Can Post-Stratification Weighting Eliminate the Need for Additional Weights Adjustments?

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Abstract

Oftentimes surveys use weighting adjustments and post-stratification weights to produce reliable estimates that reduce bias and variance. The most recent Residential Energy Consumption Survey (RECS) used weighting adjustments for insufficient addresses, unknown vacancy and primary housing unit status, and nonresponse. After these adjustments, the weights were then post-stratified to several control totals from the American Community Survey (ACS). Post-stratification is a complex process, with the choice of control totals possibly having unknown effects on survey estimates. These processes take a significant amount of time, money, and effort, and there is interest in finding a faster, simpler, yet effective weighting adjustment method for the RECS. This research will consider the impact to survey estimates by eliminating the additional weighting adjustments as well as calculating alternative post-stratification weights.

Key Words: Post-stratification, Residential Energy Consumption Survey, weighting

1. Introduction

The Residential Energy Consumption Survey (RECS) is the only nationally-representative study of energy usage in American households. The 2015 RECS, the most recent survey cycle, used Computer-Assisted Personal Interviewing (CAPI), mail, and web survey modes. To accommodate for all three survey modes, the weighting procedures were quite complex. After the initial design weights, there were five weighting adjustments. After the initial four adjustments, the weights were then post-stratified to several control totals from the American Community Survey (ACS). The weighting process took a significant amount of time, money, and effort, and there is interest in finding a faster, simpler, yet still effective weighting methodology. This research will consider changes to the weighting adjustments and their effects to survey estimates.

2. The Current Weighting Procedures

There were five weighting adjustments: bad/insufficient addresses, unknown vacancy, primary housing unit status, nonresponse, and post-stratification. Each of these adjustments were calculated using a variety of complex methods. Table 1 provides a description of each adjustment.

Table 1. Current Weighting Adjustments

Adjustment	Description
Bad/insufficient addresses (BA)	A ratio adjustment to account for sampled housing units with bad addresses or drop points
Unknown vacancy (UV)	An adjustment based on a latent variable process to predict the probability that a sampled housing unit was not vacant
Primary housing unit status (PHU)	An adjustment based on a logistic regression model to predict the probability that a nonresponding housing unit was not a primary residence
Nonresponse (NR)	A nonresponse adjustment calculated through a generalized exponential model
Post-stratification	An adjustment to ensure that the final survey weights sum to a specified set of control totals

Two sets of weights were calculated as a result of the adjustments to the design weight (DESIGNWT), the eligibility weight (ELIGWT) and the nonresponse weight (NRWT). The weights are calculated as follows:

ELIGWT = DESIGNWT * UV * PHU
NRWT = DESIGNWT * UV * PHU * NR

The post-stratification adjustment was applied to the nonresponse adjusted weight (NRWT) to produce final survey weights. The weights were adjusted to sum to the following ACS control totals: Census division, housing unit type, tenure (home owner/renter status), number of bedrooms, and the year the housing unit was built.

3. Alternative Weighting Procedures

The methods explored in this analysis use three different starting weights and four different survey control total specifications for post-stratification. The three starting weights are the original design weight (DESIGNWT), the eligibility adjusted weight (ELIGWT), and the nonresponse adjusted weight (NRWT). Instead of post-stratifying to Census division, housing unit type, tenure, number of bedrooms, and the year the housing unit was built, the following post-stratification schemes were used:
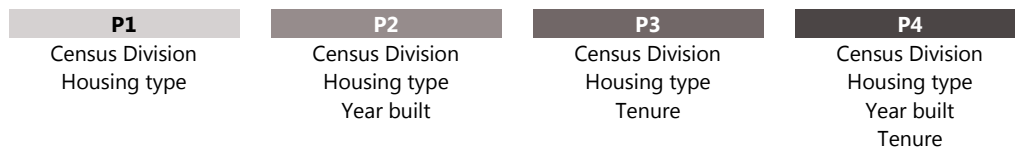
P1	P2	P3	P4
Census Division	Census Division	Census Division	Census Division
Housing type	Housing type	Housing type	Housing type
	Year built	Tenure	Year built
			Tenure

Figure 1: Post-Stratification Schemes

Combining the three starting weights and four post-stratification schemes, there are twelve weights to consider:

DP1	DP2	DP3	DP4
DESIGNWT post-stratified to *Census division & housing type*	**DESIGNWT** post-stratified to *Census division, housing type & year built*	**DESIGNWT** post-stratified to *Census division, housing type & tenure*	**DESIGNWT** post-stratified to *Census division, housing type, year built & tenure*
EP1	**EP2**	**EP3**	**EP4**
ELIGWT post-stratified to *Census division & housing type*	**ELIGWT** post-stratified to *Census division, housing type, & year built*	**ELIGWT** post-stratified to *Census division, housing type & tenure*	**ELIGWT** post-stratified to *Census division, housing type, year built & tenure*
NP1	**NP2**	**NP3**	**NP4**
NRWT post-stratified to *Census division & housing type*	**NRWT** post-stratified to *Census division, housing type & year built*	**NRWT** post-stratified to *Census division, housing type & tenure*	**NRWT** post-stratified to *Census division, housing type, year built & tenure*

Figure 2: Combined Weight and Post-Stratification Schemes

4. Estimation using the Alternative Weights

The alternative weights were able to produce similar estimates to those published for the 2015 RECS. Three estimates at the US, region, and division levels were selected to compare the published estimates to the 12 alternative weights. Figure 3 shows comparisons of the number of US housing units using propane, the number of housing units with clothes washers in the South, and the number of housing units without microwaves in New England. For just these three estimates, the closest alternative weights are different (DP2, EP3, and NP1). The nonresponse weight post-stratified to Census division and housing type, NP1, was the closest of the three comparisons, only differing from the published estimate by 287 housing units.
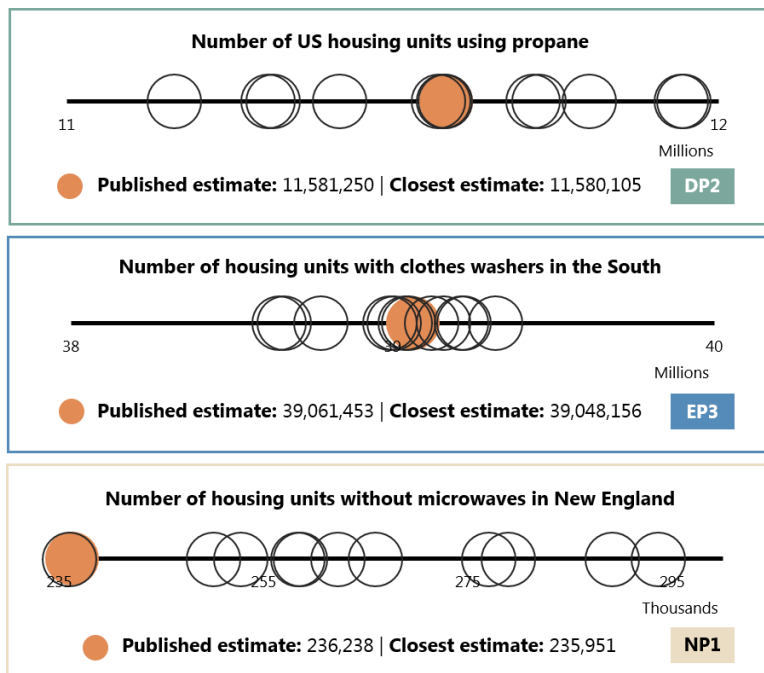

Number of US housing units using propane

11   12
Millions

● **Published estimate:** 11,581,250 | **Closest estimate:** 11,580,105   DP2

Number of housing units with clothes washers in the South

38   40
Millions

● **Published estimate:** 39,061,453 | **Closest estimate:** 39,048,156   EP3

Number of housing units without microwaves in New England

235   255   275   295
Thousands

● **Published estimate:** 236,238 | **Closest estimate:** 235,951   NP1

Figure 3. Comparisons of Published Estimates

To find the optimal alternative weight, estimates from a much larger sample of the published estimates was taken to reflect the various levels on which estimates are produced. There are almost 100 household characteristics tables filled with thousands of individual estimates. In addition to estimates by division, region, and the US, estimates are also calculated by housing unit type, tenure, year of home construction, number of household members, household income, climate region, and home size. For this analysis, 2,360 estimates were used for comparison.

When looking at this larger set of estimates, one set of alternative weights outperformed the others. The nonresponse adjusted weight post-stratified to Census division, housing type, and tenure, NP3, was the closest to published estimates most often (15%). Figure 4 shows the percentage of alternative weights closest to published estimates. For over half of the comparisons (51%), the nonresponse adjusted weights (NP1, NP2, NP3, and NP4) were closest to the published estimates. Each represents at least 12%. The eligibility weights were closest to the published estimates the least (23%), and at 5%, EP1, the eligibility weight post-stratified to Census division and housing type, was closest the least. On average, the difference between the alternative estimates and the published estimates was 38,753. The median difference was 11,975. About 9% of the differences were greater than 100,000, and about 5% of differences were 500 or less.
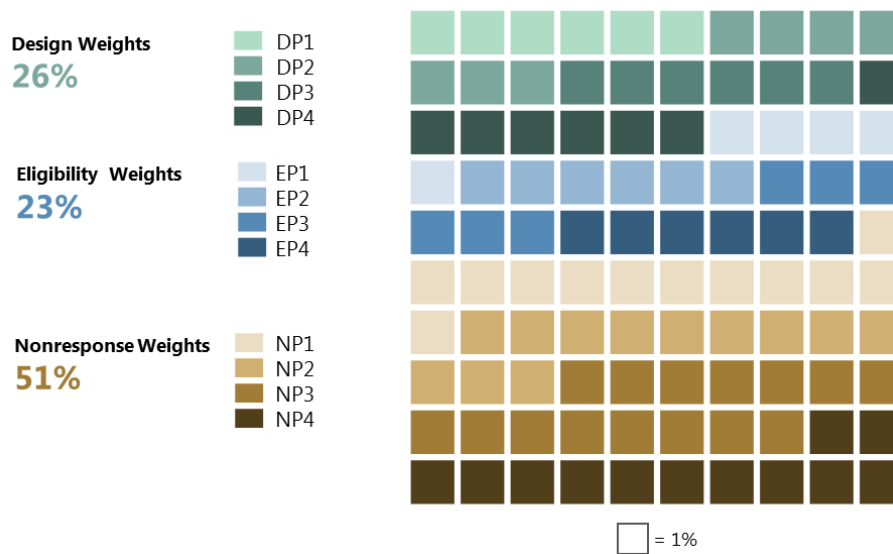

Figure 4. Percentage of Alternative Weights Closest to Published Estimates

Looking at the post-stratification schemes, the results were somewhat similar (Table 2). Weights post-stratified to Census division, housing type, and tenure (P3) were closest to the published estimates most often.

Table 2. Comparing Post-Stratification Schemes to Published Estimates

Post-Stratification Scheme	Percent Closest to Published Estimate
P1 *(DP1, EP1, NP1)*	23%
P2 *(DP2, EP2, NP2)*	26%
P3 *(DP3, EP3, NP3)*	27%
P4 *(DP4, EP4, NP4)*	25%

5. Conclusions

Although post-stratifying from the design and eligibility weights were not as successful as the nonresponse adjusted weights, post-stratifying to fewer variables can produce similar estimates to those published for the 2015 RECS. Instead of post-stratifying to five control totals, which can be computationally intensive and complex, similar results were found using only three control totals (Census division, housing unit type, and tenure) which were the closest to the published estimates most often. Additional research is planned to use this alternative post-stratification adjustment on other RECS datasets to determine if the results found in this research are reproducible.

This analysis also showed that the nonresponse adjustment is a helpful and necessary component to the weighting process. Since this adjustment is needed, additional research is also planned to look more closely at the nonresponse adjustment and consider alternative methods to calculate a nonresponse adjustment. The RECS weighing process has the opportunity to simplify and improve, which has several benefits, including faster release of estimates and reduced survey costs.

References

U.S. Energy Information Administration (May 2018). 2015 RECS Household Characteristics Tables. Available at https://www.eia.gov/consumption/residential/data/2015/index.php?view=characteristics