Updating the Measures of Size of Local Areas Late in the Decade Using USPS Address Lists

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Abstract

Area household surveys conducted in the United States most often rely on data from the Census Bureau to calculate measures of size (MOS) of secondary sampling units (SSUs or segments). Yet, late in the decade housing or demographic data from the last decennial census are likely to be inaccurate in local areas with considerable growth or demographic shifts since the census taking and intercensal estimates are not available at the required level.

Address lists available from the United States Postal Service (USPS) have been incorporated into survey sample designs in various capacities over the past decade: telephone surveys are using these lists as a first phase of selection; in-person area surveys are using them in place of the traditional address listing process; and mail surveys are becoming much more prevalent. In all these instances, the lists are being used as sampling frames. This paper will present two implementations of the use of address lists as a means of updating segment MOS late in the decade and demonstrate their effectiveness.

Key Words: USPS, area sample, measure of size (MOS)

1. Overview

Towards the end of the decade, surveys which rely on probability sampling proportionate to measures of size (MOS) based on decennial census data have to employ strategies to deal with the out-dated data. Using out-dated data as MOS could result in considerable differences between the number of ultimate sampling units and the expected counts, and increased variation in the number of sampling units across segments. Varying approaches have been proposed to deal with this issue, including those which employ a different sampling approach and use alternative sources of data for the MOS other than (or in combination with) the usual detailed decennial census data.

Most commonly, census blocks (or groups of blocks) have been used in area household surveys as the secondary sampling units (or segments) to produce efficient work-loads for field staff.[1] However, there is no update to the decennial census data later in the decade.

[1] Blocks are very fine partitions of the United States, formed using visible semi-permanent features such as roads, railroad tracks, mountain ridges, bodies of water, and power lines. The only invisible boundaries used are county, state, and national boundaries. Minor civil division boundaries and property lines are ignored. A block group is a small group of contiguous blocks. A tract is a collection of contiguous block groups all within the same county.

Data from the census Bureau's American Community Survey is now available at the sub-county level, but is not recommended for use in estimates at its lowest level of geography, the block-group level. Housing unit intercensal estimates may also be purchased at the block-group level, or calculated using auxiliary data; these estimates have unknown levels of certainty associated with them, however.

Two methods used to update MOS late in the decade include building permit sampling (Bell, et al., 1999) and two-phase segment sampling approach (Montaquila et al., 1999, 2002). Building permit sampling has been proven effective for reducing the variation in segment sizes which, in turn, leads to improved fieldwork predictability, cost efficiency, and precision. Not all areas can benefit from this method since the issuance of building permits may not be required for new construction, or permits may only be stored in hard-copy form, and/or be simply difficult to access. Additionally, permit issuance is not affirmation that construction has occurred, and is not required for units such as mobile homes.

Two-phase segment sampling involves selection of a larger sample of segments at the first phase. The MOS for the first phase segments is then updated based on more recent estimates of the number of dwelling units (DUs) in the area. The original method to obtain the more recent estimates of DUs is windshield canvassing which requires that field staff drive through the segments and count the number of DUs within the segment boundaries. This is meant to be a rough count; a full enumeration is conducted at the field listing stage (when the addresses of all units in the final sample of segments are captured).

While windshield canvassing is less time consuming than the listing process, it requires time and travel. The introduction of geospatial and satellite digital imagery applications allows users to view images of an area without travel costs. In many instances, it is possible to discern individual DUs and count the number of units in an area, or, in essence, "digitally canvass" the area. Dohrmann, Harding, and Li (2008), presented a hybrid canvassing method of updating the MOS of first phase segments. With this approach, attempts are made to digitally canvass all segments first; segments for which reliable digital counts cannot be obtained, windshield canvassing is used. The hybrid method performed just as well as windshield canvassing alone, at a fraction of the cost.

This paper will present methods of adapting these methodologies to incorporate address counts of United States Postal Service (USPS) addresses within geographic areas. These address counts can be made available at the block level and are generally provided at little or no cost from address list vendors.

2. Creating Segment-level Housing Unit Estimates Using USPS Addresses

Using purchased address lists originating from the USPS in place of traditional listing[2] in area surveys is becoming increasingly popular, and is known as Address Based Sampling or ABS. There are several sources of potential undercoverage of these lists when used for in-person area surveys. Households in areas without residential mail delivery may receive their mail either at a general mail delivery facility or a Post Office Box, making the

[2] Listing is the process in which field staff visit sampled segments months in advance of interviewing and record the address of every DU within the segment boundaries. This list then serves as the frame for DU selection.

location of their physical dwelling indeterminate. Fahimi (2010) estimated the proportion of households that receive mail at a P.O. box but not at their physical address to be about 2.8 percent nationwide.

Rural routes are another source of undercoverage. In such cases, the address consists of a route number (not a recognizable street number) and a box number. Even if the route was identifiable, the box for the route may not be near the residence. In such cases it is not possible to determine the physical location of the household based on the mailing address. Staab and Iannacchione (2003) estimated that 3.9 percent of the households nationwide have unlocatable rural routes addresses.

A third source of undercovereage may be noninstitutional group quarters (depending on the target population of a given survey). Noninstitutional group quarters include dorms, assisted living facilities, halfway homes, and shelters. Group quarters are not identified as such on the USPS lists. There is a flag that may be used to identify educational units (i.e., dorms). However, the presence of these units on the file depends on how residents of the educational facility receive their mail. Some facilities operate their own "post offices", and thus the USPS does not have information on individual mailing addresses of the residents. Other facilities, such as assisted living facilities, halfway homes, and shelters may be operated by a business or charitable organization. If residents' mail is not delivered to individual dwelling units, but instead to the business unit, the facility will not be included on a purchased residential address list.

Westat has a contract with Marketing Systems Group (MSG) to extract lists from their copy of the USPS Computerized Delivery Sequence file. Included on the file are approximate census geographic indicators (tract, block group, and block) so that lists may be purchased for specific geographies. As such, counts of addresses are available at the segment level and lists may be purchased for specific segments, if the segments are formed using census geography. However, the process of attaching these indicators to the addresses is only approximate since MSG uses the latitude and longitude associated with the ZIP+4 centroid of an address to estimate its geographic location for the assignment of census geography, rather than street-level coordinates. As a result, many addresses are in the incorrect geography, especially at the block level. Counts of addresses provided or lists purchased for a particular segment may include addresses actually outside the segment, and exclude some address actually inside the segment. However, area segments are generally combinations of several blocks, so the amount of error is limited at the segment level.[3]

Despite of geocoding errors and potential undercoverage, using address counts as estimates for the number of housing units in a segment is attractive. The counts are generally provided at little or no cost from vendors. Also, the counts can be quite up-to-date, since vendors may update the list monthly or every other month depending on their license types with the USPS. Additionally, the presence of unlocatable addresses is not an issue since individual addresses are not being used for sampling.

One disadvantage of these housing unit estimates is that group quarters may cause undercoverage or indicate false growth of housing units, depending on whether they are included in the USPS lists and the target population of a survey. If group quarters are

[3] Note that other vendors may use other means of attaching census geography to address data that may be more accurate; at the time of this writing, MSG is researching other, more accurate, methods of attaching census geography.

included in the USPS lists, but are not part of the target population, the counts from the USPS lists may indicate false growth. On the other hand, if group quarters are not included in the USPS lists, but are part of the target population, the USPS counts may have an undercoverage problem.

Given the appeal of using address counts as housing unit estimates, we were interested in using them to update segment MOS. In the following sections we illustrate two implementations of using address lists to update segment MOS late in the decade, and then evaluate their effectiveness.

3. Using USPS Housing Unit Estimates to Update the MOS of Area Segments in a Two-Phase Design

3.1 Updating Segment MOS

Our first implementation of using address counts as housing unit estimates is in a two-phase segment selection approach described in Section 1. In the first phase, a larger number of segments were selected based on 2000 census data. Then the block-level USPS counts were summed to segment-level and compared with the number of housing units from the 2000 census. If the number of housing units estimated from the USPS counts was larger than that of the 2000 census, the USPS count was used as the segment MOS; otherwise the census 2000 count was used.

To evaluate the USPS housing unit estimates, a comparison was made between the USPS estimate and the estimate made via hybrid canvassing at the segment level. In the comparison, the counts from traditional field listing were used as gold standard; only second-phase sample segments were included since only these segments were listed. Two differences in terms of the number of housing units were calculated for each second-phase segment. The first was the absolute difference between the field listing estimate and the canvassing estimate, and the second was the absolute difference between the field listing estimate and the USPS estimate. Then, for each segment, a measure of relative improvement was calculated to compare these differences and to determine which estimate, that resulting from canvassing or the USPS, is closer to the listers' more accurate count:

$$\text{Relative improvement} = \frac{|\text{listing} - \text{canvassing}| - |\text{listing} - \text{USPS}|}{\text{listing}}$$

A positive value of the above measure indicates that the USPS estimate is closer to the number of housing units found during field listing and thus more accurate than canvassing, while a negative value indicates that canvassing is more accurate than the USPS estimate.

3.2 Evaluation

We made the comparisons for 172 segments in 7 PSUs that had county-level housing unit growth of over 12 percent in 2009/2010 since 2000 census[4]. The results are summarized by PSU and overall in Table 1. As shown in the table, the USPS and canvassing estimates were each more accurate than the other in approximately one-third of the segments, with canvassing being more accurate at a slightly higher rate. In the other one-third of

[4] The county-level housing unit growth was estimated based on the building permits data from the Census Bureau.

segments, the estimates performed equally well. When considering the USPS housing unit estimates in these latter segments, the USPS estimates were just as good, if not better, than the costly-to-obtain canvassing estimates. We also made comparisons using the 2010 census counts as gold standard and found similar results.

Table 1: Summary of Comparison Outcome: USPS Estimates versus Canvassing, by Survey Location

Estimate closest to field listing housing units	*Survey location* *1*	*2*	*3*	*4*	*5*	*6*	*7*	*Sum*	*Percent*
USPS	9	9	9	6	9	7	6	55	32.0
Canvassing	15	4	9	9	6	8	12	63	36.6
Both/either	3	11	6	9	10	9	6	54	31.4
Sum	27	24	24	24	25	24	24	172	100.0

Table 2 presents the magnitude of the improvement as a result of using the USPS housing unit estimate over the canvassing estimate. In about 73 percent of the segments, the relative improvement of the USPS estimate was quite small, within +/- 10 percent.

Table 2: Distribution of the Relative Improvement: USPS Estimates versus Canvassing Estimates

Relative improvement	*Number of segments*	*Percentage*	
No more than -25%	16	9.3	
-25% to -10%	13	7.6	
-10% to 0	34	19.8	
none	54	31.4	73%
0 to 10%	37	21.5	
10% to 25%	10	5.8	
More than 25%	8	4.7	
Sum	172	100.0	

As was mentioned in section 3.1, if the USPS estimate was smaller than the housing unit count from the 2000 census for a segment, then the census count was used as the MOS rather than the USPS estimate. This rule was used in the two-phase implementation since 1) the PSUs for which this methodology was used were known to have experienced growth since the 2000 census, and 2) due to the inherent inaccuracy of MSG's assignment of the census geography.

However, for evaluation purposes, modified USPS estimates were made without replacing the USPS estimate with the 2000 census count if the former was smaller than the 2000 census count. The resulting comparisons are shown in Table 3. We can see from the table that, once the rule was not applied, the number of instances in which the USPS and canvassing were the same was reduced and the canvassing estimates outperformed the USPS estimates by a larger margin. The reason for this is that a large portion of segments for which the two estimates were the same in Table 1 turned to favour canvassing in Table 3. The difference between the results shown in Tables 1 and 3 justifies the rule of using the 2000 census counts as a lower bound for the USPS estimates.

Table 3: Summary of Comparison Outcome: USPS Estimates versus Canvassing, by Survey Location, without Using Census Counts to Replace USPS when USPS Estimate was Smaller than Census Count

Estimate closest to field listing housing units	*Survey location*								
	1	*2*	*3*	*4*	*5*	*6*	*7*	*Sum*	*Percent*
USPS	9	11	12	8	12	9	6	67	39.0
Canvassing	15	12	11	13	9	11	15	86	50.0
Both/either	3	1	1	3	4	4	3	19	11.0
Sum	27	24	24	24	25	24	24	172	100.0

To conclude, our findings based on the seven survey locations suggest that the overall performance of the USPS estimates was very close to that of canvassing. Given that creating USPS estimates is much less costly than canvassing, using the USPS estimates as an alternative to canvassing is feasible and worth considering in the two-phase segment sampling approach.

4. Using USPS Housing Unit Estimates to Update the MOS of Area Segments in a One Phase Design

4.1 Updating Segment MOS

For this evaluation, we used a national household survey (80 PSUs and 218,000 segments) for which the area listing was conducted in April 2011 with the data collection starting in August 2011. It was thus necessary to create the frame of segments within the selected PSUs using block-level data from the 2000 census since corresponding census 2010 block data was not yet available. The segments were blocks (as defined by the 2000 decennial census) or combinations of two or more nearby blocks with a minimum MOS of 60 housing units. Blocks with no housing units and no population, according to the decennial census, were included so that all areas, some of which may contain DUs constructed after the 2000 census, would be involved in the segment formation process.

Given our experience in 2009 and 2010 with the two-phase sampling approach described in section 3, it was clear that USPS estimates obtained as described in section 2 would not be more accurate than the 2000 census housing unit counts in all 218,000 segments on the segment sampling frame. Rather, any use of the USPS estimates would only be considered in those segments for which the USPS estimates appeared to more accurately reflect the number of housing units in 2010 than the 2000 census data. Once segments were formed, the number of housing units according to the 2000 census was compared with USPS estimate. Additionally, segment-level predicted values from a model (Montaquila, et al 2011) developed to determine areas for which the USPS lists may be used in place of traditional listing activities were also calculated.[5] The model uses mostly segment-level characteristics (including the ratio of USPS housing unit counts to Census housing unit counts, urbanicity, mobility, occupancy rate, etc), which are available from the ACS and decennial census, to predict how well the USPS count can cover the actual

[5] For details about the match rate model, please refer to: *Using a "Match Rate" Model to Predict Areas Where USPS-Based Address Lists May Be Used in Place of Traditional Listing,* Jill M. Montaquila; Valerie Hsu; J. Michael Brick, Public Opinion Quarterly 2011 75: 317-335

housing unit count in a segment. For example, a predicted value of .85 means that the USPS counts can cover 85% of the actual housing units in a segment. These predicted values, referred to here as "match rate values", helped to determine areas for which the USPS housing unit estimates may be the most accurate.

After careful examination of the estimated growth according to those residential counts, and the match rate values from the model, it was decided that adjustments would be made only in the following circumstances:

- In counties for which:
  - the county-level count of USPS residential addresses exceeded the number of housing units according to the 2000 census; and,
  - the number housing units according to the 2005-2009 ACS also exceeded the number of housing units according to the 2000 census.
- In those segments with segment-level growth of over 20% indicated by USPS counts compared to 2000 Census;
- In those segments with match rate values larger than .85;
- Since dorm units are not included in the census count of housing units and not in the target population of this survey, but may be included in the USPS housing unit estimates, segments with non-zero dorm population would not be adjusted.

About 10 percent of segments in the frame met all of the above criteria. For these segments, the 2000 census segment-level housing unit counts were adjusted by the following factor:

$$\min\left\{\sqrt{\frac{\text{MSG count}}{\text{2000 census count}}}, 10\right\}. \quad (1)$$

The square root and maximum value of 10 were used in the factor to dampen the effect of USPS counts on MOS (to be conservative in our adjustment). The adjustment factor ranged from 1.096 to 10, with about a quarter of the segments inflated by more than 44 percent.

4.2 Evaluation

To evaluate the USPS counts, we compared the updated MOS with the 2000 census housing unit counts for all of the sampled segments using the counts from field listing as gold standard. The formula for relative improvement, as shown below, is similar to that in section 3 except that the USPS estimate is compared with the 2000 census count since that was our only alternative. Also for simplification, we refer to the updated segment MOS as USPS in the formula below:

$$\text{Relative improvement} = \frac{|\text{listing - Census 2000}| - |\text{listing - USPS}|}{\text{listing}}$$

For each segment, a positive value of relative improvement indicates that the USPS housing unit estimate is more accurate than the 2000 census count. In this evaluation we attempted to assess the following:

1) The accuracy of the adjusted MOS;
2) The effectiveness of the match rate model in our decision making;
3) The conservative number of segments adjusted;

4) The dampened magnitude of the adjustment.

Each of these is discussed in turn below.

4.2.1 The accuracy of the adjusted MOS

In order to determine whether our adjustment improved the segment MOS, we looked at the distribution of relative improvement in segment MOS after adjustment. As shown by Figure 1, more than half of the segments experienced a 10 percent to 25 percent relative improvement, and approximately 13 percent of the segments experienced over 25 percent relative improvement. A review of the relative improvement using 2010 census counts as gold standard found similar results. Hence, it appears that using the USPS housing unit estimate to update the segment MOS improved its accuracy.

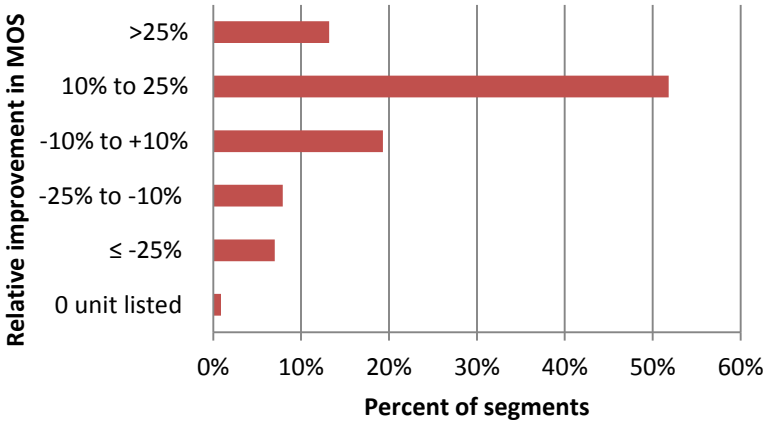

Figure 1: Distribution of the relative improvement in segment MOS: USPS over census 2000

4.2.2 The effectiveness of the match rate model in our decision making

To determine the effectiveness of the match rate model, we considered the MOS that would have resulted if we had considered only the match rate values when determining which segments to adjust. We reviewed the distribution of relative improvement when all segment MOS were adjusted by the factor in (1) compared to adjusting only those segments with predicated match rate values over .75. As shown in Table 4, when the match rate was considered, the MOS accuracy decreased in fewer segments (4% vs. 14.5%). Alternatively, the MOS accuracy was increased in fewer segments as well (11% vs. 15.6%). However, the decline in the percent of segments with more accurate MOS is much smaller than the decline in the percent of segments with less accurate MOS. Hence, it seems that overall the match rate model was an effective tool in our decision to update the MOS of the segments.

Table 4: Distribution of the Relative Improvement by Use of Match Rate

Relative improvement	*Adjust All*		*Consider match rate only (0.75+)*	
0 unit listed	0.6%		0.2%	
No more than -25%	7.1%		1.4%	
-25% to -10%	7.4%	14.5%	2.6%	4%
-10% to 10%	69.4%		50.7%	
10% to 25%	12.0%		8.9%	
More than 25%	3.6%	15.6%	2.1%	11%
Sum	100%		65.9%	
Total # of adjusted segments	901		594	

4.2.3 The conservative number of segments adjusted

As mentioned earlier, the uncertainty about the quality of the USPS housing unit estimates led us to conservatively adjust the segment MOS only in specific circumstances. Table 5 compares the distribution of the relative improvement gained by only adjusting the segment MOS under the circumstances outlined in section 4.1 to the scenario in which:

- The adjustment was made without considering the match rate values; and,
- The threshold of the ratio of the segment-level USPS housing unit estimates to the census 2000 count was lowered from 1.2 to 1.1.

Also included in Table 5 is the distribution of the relative improvement when the segment MOS was adjusted for all segments. As can be seen, when the match rate values were ignored and the threshold lowered, the number of segments with a decline in MOS accuracy increased only slightly from 1.9 percent to 2.5 percent, while the segments with increased MOS accuracy rose from 8.2 percent to 10.9 percent. Hence, more segments could have benefited from the MOS adjustment.

However, if all of the segments were adjusted (compared to the original adjustment), the percentage of segments with a lower MOS accuracy increased by 13 percent (from 1.9% to 14.5%), while the percentage of segments with higher MOS accuracy increased by only 7 percent (from 8.2% to 15.6%). By adjusting all segments, more segments suffered a loss in MOS accuracy than were improved by the adjustment. So while it appears we could have been more liberal in the number of segments adjusted, adjusting all segments would not be prudent.

Table 5: Distribution of the Relative Improvement by Adjustment Rules

Relative improvement	*Original adjustment*		*Ignore match rate & segment USPS/census threshold =1.1*		*Adjust all*	
0 unit listed	0.1%		0.1%		0.6%	
No more than -25%	0.9%	1.9%	0.9%	2.5%	7.1%	14.5%
-25% to -10%	1.0%		1.6%		7.4%	
-10% to 10%	2.4%		9.4%		69.4%	
10% to 25%	6.5%	8.2%	8.8%	10.9%	12.0%	15.6%
More than 25%	1.7%		2.1%		3.6%	
Sum	12.7%		22.9%		100.0%	
Total # of adjusted segments	114		206		901	

4.2.4 The dampened magnitude of the adjustment

As stated in section 4.1, rather than using the USPS housing unit estimate in place of the census 2000 count, we created a conservative adjustment to guard against the potential for overinflating the segment MOS. However, we wanted to determine whether we could use a larger adjustment as a means to better improve the MOS. Table 6 shows the distribution of relative improvement in MOS using two adjustment factors. The first is the adjustment factor used in our study. The other is the ratio of the USPS housing unit estimate to the census 2000 count which results in simply using the USPS housing unit estimate as the updated MOS. As shown in the last row of Table 6, using the USPS housing unit estimate as the MOS resulted in more segments (38.6% vs. 13.2%) having over 25 percent improvement in their MOS. However, it is also the case that more segments undergoing that same adjustment (30.7% vs. 14.9%) had their MOS accuracy decreased. Overall, using the conservative MOS adjustment resulted in more segments having increased MOS accuracy (65% vs. 54.4%) over using the USPS housing estimates alone. So while a larger adjustment may be appropriate, it does not appear that using the USPS housing unit estimates alone is wise.

Table 6: Distribution of the Relative Improvement by Adjustment Factors

	Adjustment factor					
	$\min\left(\sqrt{\frac{\text{USPS count}}{\text{2000 census count}}}, 10\right)$			$\frac{\text{USPS count}}{\text{census 2000 count}}$		
Relative improvement	*# of segments*	*Percent*		*# of segments*	*Percent*	
0 unit listed	1	0.9		1	0.9	
No more than -25%	8	7.0	14.9%	23	20.2	30.7%
-25% to -10%	9	7.9		12	10.5	
-10% to +10%	22	19.3		16	14.0	
10% to 25%	59	51.8	65%	18	15.8	54.4%
More than 25%	15	**13.2**		44	**38.6**	

Summary

Based on the two evaluations, we conclude that USPS address counts can be used to estimate housing unit counts to update the segment MOS late in the decade with reasonable effectiveness and at minimal cost. However, care is needed to determine when and how to update segment MOS, given USPS coverage issues and the difficulty of attaching census geographic indicators at the address level.

Our experience suggests that it is best to consider USPS housing unit estimates along with at least one secondary source, such as housing unit estimates available from the most recent decennial census or even the ACS at a more aggregate level, rather than relying on the USPS estimates alone. Further, group quarters may cause undercoverage or indicate false growth, depending on whether they are included in the USPS lists or the target population of the survey.

References

Bell, B., Mohadjer, L., Montaquila, J., and Rizzo, L. (1999). Creating a frame of newly constructed units for household surveys. In *JSM Proceedings*, Survey Research Methods Section. Alexandria, VA: American Statistical Association, 306-310.

Dohrmann, S., Harding, L., and Li, L. (2008) Using Digital Imagery to Update the Measures of Size of Area Segments. In *JSM Proceedings*, Survey Research Methods Section. Alexandria, VA: American Statistical Association, 1718-1725.

Fahimi, M., (2010). Enhancing the Computerized Delivery Sequence File for Survey Sampling Applications. Presented at the 65th Annual AAPOR Conference.

Montaquila, J.M., Bell, B., Mohadjer, L., and Rizzo, L. (1999). A methodology for sampling households late in a decade. In *JSM Proceedings*, Survey Research Methods Section. Alexandria, VA: American Statistical Association, 311-315.

Mohadjer, L., Montaquila, J.M., Sherris, E. (2002). Evaluation of a Two-phase Approach to Segment Selection for Area Probability Samples Late in the Decade. In *JSM Proceedings*, Survey Research Methods Section. Alexandria, VA: American Statistical Association, 2395-2399.

Staab, J.M., and Iannacchione, V.G. (2003). Evaluating the Use of Residential Mailing Addresses in a National Household Survey. In *JSM Proceedings*, Survey Research Methods Section. Alexandria, VA: American Statistical Association, 4028-4033.

Montaquila, J.M.; Hsu,V., Brick, J. M. (2011). Using a "Match Rate" Model to Predict Areas Where USPS-Based Address Lists May Be Used in Place of Traditional Listing. In *Public Opinion Quarterly* 75: 317-335.