Using a "Match Rate" Model to Predict Areas where USPS-Based Address Lists May Be Used in Place of Traditional Listing

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Abstract

The time and resources associated with traditional listing have led survey practitioners to consider the use of United States Postal Service (USPS) based address lists as an alternative. In our recent investigation, we found coverage of the USPS-based address lists to be generally good in urban areas, but possibly inadequate (after geocoding) in rural and high-growth areas. We develop a "match rate" (the proportion of traditionally listed addresses that would have been obtained from a USPS-based list) model that identifies areas where USPS-based lists could be used in place of traditional listing. We use multiple regression to predict match rate with respect to characteristics associated with the geographic areas of interest. In this paper, we also discuss identifying a match rate threshold that is used to make an a priori decision of when it is acceptable to rely on USPS-based lists.

Key Words: Address-based sampling; Computerized Delivery Sequence File

1. Introduction

Increasingly, survey practitioners are considering the use of address-based sampling (ABS) frames for household surveys. The primary sources of these ABS frames are address lists based on the U.S. Postal Service (USPS) Computerized Delivery Sequence (CDS) File. These lists of addresses are compiled and maintained by third-party vendors; some vendors offer other services or enhancements to these lists. The recent consideration of the use of these lists as sampling frames has been made possible by changes in addressing, particularly those resulting from the development of Enhanced-911 address-locating systems, and improvements in geocoding methods and databases. We refer to the lists based on the USPS that are available from different commercial vendors generically as USPS lists to simplify the presentation.

ABS frames are being studied as alternatives to random digit dial (RDD) frames, in light of recent declines in RDD survey response rates (Curtin, Presser, and Singer, 2005; Battaglia et al. 2008; and Holbrook, Krosnick, and Pfent, 2008) and coverage rates (Blumberg and Luke 2009; Fahimi, Kulp and Brick 2009). Additionally, ABS can be used to facilitate the use of mixed-mode methods (Link et al. 2008). With the ability to match telephone numbers to addresses, primary contact with sampled cases in an address-based sample may be in-person, by mail, or by telephone (for the subset that can be linked to telephone numbers), and other modes (such as web and interactive voice response, or IVR) may be used for follow-up. A third use of ABS frames is to supplement or replace traditional listing of addresses (O'Muircheartaigh, Eckman, and Weiss 2003; O'Muircheartaigh et al. 2006; Iannacchione, Staab, and Redden 2003). In this paper, our

focus is on the third use of ABS frames, although our findings have relevance for the other applications as well.

For decades, traditional listing has been the standard method for constructing sampling frames of dwelling units for area probability samples. Addresses compiled by trained listers generally provide nearly complete and up-to-date lists of all residential units in the sampled area, although these too have errors (O'Muircheartaigh et al. 2006). The time and resources associated with creating these listings have led survey practitioners to consider the use of the USPS listings as an alternative to traditional listing for the purpose of sampling frame development.

Previous studies have, collectively, yielded an abundance of information about the utility of ABS frames. These are reviewed in the next section. In section 3, we discuss the data and the method used to evaluate the coverage of the USPS lists relative to enhanced traditional listings. In section 4 we develop a "match rate" multiple regression model to predict the match rate (the proportion of traditionally listed addresses that would have been obtained from a USPS list) with respect to characteristics associated with the geographic areas of interest. In section 5, we describe an approach for setting threshold values of predicted match rate to determine when to use USPS lists in lieu of traditional listing. We assess the performance and utility of the constructed model in section 6. The implications of our findings and future research and evaluation needs are discussed in section 7.

2. Previous Studies

Research has evaluated the use of ABS frames in a variety of contexts. An early study by Iannachhione, Staab, and Redden (2003) was a coverage evaluation of USPS lists in Dallas, Texas. In this study, the authors used the USPS lists as a sampling frame and evaluated coverage using the half-open interval procedure (Kish 1965). They reported an estimated undercoverage rate of 1.9 percent, found that the majority of households with P.O. box addresses in Dallas also receive mail at their street addresses, and observed that the occupancy rate was consistent with rates generally found for listed housing units in studies of metropolitan areas. Although this study was restricted to a single metropolitan area, its results indicated the potential of USPS lists as sampling frames.

O'Muircheartaigh, Eckman, and Weiss (2003) compared traditional listing and "enhanced field listing." With enhanced listing, the listers were given the USPS addresses (geocoded so that they could appear in geographic sequence), with instructions to make corrections and note addresses that were missing from the USPS lists. The resulting enhanced listings were then compared to traditional listings (generated by a separate group of listers) and to the original USPS list before enhancement. The authors observed problems with using the USPS lists in rural areas due to the high prevalence at that time (2001) of rural route addresses and P.O. boxes. In non-rural areas, however, they noted the superiority of enhanced listing to traditional listing, and also concluded that this study demonstrated potential for the use of USPS lists (without enhancement) in place of traditional listing.

O'Muircheartaigh et al. (2006) used field verification to arrive at a "best" address frame. As the basis for their evaluation, they used a set of area segments that had been traditionally listed, and obtained USPS lists for these segments. The combination of these two lists served as the basis for the field verification effort. The authors concluded that,

overall, the USPS list was superior to traditional listing. They also offered a set of criteria for identifying segments where traditional listing is likely to be superior: (a) those with irregular street patterns that are more susceptible to geocoding errors; (b) those with counts of addresses from the USPS list that are substantially below the decennial census counts; and, (c) those with high rates of growth in population.

In contrast to the aforementioned evaluations that examined the potential use of USPS lists in place of traditional listing in multi-stage area probability samples, Link et al. (2008) considered USPS lists as alternative to RDD frames. Their evaluation, conducted in six states, encompassed several aspects, and they concluded that "While the [Delivery Sequence File] appears to be an effective frame for conducting address-based sampling of the general population, its true potential may be in facilitating mixed-mode surveys." (Link et al. 2008, p. 26.)

3. Evaluation of USPS Lists vs. Traditional Listing

Our evaluation uses data from the National Children's Study (NCS), a study designed to examine the effects of environmental influences on the health and development of approximately 100,000 children across the U.S. by collecting data on them from before birth until age 21. The sample design for NCS is a multi-stage area probability household sample (Montaquila, Brick, and Curtin, 2010). The first stage of sampling is the selection of PSUs, which are single counties or groups of contiguous counties. The second stage for most PSUs – third stage for the large, densely populated PSUs where geographic areas are first selected within the PSU – is the selection of segments.

In order to cluster the sample into compact units that are designed to meet established sample yield targets, allow for estimation of neighborhood effects, and facilitate the collection of environmental measures, census blocks are used as the basic building blocks to construct segments within the PSUs. The segments typically have approximately 500 to 1,200 households. The segment is the final stage of selection. The segments are constructed to yield the target number of births in the PSU and are selected to attain an approximately equal probability sample of segments. Within the sampled segments, household enumeration is attempted in all dwelling units[1] (DUs) and essentially all births that occur during the enrolment period are eligible for the Study.

One of the early steps in the household-based data collection effort for the NCS is the preparation of lists of all residential addresses in each sampled segment. Our evaluation is based on listing conducted for the NCS Vanguard Study, a pilot study in seven PSUs:

- DC: Duplin County, NC
- BYPL: Brookings County, SD; Yellow Medicine, Pipestone, and Lincoln Counties, MN
- WC: Waukesha County, WI
- MC: Montgomery County, PA
- SLC: Salt Lake County, UT
- OC: Orange County, CA
- QC: Queens County, NY

[1] In very densely populated areas the sample segment may contain too many households and may be subsampled ("chunked") to achieve the appropriate sample size.

In the Vanguard Study of the NCS, the compilation of residential addresses used traditional listing. Trained listers canvassed the sampled segment, located segment boundaries, and then compiled a hard-copy list of residential addresses as they moved in a systematic manner through the segment. For these seven NCS PSUs, the process of listing in the sampled segments was conducted in 2008 by different organizations in each PSU. In all seven NCS Vanguard PSUs, lister training was centrally coordinated and administered during in-person sessions. The lister training also included a discussion of any site-specific issues and a field listing exercise in which the trainees traveled to a designated neighborhood to practice listing.

The listing effort began shortly after training in all seven PSUs. Listing in the sampled segments was conducted in the spring and fall of 2008. Listers across PSUs followed the same listing protocol. To standardize the listing process, a set of listing materials was provided to the listers which included the segment map that shows the area to be listed and listing sheets. The paper listing sheet was developed to facilitate the recording of residential addresses in the sampled locations. Each column on the listing sheet represented a field to record a unique part of the address identifier. Listers were instructed to use standard USPS abbreviations for street suffix, pre and post directional, and unit designators.

Following the listing operation, quality control checks were done on the listed addresses and, as part of the process, the listed addresses were compared to commercially available address lists based on the USPS files. Lists of residential addresses in the ZIP codes associated with the sampled segments in the seven PSUs were obtained from a vendor within two months of the field listing. Each address was geocoded to determine the census tract and block associated with the address. Addresses that geocoded to a census block that was part of a sampled segment were retained; all non-geocodable addresses and addresses that geocoded to a location outside the segments were dropped. Non-city-style addresses (e.g., Post Office boxes and rural route addresses) were treated as non-geocodable.

With the sample design used for NCS, if the USPS lists were used in place of listing, it is likely that the approach adopted for this evaluation (explained above) would be used to determine which addresses should be kept. Although some portion of the nongeocodable addresses and the addresses that geocoded to locations outside the segment would be expected to be eligible (but not retained due to incompleteness of the geocoding databases and geocoding error, respectively), such units should be picked up during data collection by a "missed unit" procedure.

We attempted to match each traditionally listed address with an address on the USPS list using an automated matching program followed by manual matching. In some cases, we were able to positively match many addresses that did not match through the automated matching by inferring from the comments that the lister recorded. Additionally, we were able to correct keying or listing errors as a result of reviewing other house numbers on the street as well as searching on the USPS website for the address in question to see whether the website returned an error message indicating the particular address was non-deliverable.

The result of matching was an "augmented traditional listing." This list contained the addresses listed by the traditional listers excluding any addresses identified through the

quality control process to have been listed in error, along with address corrections and updates as described above. The results of this matching exercise, given in Montaquila et al. (2009), indicate that although match rates were generally higher in urban areas, there was variation in match rates at the segment level across PSUs regardless of urbanicity. Thus, while the USPS lists may have very good coverage in some areas, the within-PSU variation in coverage is an important consideration in deciding when to use the USPS lists in lieu of traditional listing.

4. Modeling Match Rates

Resources, time, and effort could be conserved if we are able to use the USPS list as a sampling frame in areas where it provides adequate coverage. In some situations, the USPS lists might even produce higher quality frames than those obtained from trained listers. Thus, it would be beneficial to identify (a priori) areas where USPS lists could be used in place of traditional listing. In this section, we describe a model for predicting the match rate between the USPS and traditionally listed addresses. The model uses data available from various Census data sources to predict the match rates for the 91 segments in the 7 NCS Vanguard Study PSUs.

To fit the model we explored the relationships between segment characteristics and match rates. Selected statistics from the Census 2000 Summary File 1, Census 2000 Summary File 3, and 2005-2007 American Community Survey (ACS) were used to build the prediction model. We considered variables such as the ratio of USPS addresses[2] to Census 2000 housing unit counts, a proxy for new housing development, measures of stability of occupancy, and classifications of types of structures. Segment-level statistics were computed by summarizing block- or block group-level data extracted from the Census 2000 data, and ACS county-level estimates were also considered. The match rate was modeled as a linear function of all the covariates listed in Exhibit 1.

[2] Some address vendors are able to provide counts of addresses that they have in specific areas prior to selling the addresses

Predictor	Description
Mobility measure	Percent of population in the same house one year ago (2005-2007 ACS)
Measure of new construction (2005 and later)	Percent of housing units built in 2005 or later (2005-2007 ACS)
Measure of new construction (2000 to 2004)	Percent of housing units built between 2000 and 2004 (2005-2007 ACS)
Urbanicity	Percent of population located within urbanized areas and urban clusters (Census 2000 SF1)
Percent not institutionalized	Percent of population who were non-institutionalized (Census 2000 SF1)
Percent occupied	Percent of housing units that were occupied (Census 2000 SF1)
Percent owner-occupied	Percent of housing units that were owner-occupied (Census 2000 SF1)
Percent housing units not seasonally occupied	Percent of housing units offered "for rent," "for rent or for sale," or "for sale only" (Census 2000 SF1)
Percent older units	Percent of housing units built before 1980 (Census 2000 SF3)
Percent single unit structures	Percent of housing units that were single units (Census 2000 SF3)
Percent mobile homes	Percent of housing units that were mobile homes, houseboats, railroad cars, campers, and vans (Census 2000 SF3)
Percent public transit users	Percent of workers 16+ years using public transportation to work (Census 2000 SF3)
Percent below poverty	Percent population whose income in 1999 was below poverty level (Census 2000 SF3)
USPS to Census ratio	Ratio of USPS addresses that geocoded to blocks in the sampled segments to number of housing units in Census 2000

Exhibit 1: Variables considered in the full model

Weights were not used in fitting the model; as noted in section 3, the sample was designed to produce an approximately equal probability sample of segments, and within sampled segments all households were eligible for the Study. Although the seven PSUs were purposively selected, they were chosen to be diverse in their characteristics. Factors that might vary amongst PSUs and might also impact the quality of the USPS lists, such as urbanicity and rates of new construction, were considered as predictor variables in the model. Nonetheless, the segments included in this study do not capture the full range of situations and possible characteristics and this may affect the extent to which the results presented here are generalizable.

As a starting point, Pearson correlation coefficients were examined to determine if there was a linear relationship between match rate and each of the predictor variables listed in Exhibit 1. The strongest correlation with match rate was urbanicity, with a correlation of 0.87. The mobility measure, percent occupied, percent housing units not seasonally

occupied, percent mobile homes, percent public transit users, and percent below poverty were also significantly correlated with match rate at the $\alpha = 0.05$ level. A few predictor variables were strongly correlated with one another, such as percent single unit structures and percent owner-occupied ($\rho = 0.92$) and the measure of new construction (2000 to 2004) and percent public transit users ($\rho = -0.73$), suggesting that only a subset of the covariates was essential in the final model.

To find a more parsimonious regression model to predict match rate, a stepwise regression analysis using all of the covariates listed in Exhibit 1 and their associated two-way interactions was used. After ten iterations, eight significant predictors remained in the model, including one main effect and seven two-way interaction terms. All main and two-way effects in the reduced model were statistically significant at the $\alpha = 0.05$ level. The reduced model fit the data adequately, with $F = 106.19$ and ρ-value $< .0001$. The final model was obtained by adding to the reduced model all main effects that appeared in the interaction terms.

The final regression model used to predict match rate had 15 predictors, as shown in Table 1. The overall model fit was reasonable, with $F = 53.70$ and ρ-value $< .0001$, and the adjusted coefficient of determination, R^2, was 0.90. We examined the standardized estimates to evaluate the relative strength of each of the predictors in the final model. The analysis demonstrated that the USPS to Census ratio was the most powerful predictor, with both the interaction of urbanicity and percent occupied, and the interaction of the USPS to Census ratio and the mobility measure having large standardized coefficients.

Table 1: Final Model Parameter Estimates for Predicting Match Rate

Predictor	*Parameter Estimate*	*Standard Error*
Intercept	1.46	0.84
Percent older units	-0.62**	0.09
USPS to Census ratio	-0.41	0.53
Mobility measure	-0.63	0.66
Urbanicity	-0.68	0.69
Percent housing units not seasonally occupied	0.53	2.11
Percent occupied	-0.34	0.60
Percent single unit structures	0.01	0.04
Percent public transit users	0.03	0.09
USPS to Census ratio by mobility measure (interaction)	0.41	0.67
USPS to Census ratio by urbanicity (interaction)	0.10*	0.04
USPS to Census ratio by percent older units (interaction)	0.67**	0.09
USPS to Census ratio by percent housing units not seasonally occupied (interaction)	-1.76	1.73
Urbanicity by percent occupied (interaction)	1.00	0.74
Percent public transit users by percent single unit structures (interaction)	0.33*	0.15
Percent public transit users by percent housing units not seasonally occupied (interaction)	-2.51	1.93

**ρ-value < 0.001 *ρ-value < 0.05

We further examined the fitted model to ensure that it adequately described the data, was not heavily influenced by a small number of observations and was not subject to multicollinearity. A residual analysis was conducted to detect any peculiarities. While we did find some issues, such as potential non-normality and heteroscedasticity, these

violations of the model assumptions were not sufficient to affect the goal of developing a model for predicting match rates (Shmueli, 2009).

As a final step, the observed match rates were compared with the predictions from the model. There was a strong positive association between the fitted values generated from the model and the observed match rates obtained from the 91 NCS segments ($\rho = 0.96$). Figure 1 shows a scatterplot of the actual and predicted values of match rate. This scatterplot shows that the match rate is reasonably well explained as a function of the predictors in Table 1. Based on these results, we concluded that the final model appears to be a viable, useful tool for predicting situations in which the USPS lists can be used in place of traditional listing.

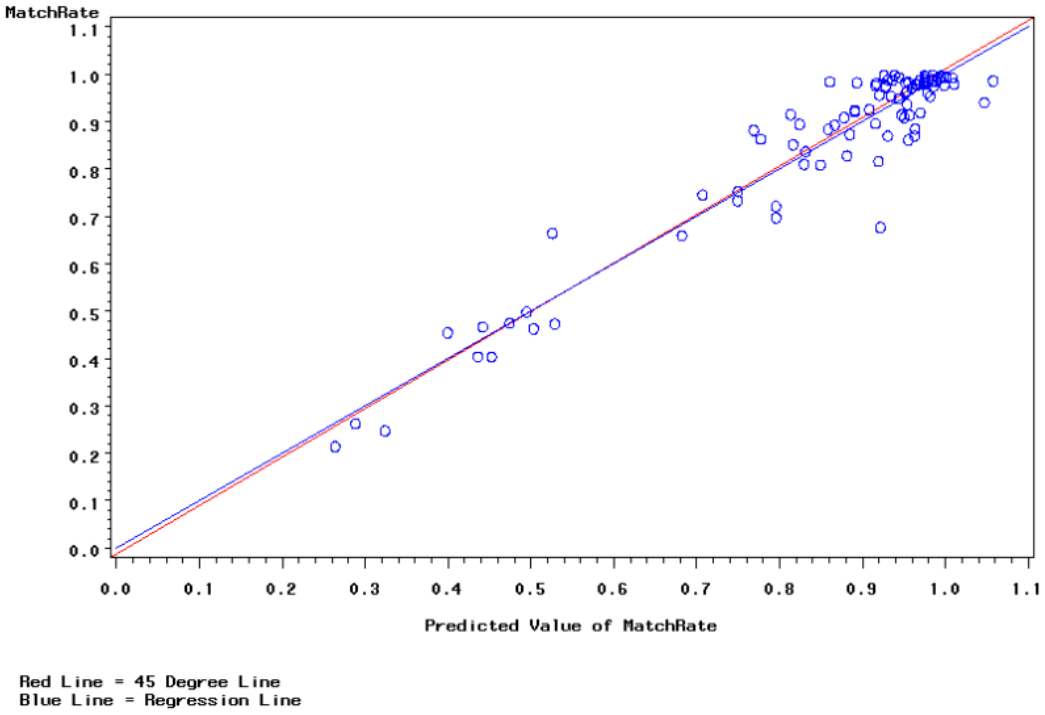

Figure 1: Match Rate vs. Predicted Value of Match Rate

5. Using Match Rate Models to Decide Which Areas to List

To use the prediction model, a threshold value must be specified to make an a priori decision of when to use USPS lists in lieu of traditional listing in frame construction. If a segment has a predicted match rate that falls below the specified threshold, then traditional listing is used; a predicted match rate on or above the specified threshold means the USPS lists are used without incurring the costs of traditional listing. The challenge is to determine a match rate threshold that defines adequate coverage and is operationally efficient.

To arrive at an operational threshold value for our study, we considered two threshold values, 0.7 and 0.8. We did not examine threshold values below 0.7 as these coverage rates were too low for the NCS. Although missed unit procedures may be used in all sampled segments during data collection to capture dwelling units that were missed on

the original frame, it is inefficient to bring in a larger proportion of eligible units through such procedures. We discuss other criteria for choosing thresholds in section 7.

The two threshold values were used with the fitted model in each of the 91 segments. Using a threshold value of 0.7 (see Table 2), the model correctly recognized all segments that had less than 70 percent coverage and required traditional listing. Of the segments that the model flagged as candidates for USPS lists, 97 percent had match rates that exceeded the threshold value. False negatives result in increased costs because the USPS lists are adequate for these segments but the model indicates a need for traditional listing. False positives can result in poor coverage or increased costs, since missed unit procedures must be used to ensure a comprehensive list of dwelling units.

Table 2: Model Performance Using Threshold Value = 0.7

		Predicted match rate		
		Below threshold	*Above threshold*	*Total*
Actual match rate	*Below threshold*	13 (100%)	2 (3%)	15
	Above threshold	0 (0%)	76 (97%)	76
	Total	13	78	91

A higher and more conservative threshold of 0.8 (see Table 3) would be more appropriate if it was crucial to obtain a frame that had adequate coverage, especially if either no missed unit procedure is planned or if there are concerns that the missed unit procedure will be ineffective. As shown in Table 3, of the segments that the model predicted as needing traditional listing using the 0.8 threshold, USPS lists could have been used in 10 percent of the segments, resulting in higher operational resource inefficiency as compared to the lower threshold. However, using the 0.8 threshold resulted in fewer coverage issues as the model correctly identified all but one segment that had USPS coverage above 80 percent.

Table 3: Model Performance Using Threshold Value = 0.8

		Predicted match rate		
		Below threshold	*Above threshold*	*Total*
Actual match rate	*Below threshold*	18 (90%)	1 (1%)	19
	Above threshold	2 (10%)	70 (99%)	72
	Total	20	71	91

6. Evaluation of Match Rate Model

Our match rate model was constructed using segments from the NCS Vanguard Study. To evaluate the performance and generalizability of the model, we assessed the predictive accuracy of the fitted regression equation on an independent set of segments from another survey that uses a multi-stage area sample. These evaluation segments were defined by Census geography (census blocks and combinations of blocks), and were obtained from six U.S. counties of varying urbanicity. The traditional listings were done in 2005 and 2006 for the 142 segments in these six counties. On average, 156 addresses were recorded within each segment. The listings were done by full-time professional listers. USPS lists for the sampled segments were obtained from an address vendor within three months of the field listing.

Ten segments were excluded from the evaluation of the match rate model for two reasons: 1) the address vendor did not "own" (i.e., have rights to obtain from the USPS) the ZIP codes covering seven of the sampled segments; and 2) three of the sampled segments were largely comprised of college dormitories or senior assisted living facilities, which were absent from the USPS lists. The purchased USPS lists were matched to the traditional listing lists using the approach described in section 3. We then obtained the set of segment- and PSU-level predictors derived from Census sources. Using the final model with the estimated regression coefficients developed from the NCS data, we produced match rate predictions for the 132 segments. The resulting correlation of actual match rates with the predicted match rates was 0.44 (p-value < .0001).

To gauge the extent to which the model's predicted match rates agree with actual outcomes, we created cross-tabulations using the threshold values 0.7 and 0.8 to estimate the error rates in classifying segments. Table 4 shows results of the model evaluation using the lower threshold value of 0.7. The model overestimated 17 percent of the segments as having predicted match rates above the 0.7 threshold when their actual match rates were below the threshold, potentially contributing to poor coverage. The error in the other direction was larger, but was less of a concern since it is a waste in resources.

Table 4: Model Evaluation Using Threshold Value = 0.7

		Predicted match rate		
		Below threshold	*Above threshold*	*Total*
Actual	*Below threshold*	22 (69%)	17 (17%)	39
match rate	*Above threshold*	10 (31%)	83 (83%)	93
	Total	32	100	132

The error rates of applying the match rate model with a more conservative threshold value of 0.8 are shown in the off-diagonal entries in Table 5. Compared to the lower threshold, a lower percentage of segments were flagged as requiring traditional listing when their actual match rates qualify for the use of USPS lists; a higher percentage of segments were incorrectly classified as candidates for USPS lists. Using the 0.8 threshold, 16 percent of all segments had predicted match rates that exceeded the threshold when their actual match rates were below the threshold.

Table 5: Model Evaluation Using Threshold Value = 0.8

		Predicted match rate		
		Below threshold	*Above threshold*	*Total*
Actual	*Below threshold*	34 (79%)	21 (24%)	55
match rate	*Above threshold*	9 (21%)	68 (76%)	77
	Total	43	89	132

As expected, the model performed less accurately on a different sample than the one used to fit it. Nevertheless, the match rate model had a high correct classification rate for predicting whether USPS lists can be used in lieu of listing when applied to an independent dataset. The prediction assessment shows the match rate model is useful for predicting future unobserved match rates on the basis of its predictors.

One additional consideration is the extent to which the match rate model improves upon the measure that could be viewed as a preliminary indicator, the USPS to Census ratio. Using the 91 NCS segments, the correlation between the actual match rate and the model-

predicted match rate is 0.96, whereas the correlation between the actual match rate and the USPS to Census ratio is 0.10. For the 132 segments in the evaluation dataset, the correlation between the actual match rate and the model-predicted match rate is 0.44, compared to a correlation of 0.22 between the actual match rate and the USPS to Census ratio. We suspect the USPS to Census ratio would have greater utility (relative to other potential predictors) early in the decade.

7. Discussion

As vendor-maintained USPS lists have become more complete and geocoding methods and databases produce more accurate locations for these addresses, ABS has emerged as an appealing alternative to traditional listing. This paper describes an approach for assessing when USPS lists could be used in place of traditional listing based on a "match rate" model. We develop the model for the NCS which has an area probability frame based on census geography. Greater coverage of the USPS lists might be achieved in other designs in which the sample is selected from a frame in which areas are defined by ZIP codes rather than census blocks.

By applying a predetermined threshold value to the predicted match rates, one can decide whether to traditionally list or use USPS lists to construct a sampling frame for each area. The threshold values considered here were used solely for illustrative purposes. The actual threshold used for a particular application should be set based on a variety of considerations, such as the skill and training of the listers, the effectiveness and cost of missed unit procedures to cover units not on the sampling frame, and the relative costs of traditional listing and USPS listings. Of course, the most useful criteria would balance the costs associated with each of the procedures against the bias in the estimates due to the coverage error. To date, studies comparing USPS lists and traditional listing have only examined coverage rates; biases due to incomplete coverage are relatively unexplored. (See Shore, Montaquila, and Hsu 2010.)

One limitation of the research design is that the NCS PSUs are purposively selected and do not represent the nation. Ideally, the model should be built based on the full diversity of geographic regions that cover all types of addresses. The representativeness of the segments used to fit the model is a potential concern. Constructing a match rate model based only on a small sample of segments may also increase the risk of obtaining spurious results. Re-examining the model using additional observations that improve the representation of the various types of locations would be worthwhile. In spite of these limitations, the model proved useful when applied to a completely independent dataset. As a result, we believe this research provides a valuable framework for building a prediction model to make an a priori decision as to whether to use the USPS lists in place of traditional listing.

The model presented in this paper used covariates from Census 2000 and ACS. As Census 2010 and additional ACS data become available, re-fitting the model would be useful. We expect the ratio of USPS addresses to housing unit estimates will become a very powerful predictor once the new census data are available. There is also the potential that including covariates that address vendors can provide such as rates of simplified addresses could improve the predictive power of the match rate model.

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