ANALYSIS OF NONRESPONSE IN CROSS-SECTIONAL RDD SURVEYS

Randal ZuWallack, Leslyn Hall, Ronaldo Iachan
ORC Macro, 126 College Street, Burlington, VT 05401

Keywords: Response Propensity, Auxiliary Data, Bias

Introduction

In recent years, response rates to telephone surveys have been consistently declining. This industry-wide trend is due to a variety of factors including the increasing use of telecommunications barriers such as privacy managers, answering machines, caller ID, etc. In many areas of the country, these features are fast becoming part of the standard service package. Although 'do-not-call' lists and much of the Telephone Consumer Protection Act (TCPA) do not apply to survey research, increased public awareness of this legislation has negatively impacted survey cooperation and response rates. The general public may not differentiate between types of unsolicited calls—no matter how noble the intentions. The increasing use of cell phones and telephone number portability have also hurt telephone surveys; it is not legal to knowingly and/or without permission survey individuals on their cell phones. Furthermore, population expansion and cell phone popularity have resulted in the rapid expansion of telephone exchanges, particularly mixed use exchanges, and working banks. As a result, telephone sampling frames are increasingly inefficient and response rates suffer as a result of more telephone numbers where eligibility cannot be determined. While the telephone survey industry is constantly experimenting with methods to counter these trends, there is also the need to understand the data quality implications of telephone research in its current state.

Response rates are often used as quality measures for survey data. The U.S. Department of Housing and Urban Development (HUD) has been very proactive in researching ways to improve response rates for their Fair Market Rent (FMR) surveys. HUD has experimented with question wording, question order, sending advance letters, leaving answering machine messages, Internet options, and so forth. Some of these initiatives resulted in slight response rate increases. Improving telephone survey response rates in an environment where legislation, technology, and demographic changes are all working to decrease them is a struggle. HUD commissioned ORC Macro to evaluate nonresponse in FMR surveys.[1]

Background: The Fair Market Rent Program

To comply with Section 8 of the United States Housing Act of 1937, HUD conducts an annual assessment of rental housing markets to establish FMRs. The ultimate goal is to ensure decent, safe and sanitary housing and living environments for all Americans. As part of this mission, HUD provides assistance to hundreds of thousands of individuals and families each year in the form of rent certificates and vouchers. FMRs are the national payment standard for assisted rental housing units. Their intent is to represent the market cost of privately owned, decent, safe, sanitary rental housing. The current measure is the 40^{th} or 50^{th} percentile gross market rent (i.e., shelter rent plus the cost of all tenant-paid utilities) for eligible units. The objective of these measures is to establish a standard that is high enough to allow sufficient housing choice, yet low enough to serve as many families as possible.[2] Accuracy is critical--billions of dollars in annual subsidies are tied to FMR standards.

HUD uses multiple data sources to establish FMR base year standards including: the decennial census; The American Housing Survey[3], and the FMR Area surveys. The FMR Area surveys are random digit dial (RDD) computer assisted telephone interview (CATI) surveys commissioned by HUD to measure rent for selected metropolitan areas or nonmetropolitan counties.

ORC Macro has conducted the Areas surveys since their inception in the FMR program in 1992. The purpose of the Area survey is to establish a point-in-time estimate of the 40^{th} and 50^{th} percentile contract rent value for relatively small geographic areas defined as metropolitan statistical areas (MSA), primary metropolitan statistical areas (PMSA), or clusters of counties. The survey is a random digit dial (RDD) computer

[1] A second paper, *Assessing Nonresponse Bias in Telephone Surveys*, also reports on the evaluation.

[2] Federal Register, Vol 68, No. 190, Wednesday, October 1, 2003, pp. 56704-56707.

[3] The American Housing Survey is a Census Bureau survey commissioned by HUD to measure rent for selected large metropolitan areas.

assisted telephone survey (CATI) administered over a short period of time.

Nonresponse Approach

Survey nonresponse is a difficult topic to address, primarily since little is known about the nonrespondents. Generally, nonresponse is evaluated using two approaches. One approach targets individual nonresponding units directly. This micro-level method provides information concerning the nonrespondents, but is costly, typically involving personal follow-up visits or re-interview surveys to establish patterns of nonresponse. Another less costly approach is to compare the sample distributions to known demographic, socioeconomic, and geographic distributions. Assuming a sample is representative of the population from which it is selected, deviations from the population distributions may be attributed to differential nonresponse. While inexpensive, this macro-level approach evaluates unit nonresponse for large domains. Patterns of nonresponse may be lost in the expanse of the measures.

In the FMR surveys, traditional means of evaluating nonresponse are problematic for a number of factors. First, the sampling unit for the FMR surveys is "occupied housing units" rather than an individual; it is not intuitive to think of the characteristics of "nonresponding housing units" in the way it is to consider nonresponding individuals. Different people can move in and out of the same housing unit; one might choose to participate in the survey and another might not and yet the characteristics of the residence important to HUD would remain unchanged. Further, people living in the same household may differ in their likelihood to respond, and yet both would be potentially eligible respondents. Second, the Area survey questionnaire is streamlined, asking only survey eligibility and rent related questions. The questionnaires do not include the demographic and socioeconomic questions typically used in evaluating nonresponse of individuals; because these variables are not relevant to the purpose of the survey. So not only do we know little about the nonresponding units, we know little more about the responding units. Compounding the situation are the narrow eligibility criteria for the survey. Eligible units include only non-public housing, two-bedroom non-seasonal rentals where the tenant does not perform work for the landlord and the landlord is not a relative of the tenant. Refusals typically occur at the screening stage before establishing survey eligibility.

Given the limitations in the data available to us, and our budget, neither of the two traditional approaches towards nonresponse analysis was feasible. Therefore, we turned to a more creative approach. We used the only piece of information that we undoubtedly know in an RDD survey, the telephone number. Obviously, the telephone number tells us nothing about the respondents and nonrespondents directly, but we can map the telephone number to a geographic location (within a tolerable error,) such as a census tract. Once mapped, a world of external population data as measured in the 2000 Decennial Census is available for comparisons with the FMR data. This approach has two clear benefits in evaluating nonresponse for the FMR surveys: 1) we strike a cost-effective balance between a micro- and macro-level evaluation; and 2) we gain neighborhood level insight for both respondents and nonrespondents. Instead of evaluating nonresponse based on personal characteristics, we are evaluating nonresponse in terms of neighborhood characteristics.

Initial Assessment

As a first step in the evaluation, it was necessary to establish whether the FMR gross rent estimates are impacted by nonresponse or other potential bias-inducing survey errors. In other words, before evaluating if and where we see patterns of nonresponse, we first want to know if FMR rent estimates are biased, and if so, to what extent.

The bias of an estimate is defined as the difference between the estimate and the true value. In lieu of the true value, we need to rely on a target, or "gold standard" to use as a proxy for the true value in our comparisons; we used the Census 2000 as our measure, or target, and compared these values to the Areas 2000 FMR data. The Census Bureau does not publish median gross rent for two bedroom rental units, but they do publish a gross rent frequency distribution for two bedroom rentals. Therefore, we took the following two approaches in comparing the two sources of rent data:

1) Use linear interpolation to estimate the target (Census 2000) median and construct bias estimates by subtracting HUD gross rent estimates from the target rent estimates; and
2) Compare the frequency distributions between the HUD surveys and Census 2000 using goodness of fit tests.

As seen in Figure 2, there are areas where the HUD Area survey gross rents tend to be higher than the Census 2000 estimates. Generally, the differences are larger when estimating the 40th percentile. Across all areas, the 40th percentile estimates average about $28 higher than the corresponding census estimate and the 50th runs about $10 higher. These values are about 5.0 percent and 1.5 percent higher than census values for 40th and 50th percentile, respectively. The relative differences range from -10.0 percent to 15.0 percent for the 40th percentile and -14.7 percent to 11.5 percent for the 50th percentile. Of the 53 areas studied, 41 (33 significant) 40th percentile biases were positive (overestimates) and 12 (4 significant) negative. For the 50th percentile, 33 (22 significant) differences were positive and 20 (10 significant) negative. (Refer to Table 1 for summary statistics.)

The chi-squared tests substantiate the tendency for HUD to estimate rents higher relative to Census. Comparing the HUD gross rent distribution to the Census 2000 distribution results in test statistics significant for all areas except two (p-values equal to 0.0930 and 0.0966.) Both of these cases were not significant in the percentile difference testing. Typically, we see a shortage of low gross rents ($0-300) respondents relative to the census tend to be over represented from Middle gross rent ($500-750). In the negative 40th percentile bias areas, there tends to be under representation from higher rent ($750-1000 or $1000+) respondents and over representation from the middle rent categories. Often with the non-significant 40th percentile bias areas, the under representation in lower income categories is balanced with under representation in the higher income categories.

This analysis indicates that there is potentially some difference between the HUD estimates and census estimates, but the difference may not be attributable to nonsampling or survey errors, but rather a different measurement scope. The FMR surveys target two-bedroom apartments that are not run by a Public Housing Authority (PHA): these units are screened out of the survey. On the other hand, the Census estimates include PHA units. In addition, HUD and Census calculate gross rents differently. The Census calculates gross rent by adding tenant estimates of utility costs to contract rents. HUD uses local PHA utility schedules rather than tenant supplied utility cost data to the contract rent. These differences in scope and measurement may account for some of the differences between HUD and Census estimates.

Nonresponse Assessment

Having established that there is potentially some amount of bias to the estimates produced for the 2000 Area surveys, we then decided to focus the assessment on comparisons of nonresponse across different covariate classes and the development of response propensity models. These models express the probability of a unit responding as a function of characteristics, or predictors, that are potentially related to the propensity to respond. This analysis not only advances the understanding of possible bias sources and components, but also supports the development of methods to compensate and adjust for this bias.

To identify eligibility for the HUD surveys, the questionnaire starts with multiple screening questions, with only eligible cases continuing the interview. When a potential survey respondent cannot be reached, or does not answer the screening questions, eligibility is undetermined, or unknown. Attempts to reach respondents by telephone can have many different outcomes; the call history of any record indicates numerous specific outcomes, but for analyzing nonresponse, we summarize them as follows:

- *Complete interview.* The phone number is eligible for the survey and an interview was completed.
- *Known ineligible*. The phone number is determined to be ineligible for the survey.
- *Unknown eligibility*. Eligibility for the survey is not determined due to such things as refusals, hang-ups, or non-contacts.

For this analysis, we focus on unknown eligibility, as these are the nonresponding, or unresolved units. The probability of unknown eligibility is the probability that we do not confirm eligibility status.

Using logistic regression, we modeled $E(y|\underline{x}) = Pr(y=1|\underline{x})$, where the outcome variable y is defined as 1 if the case has unknown eligibility and 0 if the case has known eligibility. The independent variables for the model were derived from Census 2000 tract statistics. These tract statistics describe the location where both respondents and nonrespondents reside. Information we used to describe the tract includes distributions or statistics for the following:

- Density/urbancity
- Educational attainment
- Years at residence
- Foreign-born

- Household income
- Rent
- Commute times
- Race/origin/tenure
- Units in structure/year built
- Work status (full, part, unemployed)
- Telephone service available
- Household type (size, children, etc.)
- Language other than English at home

To aid variable selection, we formed quartiles for all potential tract level covariates. Using the quartile mean comparisons as a guide, we introduced variables into the model keeping only those with effects significant at the 1 percent error level. We included interactions in the model for variable combinations that we perceived to be correlated, such as percentage foreign born and percentage speaking a language other than English at home. The model is presented in Table 2.

As seen in Table 3, the model appears to perform adequately in discriminating between various levels of likelihood. For example in the 1st decile, or the ten percent of cases with the lowest unknown status probability, the average probability measure is 0.1977. The actual proportion of completes for these cases is 0.1943. Similarly for the 10th decile, the predicted probability average is 0.4490 and the actual proportion is 0.4388. An interesting result is the tendency of rents to increase as the likelihood of getting an unresolved status increases. The final column in the table is the median value of the tract level median census gross rent for each decile. Median rents increase as unknown status probabilities increase, $399.00 in the 1st decile to $797.00 in the 10th decile.

The resulting model is quite complex with many angles for analysis. Being in the survey operations business, we were interested in examining factors that we could control -- such as what are the impacts of interviewing in non-English languages, such as Spanish. The HUD FMR surveys are always conducted in both English and Spanish at a minimum, and other languages when the need is identified. A positive answer to this question would indicate the potential cost effectiveness and benefits of interviewing in additional languages more frequently than had been in the past. A negative answer to this question would indicate that the increased cost of planning and conducting non-English interviews would not be justified given the limited impact on overall response.

With several confounding variables that may help assess the impact of Spanish interviewing, we approached the question from two angles. First, we examined the estimated odds ratio for a 5% increase in the percentage of foreign-born population in the tract. We examine the estimated odds for three levels of the proportion speaking a language other than English in the home (0.00, 0.25, 0.50). In addition, we evaluated the odds for three race and Hispanic origin scenarios:

- Low Hispanic and low white population (0% Hispanic and 0% white)
- Low Hispanic and high white population (0% Hispanic and 90% white)
- High Hispanic and low white population (75% Hispanic and 0% white)

As seen in Figure 2, the model suggests a slight increase in the likelihood of unresolved status in areas of high Hispanic and low white as well as in areas of low Hispanic and high white populations. On the other hand, the likelihood decreases in areas of low Hispanic and low white populations. For all three scenarios, the increase seems to tail down for the higher proportions of population speaking a language other than English at home.

For a second angle, we looked at the estimated odds ratio for a 10% increase in the percentage of population speaking a language other than English at home in the tract. Again, we examine the estimated odds for a couple levels of the proportion foreign-born population (0.10, 0.25). In addition, we evaluated the odds for five race and Hispanic origin scenarios:

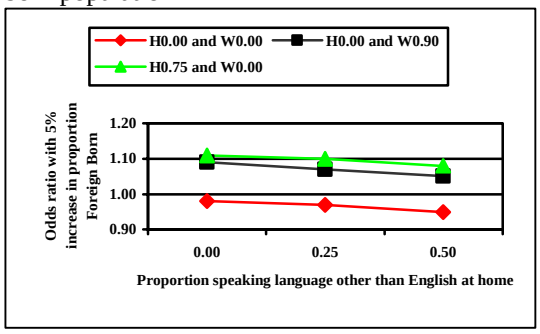
- Low Hispanic and low Asian population (0% Hispanic and 0% Asian)
- Medium Hispanic and low Asian population (25% Hispanic and 0% Asian)
- High Hispanic and low Asian population (75% Hispanic and 0% Asian)
- Low Hispanic and medium Asian population (0% Hispanic and 25% Asian)
- Low Hispanic and high Asian population (0% Hispanic and 75% Asian)

Referring to Figure 2, the model indicates a decrease in the likelihood of unresolved status in four out of five race and Hispanic origin scenarios. The exception is areas of low Hispanic and high Asian population, where we see a 10-12% increase in the likelihood of unresolved status. In contrast, the model reports a 10-11% decrease in the likelihood in areas of high Hispanic and low Asian.

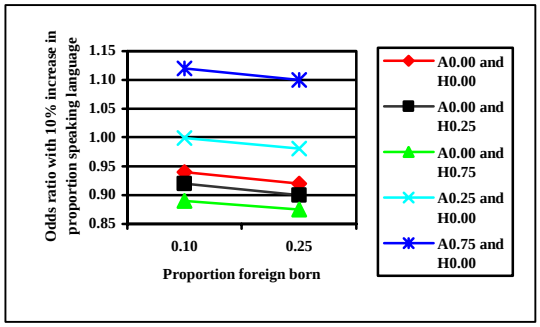
The second result speaks strongest in support of Spanish interviewing. This result suggests that in areas of high Hispanic population,

the likelihood of unresolved status decreases as the proportion of population speaking a language other than English in the home increases. There are likely other factors so this result in itself does not suggest that the decrease in likelihood is a result of Spanish interviewing. However, strengthening the argument is the contrasting result in high Asian areas.

Figure 2. Estimated Odds of Unresolved Status
(a) For a 5% increase in the proportion foreign born population



(b) For a 10% increase in the proportion of the population speaking a language other than English in the home.



Conclusions and future work

Analysis of nonresponse in the HUD FMR Area-specific surveys proved challenging. Analyzing nonresponse with respect to area composition variables seems promising in that areas fitting a certain profile can be evaluated. The results of these evaluations may lead to further analysis and possibly program initiatives that alleviate the underlying reasons for high nonresponse. At a minimum, these results would seem to indicate the possible benefits of interviewing in other non-English languages, particularly Asian, and the need for more research into this subject.

For the model developed for the HUD FMR, we found that there were many effects, yet most were very subtle. Ultimately, by exploring additional data sources or introducing the current model variables in an alternative form, we hope for a more parsimonious model, easing interpretation and isolating the key model effects. There is a bounty of information as a result of the survey operations such as interviewer data (experience, socio-demographics, shift length, etc.) and call history data. However, harnessing this data into model usable form is a challenge. These case-level variables coupled with the area-level variables will likely strengthen the model and provide additional insights to understanding nonresponse. Operational information as related to nonresponse provides supporting data for maintaining current procedures or initiating changes.

For future modeling endeavors, we will explore splitting and separately modeling (or jointly modeling) types of unresolved status. For instance areas with high noncontacts may differ from areas with high refusals. Currently refusals and noncontacts are combined as unresolved cases, blurring the differences between the two. For instance, refusals may be dependent on variables such as interviewer experience and shift length, but noncontacts are likely not.

Acknowledgements

The research for this paper was funded in part by the Department of Housing and Urban Development. The authors would like to thank the Office of Policy Development in the Economic Market Analysis Division of HUD. We would also like to thank Joe Riley (Director, Office of Policy Development) for sharing his insight to the FMR program and his comments on this paper.

References

Federal Register, Vol 68, No. 190, Wednesday, October 1, 2003, pp. 56704-56707.

Groves, Robert M., and Mick P. Couper, (1995) "Theoretical Motivation for Post-Survey Nonresponse Adjustment in Household Surveys," *Journal of Official Statistics*, Vol. 11. No. 1, pp.93-106.

Woodruff, Ralph S., (1952) "Confidence Intervals for Medians and Other Position Measures," *Journal of the American Statistical Association*, Volume 47, Issue 47, pp. 635-646

ZuWallack, Randal, Ronaldo Iachan, and Leslyn Hall. (2004) "Assessing Nonresponse Bias in Telephone Surveys," *Proceedings of Survey Research Methods Section, American Statistical Association*, Alexandria, VA, American Statistical Association, to appear.

Table 1. 2000 HUD Areas survey: Summary of 40th and 50th bias estimates

Percentile	Estimate	Mean	Median	Minimum	Maximum	Mean sq bias
40th	Bias	28.22	33.75	-47.19	98.86	1948.07
	Relative bias	0.0498	0.0591	-0.1004	0.1505	0.0060
50th	Bias	9.97	17.02	-66.71	93.52	1339.68
	Relative bias	0.0148	0.0277	-0.1467	0.1154	0.0035

Table 2. Estimated Unknown Eligibility Model Parameters

Parameter	**Est**	**St Err**	**Parameter**	**Est**	**St Err**
Intercept	-0.5875	0.0381	Prop employed full time, low (1st quartile)	0.2396	0.0257
Census Region (compared to Northeast)			Prop of multi-structure units, mid-high (3rd or 4th quartile)	-0.0593	0.00982
West	-0.4474	0.0116	Median years at residence, high (4th quartile)	0.6431	0.0699
South	-0.4524	0.00972	Vacancy rate * Prop of multi-structure units, mid-high	0.5361	0.0616
Midwest	-0.3726	0.00909	Prop foreign born* Prop Hispanic	3.4000	0.3477
Population density	0.000072	3.575E-6	Population density * Median gross rent	-4.14E-8	2.927E-9
Vacancy rate	0.3428	0.0536	Population density * Prop of renter occupied housing units, mid-high	-0.00004	3.082E-6
Median gross rent	0.000365	0.000020	Population density * Prop of renter occupied housing units, high	-0.00003	2.775E-6
Prop foreign born	-0.3915	0.2374	Median gross rent * Prop of renter occupied housing units, mid-high	-0.00010	0.000028
Prop non-Hispanic White race	-0.2242	0.0216	Median gross rent * Prop of renter occupied housing units, high	0.000210	0.000041
Prop Hispanic	0.1618	0.1018	Prop of married family hhs, mid-high * Prop of single parent family hhs, low	0.0995	0.0178
Prop non-Hispanic Asian race	-0.8041	0.1830	Prop of married family hhs, mid-high * Prop of married family hhs with own children 0-18	-0.5752	0.0382
Prop graduate or professional degree	-1.3355	0.1357	Prop of married family hhs, mid-high * Prop of family hhs with own child 0-18, high	0.1261	0.0158
Median household income	-1.09E-6	3.354E-7	Prop associate or college degree, low * Prop graduate or professional degree, mid-low	0.3087	0.0230
Prop speaking language other than English	-0.4671	0.1287	Prop associate or college degree, mid-low * Prop graduate or prof degree, mid-low	0.0575	0.0163
Median commute	0.000501	0.00107	Prop graduate or professional degree* Prop associate or college degree, low	3.9977	0.5771
Median age, high (4th quartile)	0.1162	0.00711	Prop unemployed, low-mid * Prop employed full time, low	0.0898	0.0137
Prop of family households, low (1st quartile)	-0.3052	0.0235	Prop associate or college degree, low * Prop unemployed, low-mid	0.0901	0.0140
Prop of married couple family households, mid-high (3rd quartile)	-0.0924	0.00744	Prop associate or college degree, low * Prop employed full time, low	-0.1823	0.0157
Prop of single parent family households, low (1st quartile)	-0.0589	0.00899	Prop associate or college degree, mid-low * Prop employed full time, low	-0.1083	0.0156
Prop of married couple family hhs with own children 0-18, low (1st quartile)	-0.0311	0.0104	Prop graduate or professional degree* Prop graduate or professional degree, mid-low	-4.9505	0.5164
Prop of family households with own children 0-18, high (4th quartile)	0.00943	0.00952	Prop living in same location in 1995, mid-high * Median years at residence, high	-0.7322	0.0699
Prop of renter occupied housing units, mid-high (3rd quartile)	0.1803	0.0195	Median household income * Prop of family households, low	5.424E-6	5.08E-7

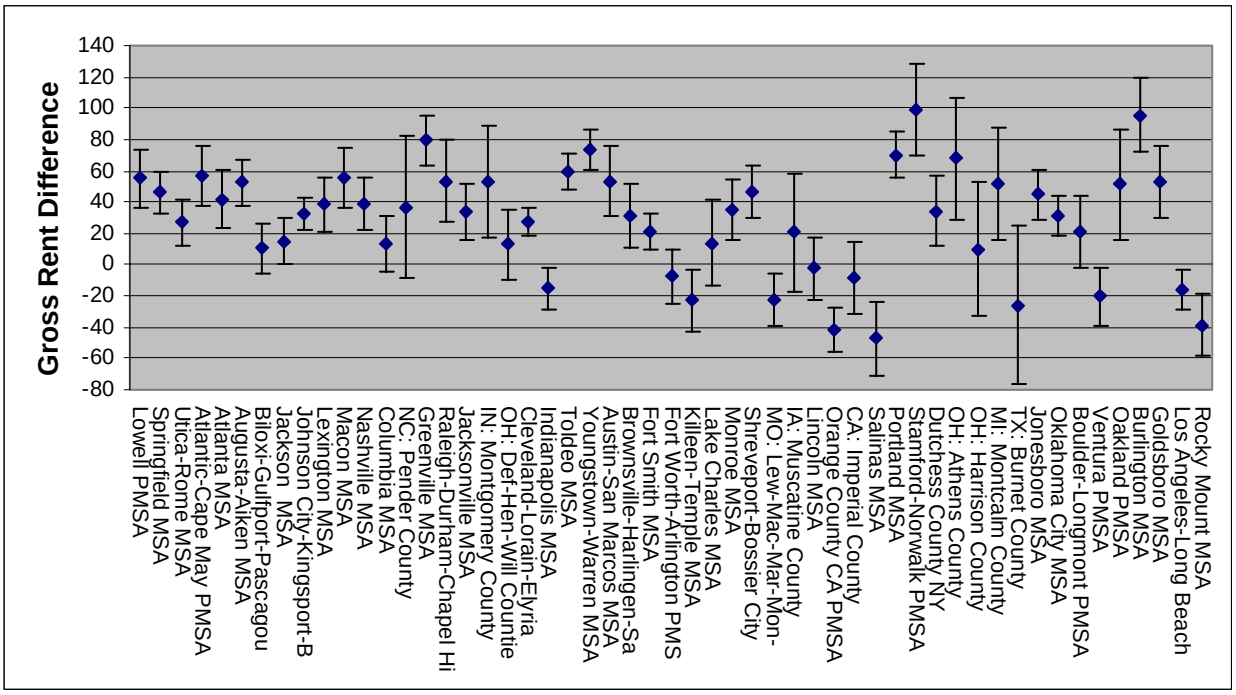
Parameter	**Est**	**St Err**	**Parameter**	**Est**	**St Err**
Prop of renter occupied housing units, high (4th quartile)	-0.1456	0.0311	Median commute * Median commute, high	0.00732	0.00248
Mean renter occupied household size, low-mid (1st or 2nd quartile)	0.1371	0.00719	Median commute * Prop employed full time, low	-0.00961	0.00112
Prop living in same location in 1995, mid-high (3rd or 4th quartile)	-0.1160	0.00690	Prop graduate or professional degree* Median commute	0.0527	0.00599
Prop associate or college degree, low (1st quartile)	-0.2278	0.0198	Prop foreign born * Prop speaking language other than English	-1.2478	0.3414
Prop associate or college degree, mid-low (2nd quartile)	0.0165	0.0107	pasian* Prop speaking language other than English	2.3408	0.3728
Prop graduate or professional degree, mid-low (2nd quartile)	0.1915	0.0337	phisp* Prop speaking language other than English	-0.7446	0.1527
Median commute, high (4th quartile)	-0.1748	0.0772	Prop foreign born * Prop non-Hispanic White race	2.2655	0.2353
Prop unemployed, low-mid (1st or 2nd quartile)	0.0513	0.00704			

Table 3. Deciles of probability of unknown eligibility status

	Phone numbers	Proportion unknown eligibility	Mean probability estimate	Maximum probability estimate	Minimum probability estimate	Median Census rent
Total	862840	0.3135	0.3135	0.1521	0.6023	$555.00
1st decile	86299	0.1943	0.1977	0.1521	0.2334	$399.00
2nd decile	86745	0.2364	0.2463	0.2334	0.2579	$450.00
3rd decile	85999	0.2701	0.2669	0.2579	0.2770	$486.00
4th decile	87300	0.2992	0.2869	0.2770	0.2954	$522.00
5th decile	85375	0.3057	0.3039	0.2954	0.3115	$526.00
6th decile	85992	0.3244	0.3182	0.3115	0.3265	$639.00
7th decile	86452	0.3412	0.3341	0.3265	0.3397	$632.00
8th decile	86681	0.3408	0.3530	0.3397	0.36584	$738.00
9th decile	85723	0.3852	0.3802	0.3658	0.3973	$714.00
10th decile	86274	0.4388	0.4490	0.3973	0.6023	$849.00

Figure 2. Difference Between HUD and Census 2000

. (a) 40th Percentile Gross Rent



(b). Median Gross Rent Difference