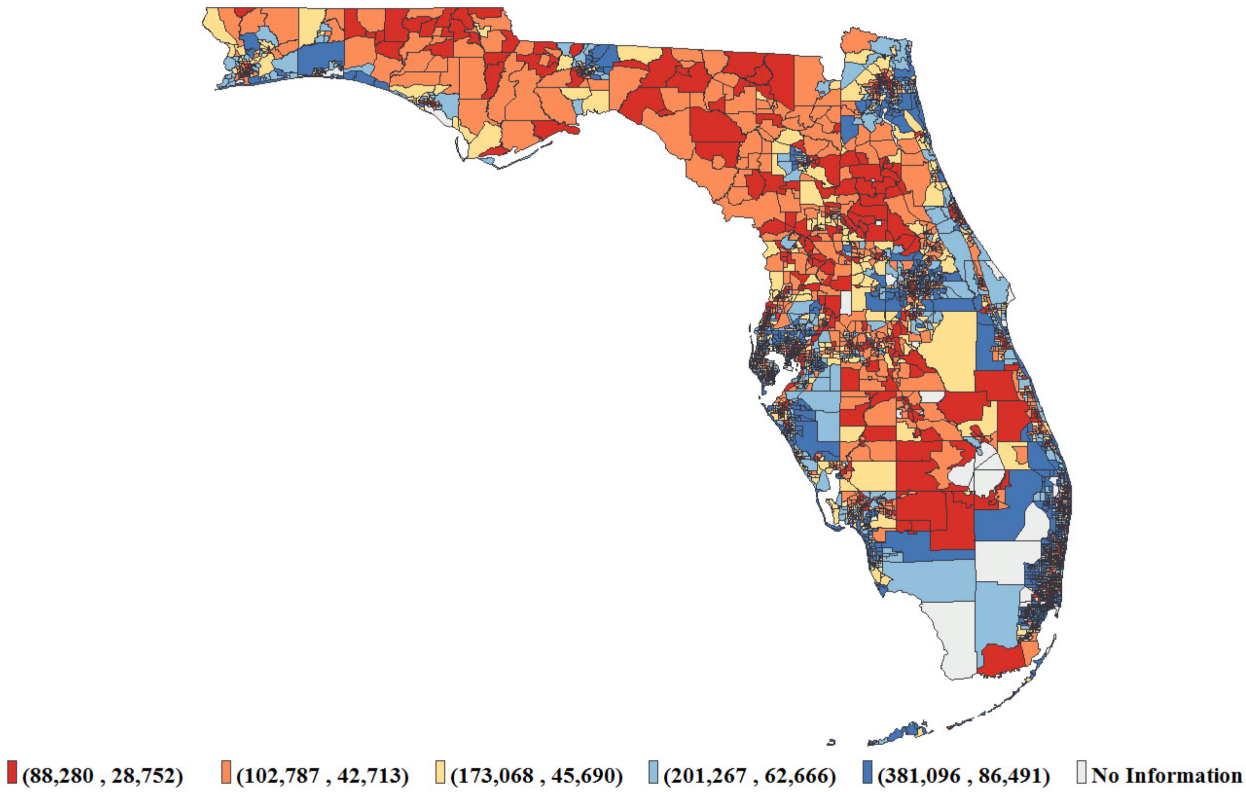


Figure 2. The Census tracts in Florida are mapped by their cluster stratification assignment and the cluster centers are provided below the map. Highly populated tracts are small geographic areas which appear gray-black and predominate along the coast.

Table 3. Florida state expenditure means and SEs and Miami MSA means

| | CE's Estimated State Expenditures for 2013 | | Miami MSA for 2013-2014 |
|---|---|---|---|
| Expenditure Category | Mean ($) | SE ($) | Mean ($) |
| Average annual expenditures | 45,944 | 1,787 | 43,066 |
| Food | 6,142 | 370 | 5,610 |
| Alcoholic beverages | 383 | 68 | 375 |
| Housing | 16,719 | 591 | 16,981 |
| Apparel and services | 1,392 | 209 | 1,350 |
| Transportation | 8,304 | 629 | 7,243 |
| Healthcare | 2,976 | 177 | 2,433 |
| Entertainment | 1,970 | 161 | 1,565 |
| Personal care products and services | 647 | 97 | 712 |
| Reading | 69 | 11 | 54 |
| Education | 480 | 111 | 632 |
| Tobacco products and smoking supplies | 232 | 30 | 172 |
| Miscellaneous | 494 | 166 | 376 |
| Cash contributions | 1,243 | 260 | 739 |
| Personal insurance and pensions | 4,895 | 427 | 4,823 |

Table 4. CE and ACS comparison of Florida expenditures

| | Florida | | |
|---|---|---|---|
| Expenditure Category | CE ($) | ACS ($) | CE/ACS |
| Electricity and natural gas | 1,671.94 | 1,905.32 | 0.88 |
| Rented dwellings | 3,605.01 | 4,229.70 | 0.85 |

## 8. State Estimates–California

California has the largest number of Census tracts of any state in the United States, 8,057 and it was important to test whether the stratification cluster algorithm could solve a problem with 40,285 decision variables. The algorithm successfully assigned Census tracts to stratification clusters and the mapping is shown in Figure 3. The high-income and densely populated areas are primarily along the coast.

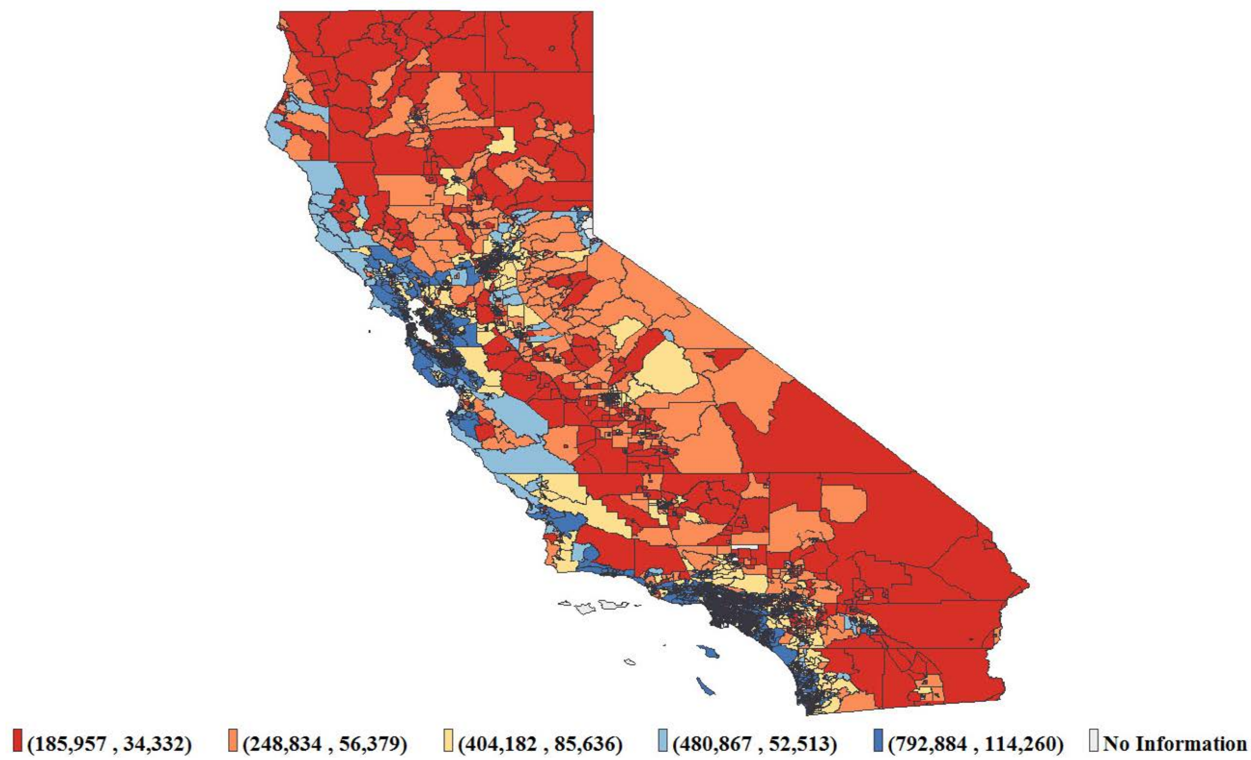


Figure 3. The Census tracts in California are mapped by their cluster stratification assignment and the cluster centers are provided below the map. The first coordinate is the median household property value and the second coordinate is median household income. The higher income and property value tracts predominate along the coast and the interior Census tracts have lower population, median household property value, and median household income.

California has three self-representing PSUs and several non-self-representing PSUs. The self-representing PSUs are: San Francisco, San Diego, and Los Angeles and its suburbs. Approximately 76% of California's population resides in these three PSUs and a survey designed specifically for California would be heavily concentrated in Los Angeles, San Diego, and San Francisco.

Table 5 shows the state expenditure means and SEs for California and the MSA means for Los Angeles, San Diego, and San Francisco. The California state expenditure estimates are within the range of the three MSA expenditure estimates, which is expected because of the predominance of the three large metropolitan areas in the survey and state.

Table 5. California state and MSA means for CE's primary expenditure categories

| | CE Estimated Weights | | CE's MSA Tables for 2013-2014 | | |
|---|---|---|---|---|---|
| | Expenditures for 2013 | | Los Angeles | San Diego | San Francisco |
| Expenditure Category | Mean ($) | SE ($) | Mean ($) | Mean ($) | Mean ($) |
| Average annual expenditures | 58,583 | 1,358 | 55,546 | 63,189 | 68,765 |
| Food | 7,441 | 258 | 7,278 | 6,936 | 8,152 |
| Alcoholic beverages | 552 | 50 | 478 | 681 | 721 |
| Housing | 22,574 | 519 | 21,501 | 23,774 | 25,663 |
| Apparel and services | 1,901 | 124 | 1,920 | 1,977 | 2,227 |
| Transportation | 8,566 | 372 | 8,315 | 10,319 | 9,404 |
| Healthcare | 3,352 | 149 | 3,178 | 4,395 | 4,459 |
| Entertainment | 2,661 | 114 | 2,427 | 2,894 | 3,329 |
| Personal care products and services | 791 | 39 | 781 | 744 | 850 |
| Reading | 115 | 9 | 79 | 162 | 161 |
| Education | 1,558 | 185 | 1,601 | 1,068 | 1,900 |
| Tobacco products and smoking supplies | 193 | 19 | 163 | 232 | 187 |
| Miscellaneous | 554 | 62 | 608 | 1,091 | 813 |
| Cash contributions | 1,868 | 387 | 1,291 | 1,752 | 2,460 |
| Personal insurance and pensions | 6,457 | 250 | 5,926 | 7,162 | 8,438 |

The CE and ACS comparison for two California expenditure categories, Electricity and natural gas and Rented dwellings, are presented in Table 6. For Electricity and natural gas, the CE/ACS California ratio is 0.84, which although lower than the national CE/ACS ratio of 0.86, is not of concern. For Rented dwellings, the California CE/ACS ratio is 0.88 which is higher than the national CE/ACS ratio of 0.79. In conclusion, the CE/ACS ratios are as good or better than the national CE/ACS ratios indicating that the state weighting algorithm is effective.

Table 6. CE and ACS comparison of California expenditures

| | California | | |
|---|---|---|---|
| Expenditure Category | CE ($) | ACS ($) | CE/ACS |
| Electricity and natural gas | 1,449.44 | 1,723.91 | 0.84 |
| Rented dwellings | 6,315.01 | 7,148.09 | 0.88 |

## 9. Conclusion

The primary difference in the calculation of state versus regional or national expenditure estimates is the probability of selection. Both use the same assignment algorithm to either assign Census tracts or PSUs to stratification clusters, which are constrained by population bounds. Both procedures use noninterview adjustment and calibration to adjust the weights to known population counts from the Current Population Survey. The state estimates use jackknife to calculate the variances, whereas regional and national estimates are calculated using BRR.

The states selected, New Jersey, Florida, and California, have a range of number of Census tracts as well as PSU coverage. In New Jersey, every county was in a self-representing PSU, allowing for the dropping of counties, re-calculating the CU weights and expenditure estimates, and comparing with the expenditure estimates using all counties. The estimates were close, indicating that the state weight algorithm will produce accurate state expenditure estimates for states with less sampled population. Florida has one self-representing PSU, Miami, and multiple non-self-representing PSU. California has multiple self-representing PSUs and one or more non-self-representing PSUs. For all three states, the expenditure estimates are similar to CE's two-year MSA tables. It is important, but often difficult to compare CE's estimates to other surveys. The survey purposes are different, and the other survey may oversample in certain demographics. It is seldom an exact comparison. For the two expenditure categories: Electricity and natural gas and Rented dwellings, CE's estimates were consistently lower than ACS's estimates. The state CE/ACS ratios were equivalent or better than the national level ratios, indicating that the quality of the state estimates is equal to the national estimates.

It might be beneficial to calculate state estimates using two years of data. This would increase the sample size, making the mean and variance more precise.

Although, the procedure to calculate state weights is experimental, it is a promising approach, producing consistent expenditure estimates under varying PSU coverage.

## 10. Disclaimer

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

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