A Coverage Profile of Area Frame Blocks on the United States Census Bureau's Master Address File

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Abstract

With the availability of national address list frames, the future of area frame listing in the United States is uncertain. Before embracing address lists as a sampling frame, survey methodologists and statisticians would like to assess the coverage of such frames relative to area listing. As a response to this concern, this paper explores characteristics of gross undercoverage and overcoverage on a list frame, the U.S. Census Bureau's Master Address File (MAF), within blocks that are primarily rural and susceptible to coverage problems. The results presented indicate that more research is necessary to assess the impact of undercoverage in primarily rural areas on key statistics.

Keywords: Coverage, Sample Redesign, Frame Creation, Master Address File, Current Population Survey, Area Frame Listing

1. Introduction

Many government, academic, and for-profit survey organizations use area listings to build frames for household surveys. Although expensive and time consuming, area frames built from field operations are thought to have better coverage than frames based on commercial address lists. However, with the availability of the Delivery Sequence File (DSF) from the United States Postal Service as a sampling frame, many survey organizations are trying to better understand the coverage of list frames.

O'Muircheartaigh, Eckman, and Weiss [2002] from the National Opinion Research Center (NORC) used a dependent listing for the General Social Survey to evaluate the coverage of the DSF in 14 segments with city-style addresses. From their research, they proposed that sampling directly from the DSF in urban and suburban segments would be cost-effective and provide adequate coverage. Interestingly, they also found that field listings dependent on the DSF are of superior quality to independent listings.

NORC is not the only survey research center looking at mailing lists. Staab and Iannocchione [2003] from the Research Triangle Institute (RTI) International compared current Census projections to counts of residential addresses on a national list from ADVO, a direct mail media company. They found reasonable net coverage when using a Half Open Interval (HOI) in areas with locatable mailing addresses. They also acknowledged that rural routes and other non-locatable addresses present a source of undercoverage for such address lists.

In addition, Johns [2005] from the U.S. Census Bureau also compared census estimates to an address list -- the Master Address File (MAF). The MAF originated as a file of addresses and housing units from the 1990 U.S. population census. It was updated during Census 2000. Since then, it has been refreshed twice a year with new addresses from the DSF. Furthermore, area frame listings that support the Census Bureau's current surveys and the American Community Survey are used to update the MAF on an ongoing basis. In his evaluation of the MAF, Johns found that in terms of net coverage, the MAF is an attractive sampling frame. Johns also noted that filtering rules have a large impact on net coverage. Because the MAF contains addresses for businesses, units not yet built, demolished units, and units that are otherwise out-of-scope for household surveys; it is necessary to filter out all of the out-of-scope addresses. Separating net coverage from gross coverage, Kennel and Corlett [2005] found areas needing improvement on the MAF. Thus, only looking at net coverage can make some frames appear better than they are.

One final study by Thompson and Turmelle [2004] compared an independent area frame listing, an address registry, and a dependent listing in four major Canadian cities and one town. Within their sample, they found that the dependent listing had the least undercoverage, while the independent listing had the most undercoverage. On the other hand, the independent listing had the least overcoverage, while the address registry had the most. Furthermore, Thompson and Turmelle tested a model to screen clusters into one of the three methods for future frame creation in the Canadian Labor Force Survey. They used variables related to the number of unlocatable addresses on the address registry and growth since the previous Census. Also looking at targeting rules, Dean [2005] from the U.S. Census Bureau compared MAF undercoverage in targeted blocks to MAF undercoverage in a random sample of area frame blocks. Dean found that the percent of addresses on the MAF that match to the DSF along with the dominant type of address (city-style, P.O. box, rural route) could

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successfully be used to target blocks with coverage problems on the MAF.

All of these studies suggest that advances in residential mailing lists are changing frame creation operations and area frames. Although most of the papers reviewed express concern in areas with few city-style addresses, more research is necessary to assess the impact of undercoverage in rural segments. Moreover, although many survey centers make decisions to list a block or use addresses from a list frame, only a few papers have been published evaluating such decisions. There is even less research exploring the potential biases of using a list frame in areas where coverage is likely to be poor. Nevertheless, survey methodologists and survey sponsors are concerned with coverage errors. For example, every month the Current Population Survey (CPS) produces coverage ratios for various domains, including gender, race, and ethnicity. These coverage ratios are at the person level and reflect within household coverage, which may or may not be indicative of housing unit level coverage. Nevertheless, these coverage ratios suggest that the Current Population Survey sample is undercounting minorities more than Whites, Hispanics more than non-Hispanics, and males more than females. Of course, weighting adjustments for the CPS correct for such differences.

The focus on undercoverage in the literature is warranted. Although overcoverage can inflate costs and variances, it rarely biases statistics to the extent that undercoverage does. The exception is duplication, which is difficult to identify and can bias statistics, if undetected and correlated with the key variables of interest. Kennel and Corrlett [2005] showed that duplication accounted for about 11% of all overcoverage on the MAF in area frame blocks. Furthermore, the consequences of undercoverage are more severe than overcoverage in the political sphere.

In this paper, I will investigate demographic characteristics associated with gross undercoverage and overcoverage on the MAF. These results will help assess the potential coverage bias of using a list frame instead of an area frame. Furthermore, these results may help sampling statisticians to better target blocks needing field listing.

After controlling for geographic characteristics, I will investigate the relationship between race, ethnicity, age, sex, household tenure, occupancy status, type of housing unit, and household size and undercoverage and overcoverage on the MAF in areas currently covered by an area frame.

2. Methodology

2.1 Design

Most current household surveys at the Census Bureau use a multiple frame design. Approximately 12% of each survey's sample housing units are listed by field representatives in an area frame. Blocks are screened into the area frame if

- more than 4% of the addresses from Census 2000 lack either a house number or street name, or
- the block is not covered by a building permit office, or
- the block adjoins a college campus.

Most of the area frame is in rural blocks that lack city-style addresses. City-style addresses are addresses with both a house number and a street name. The relatively small number of blocks adjoining college campuses tend to be more urban than blocks with more than 4% non city-style addresses

The focus of this study is on areas where the MAF may have coverage problems. Overall, the area frame contains 928,551 out of the 4,661,684 combined blocks in the United States. An average combined block is a collection of two to three adjacent Census tabulation blocks. However, a combined block may have as little as one tabulation block or as many as 50 tabulation blocks.

For this study, I used area listings from the Current Population Survey (CPS) and the State Children's Health Insurance Program Survey (SCHIP). Both surveys selected their samples at the same time using procedures described in chapter 3 of Technical Paper 63RV [U.S. Census Bureau, 2002]. For area frame sampling, counties or groups of counties are selected with probabilities proportional to their size. Some counties are selected with certainty. In the second stage of sampling, clusters of four expected housing units, called *measures*, are selected. Then combined blocks containing sample measures are listed. After listing, housing units within the selected measures are then interviewed.

In November 2004, CPS and SCHIP completely phased in their 2000 sample redesign. Unlike previous designs, the 2000 area frame listings are a dependent listing based on the MAF. This new design provided an opportunity to use dependent field listings to evaluate the coverage of the MAF in area frame blocks. The listings included in this project were completed between December 2003 and April 2006.

The listing procedures for the 2000 sample design required all area frame combined blocks with selected measures to be populated with addresses from the MAF and sent to the field for dependent listing. During listing, field representatives updated the list by adding, deleting, changing, moving, or verifying addresses. Field representatives were given a list of ungeocoded addresses within the county and addresses in neighbouring blocks to assist them in listing. Before adding a unit, field representatives were encouraged to search the ungeocoded list to see if the address was on it.

The enhanced listings were edited at headquarters. All records were standardized and then merged to the MAF. Next, the MAF was updated. Nonmatches were added to the

MAF. In the case where multiple listings matched to the same existing record on the MAF, only one record was updated on the MAF. After updating the MAF, the enhanced MAF was matched to the version of the MAF that was originally sent out to the field for dependent listing.

2.2 Dependent Variables

By merging the unenhanced MAF to the enhanced MAF on a unique control number, I could easily define overcoverage and undercoverage.

Undercoverage includes both omissions and erroneous exclusions. A housing unit was considered an omission if it did not exist on the unenhanced MAF, but is on the enhanced MAF as a valid unit. A unit was considered an erroneous exclusion if the unit existed on the unenhanced MAF and an invalid unit, but existed on the enhanced MAF as a valid unit. For this study, erroneous exclusions may be the result of an imperfect filter, a coding error, or a geocoding error. For example, consider an address classified as a business on the unenhanced MAF that turns out to be a valid residence during listing. Erroneous exclusions are the product of an imperfect filter or of miscoded data on the MAF.

The universe for undercoverage includes all valid units on the enhanced MAF in the listed combined block. Naturally, it contains all added units that were not on the unenhanced MAF. It may also contain units that were initially outside the block or that were ungeocoded, but were moved into the block during listing. There were 2,523 combined blocks containing 144,477 housing units in the undercoverage universe.

Overcoverage includes all units that were valid on the unenhanced MAF, but invalid on the enhanced MAF. Units on the MAF that were determined to be nonresidential, nonexistent, duplicates, or outside the block of interest are all classified as out-of-scope.

The universe for overcoverage only includes units on the unenhanced MAF that were geocoded inside the block. Thus units that moved inside the block or were ungeocoded on the unenhanced MAF were excluded from the overcoverage rate. There were 2,544 combined blocks containing 142,344 housing units in the overcoverage universe.

2.3 Independent Variables

I am interested in the relationship between demographic and housing characteristics and coverage. Specifically, this study deals with the following variables of interest:

- Race,
- Ethnicity (Hispanic Origin),
- Age,
- Sex,
- Tenure,
- Occupancy status, and
- Household size.

All of these variables came from the 2000 Census Short Form.[*] Because none of these characteristics were captured during listing, I had to get this data from another source. Although I could not find these variables at the individual or housing unit level, I did find tabulation block level summaries from the Census 2000.

Summary File 1 contains totals at the tabulation block level. To minimize the effect of block size, I divided the totals within each category by the total number of housing units or persons in the block. For example, I divided the total number of black persons in the tabulation block by the total number of people in the block to get the proportion of black people in the block. Then, I used the following arcsine transformation on these proportions:

$$Y = 2\arcsin\left(\sqrt{p}\right)$$

2.4 Control Variables

For undercoverage, I controlled for the following characteristics,

- Permit issuing status,
- Census region,
- Type of housing unit (mobile home),
- Urban/rural status,
- Proportion of city-style addresses,
- Proportion of DSF matches,
- Growth of the block since Census 2000,
- Number of housing units at the basic street address,
- Census 2000 housing unit count,
- Proportion of Locatable Address Conversion System (LACS) matches, and
- Census 2000 person count.

The permit issuing status is a dummy variable indicating if the block was covered by a building permit office in 2000. The census region contains four regions defined by the census bureau: Midwest, Northeast, South, and West. The type of housing unit was collected during listing. It is a dummy variable indicating if the unit is a mobile home or a conventional housing unit. Because this variable was collected during listing and not collected for nonexistent and other overcovered units, it only plays a part in the undercoverage model. The urban/rural status was defined during Census 2000.

In addition to the four categorical variables, I used seven continuous variables. With the exception of the number of

[*] Summary File 1 can be accessed at http://www.census.gov/Press-Release/www/2001/sumfile1.html.

housing units at the basic street address, all of the following variables were defined at the tabulation block level. Furthermore, all proportions were transformed using the arcsine transformation and all total counts were transformed using a square root transformation.

The proportion of city-style addresses is the number of housing units in the tabulation block with city-style addresses on the MAF divided by the total number of housing units in the block. Housing units can have a city-style address, a rural address, a post office box, or a location description. The proportion of DSF addresses is the proportion of addresses on the unenhanced MAF that matched to the DSF. The growth of the block since Census 2000 is the square root of the difference between enhanced MAF count and Census 2000 count. The number of housing units at the basic street address was defined for every housing unit based on address information on the MAF. The total Census 2000 housing unit count was obtained from Summary File 1. This count has been included as an transformed count and as a count with the square root transformation. This is equivalent to including the variable and it's square. The proportion of Locatable Address Conversion System (LACS) matches is the proportion of housing units in the block that matched to the LACS files. As part of broadening the emergency 911 phone system, non city-style addresses are being converted to city-style addresses in some areas. The LACS file is designed to contain the link from all non city-style to city-style addresses in the nation. Thus, the percent of addresses on the LACS File is a proxy for areas that are undergoing addresses conversion due to emergency 911 updating. Lastly, the Census 2000 total population count at the tabulation block level came from Summary File 1. I am controlling for many of these variables because either Census 2000 evaluations or Kennel and Corlett [2005] found them to be related to coverage errors.

The overcoverage model includes the same variables I used for the undercoverage model with the addition of one housing unit level variable on the MAF: the unenhanced DSF status. The DSF status is a categorical variable indicating if the address was classified as a residential unit, nonresidential unit, uncertain, or not on the DSF.

2.5 Weights

Because the CPS/SCHIP sample design is a complex stratified multi-stage probability sample, housing units needed to be weighted to reflect their different probabilities of selection. Unfortunately, block selection is not one of the stages in the CPS/SCHIP design. Thus, probabilities of selection could only be calculated for counties and measures. Furthermore, only sampled housing units were assigned base weights. For this reason, I faced challenges when assigning weights to all listed units.

The method I used results in weights for each block that are proportional to the estimated size of the block, which is consistent with the CPS/SCHIP sampling methodology. Furthermore, it is not too far from the weighting described by Ott *et al*[1997].

Ott *et al*[1997] estimated the block weight by dividing the sampling interval by the estimated number of housing units in the combined block. Since CPS/SCHIP can select multiple measures in each block, I divided the sampling interval by the estimated number of housing units in the combined block and then multiplied by the number of estimated sample units in the block. That is, the base weights are:

$$\text{Weights} = \left(\frac{N_h}{n_{\alpha h}}\right) * \left(\frac{n_{\alpha h}}{\text{Mos}_{h\alpha}}\right) = \frac{N_h}{\text{Mos}_{h\alpha}}$$

where

$n_{\alpha h}$ is sample size in the α^{th} combined block within the h^{th} stratum,

$Mos_{\alpha h}$ is estimated size of the α^{th} combined block within the h^{th} stratum, and

N_h is estimated size of the h^{th} stratum.

For the CPS/SCHIP, $\left(\frac{N_h}{n_h}\right)$ represents the unconditional sampling interval and also the base weight.

2.6 Standard Errors

Because the CPS/SCHIP select one primary sampling unit in each strata for the non-self representing strata, direct estimates of sampling errors for the model coefficients cannot be computed. The methodology for calculating sampling errors for the CPS/SCHIP is complex and would require excessive processing time for this project. Therefore, I simplified the standard error computation by treating the state as the strata and each county as a cluster. Then, I computed standard errors using the delete a group jackknife. I used SUDAAN to estimate the logistic models and the standard errors.

3. Results

3.1 Descriptive Statistics

The undercoverage universe contains 144,477 housing units in 2,523 combined blocks. These combined blocks are in 669 counties and represent 15,138,000 (s.e 55,000) housing units on the enhanced MAF.

The overcoverage universe contains 142,344 housing units in 2,544 combined blocks. These combined blocks are in 684 counties and represent 13,938,000 (s.e 50,000) housing units on the unenhanced MAF.

Most of the sample is in rural areas. In fact, an estimated 17.0 (s.e. 1.4) percent of the undercoverage universe is in urban areas. Furthermore, because the Northeast is largely urban, most of the area frame blocks are in the other three regions. The undercoverage universe is distributed across the four Census regions as follows:

- 23.2% (s.e. 1.6) Midwest,
- 10.4% (s.e. 1.2) Northeast,
- 55.9% (s.e. 1.8) South, and
- 10.5% (s.e. 0.8) West.

Furthermore, the gross undercoverage rate is 12.64% (s.e. 0.59) for the MAF in area frame blocks. Undercoverage can be decomposed into omissions and erroneous exclusions. Housing units in area frame blocks are missing from the MAF at a rate of 9.29% (s.e. 0.50) and they are erroneously excluded at a rate of 3.35% (s.e 0.17). The gross overcoverage rate is 13.97% (s.e. 0.47) for the MAF in area frame blocks. Of course, these coverage rates are only for area frame blocks, which tend to be rural and have many non city-style addresses. These gross coverage rates are not indicative of overall MAF coverage and only represent coverage for approximately 12% of all housing units on the MAF.

3.2 Models Fit

Table 1 shows the results of the two logistic regressions I fit using SUDAAN. I also fit the same models using SAS. SAS calculated the coefficient of concordance as 0.673 for the undercoverage model and 0.698 for the overcoverage model. The coefficient of concordance measures how often the model predicts the observed value. A value of 0.5 can be achieved with a model that only includes an intercept. Of course a value of 1.0 indicates that the model fits the data 100% of the time. The variables in my model are better than a model with only an intercept, but they are still far from 1.0.

Furthermore, the adjusted R square value using the Cox & Snell methodology for the undercoverage model is 0.09 and for the overcoverage model is 0.06. These values indicate poor fit.

Nevertheless, despite these measures, the approximate chi-square statistic from the log likelihood is highly significant for both models at the 0.001 level. Thus, we can conclude that the coefficients are not all simultaneously zero. Indeed, the models show there are many coefficients significantly different from zero.

3.3 Coefficients

For both models, I estimated the probability of an error; thus positive coefficients tend to increase undercoverage or overcoverage. Because the control and key variables have been transformed, they cannot be interpreted without back transforming them. Since the focus of this paper is to explore what significant effects exist and their direction rather than exact coefficient estimates, I am not concerned with back transforming the variables.

The reference group for the undercoverage model is for mobile homes in urban permit issuing blocks in the West. And the reference group for the overcoverage model are units on the MAF that matched to the DSF but the mail delivery point could not be distinguished between residential and commercial in urban permit issuing areas in the West.

4. Discussion

4.1 Model Fit

As seen from the fit statistics, both models do not have strong predictive power. In this section, I will highlight several possible reasons for the lack of fit.

The model might be misspecified. The lack of interaction terms, spatial variables such as the proximity to a block boundary, and housing unit level variables may be responsible to the poor fit. Moreover, the logistic regression model makes use of the logit-log link, which might not capture the underlying hierarchical relationships. Indeed, the model might not capture the hierarchical nature of the data. Since many of the independent variables are aggregates at the tabulation block level, they do not capture the within block variation at all. Furthermore, modeling from a design based perspective has likely overestimated the coefficient standard errors.

In addition to model misspecification, there are also a number of data problems, which may decrease the fit. The presence of outliers, multicollinearity, and highly variable weights might increase the standard errors considerably from a design based framework.

Certainly there are many opportunities for future work and improvement.

4.2 Coefficients

Given the lack of model fit, it is difficult to make conclusions about the coefficients. However, there are still a few trends worth noting.

For the most part, the control variables are all in the direction supported by previous studies. The undercoverage of mobile homes is well established. It is also known that coverage is better in areas with city-style addresses and in low growth areas when looking at both undercvoerage and overcoverage. Since the DSF is a major source of new addresses on the MAF in the years between censuses, it is easily seen that undercoverage will be smaller for blocks with a high percent of DSF matches. The LACS variable

measures the percent of addresses that are converting between city-style and non city-style. Because of the many changes in blocks with lots of addresses conversions and the difficult matching between city-style and non city-style addresses, it is reasonable to believe that such areas have undercoverage and overcoverage problems.

4.3Conclusion

Using regression, I investigated if nine housing and demographic variables were associated with undercoverage and overcoverage after controlling for a number of geographic and address characteristics.

This project looked at nine variables associated with undercoverage and overcoverage on the Census Bureau's Master Address File for area frame blocks. It focused on the significance and direction of demographic and housing variables on undercoverage and overcoverage. I fit models that tested variables drawn from previous research, but the models did not fit the data very well as seen by the small coefficients of determination. Certainly more work is needed to specify models that fit the data.

To get a more complete picture of coverage and better target areas with coverage problems on the MAF, it would be wise to broaden the scope of this project to evaluate the entire MAF in all four frames. Since this research only looked at the area frame, it only represents about 12% of all addresses on the MAF. For a full picture of errors, a future comparison of the MAF to all four current surveys' frames would be necessary. Furthermore, it would be informative to run the sample units on the unenhanced MAF through the weighting, calibration, and estimation systems to further investigate the impact of undercoverage on the CPS estimates of unemployment.

In conclusion, more work is needed to help build the Current Survey's sampling frame at the Census Bureau. Indeed, there are many questions yet to be answered.

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Table 1: Logistic regression coefficients for undercoverage and overcoverage

Coefficient	Undercoverage	Overcoverage
Intercept	0.505*	-0.245
Control Variables		
DSF Status		
Not on DSF		-1.119**
Residential		-1.226**
Commercial		0.071
Unknown		
Permit Status		
Not Permit Issuing	0.114	0.131
Permit Issuing		
Region		
Midwest	-0.410**	0.179
Northeast	-0.376**	0.028
South	-0.154	0.389**
West		
Type of Housing Unit		
Not a Mobile Home	-0.900**	
Mobile Home		
Urban/Rural		
Rural	0.031	-0.159
Urban		
City Style	-0.196**	-0.586**
DSF Matches	-0.258**	-0.063
Growth	0.267**	0.070**
Housing Units at BSA	-0.013**	0.005**
Housing Unit Count	-0.137**	0.054**
Housing Unit Count^2	0.002**	-0.003**
LACS Matches	0.090**	0.078**
Population	0.010	0.022
Variables of Interest		
White	-0.032	0.081
Black	-0.085	0.080
Multiple Races	-0.025	-0.060
Hispanic	0.089	0.214**
Age	-0.009**	-0.012**
Male	0.111	0.283
Rented	-0.029	0.111
Occupied	-0.017	-0.060
Household Size	-0.190**	-0.079

* Indicates significant at the 0.10 level
** Indicates significant at the 0.05 level.