

Undeliverable-as-Addressed Mail Research for Vacant and Nonexistent Housing Unit Identification¹

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Abstract

Preparing for the 2020 Census, the U.S. Census Bureau is researching the use of Undeliverable-as-Addressed (UAA) mail from the United States Postal Service in the prediction of vacant and nonexistent housing units in the Nonresponse Followup universe. This is part of an effort to reduce the cost of the 2020 Census while maintaining data quality. For the majority of addresses, the Census Bureau sends multiple mail pieces to encourage response, such as an advance letter and internet invitation postcard. When these mailings are returned as UAA, the specific reason assigned by the postal carrier provides useful information about the status of the address. In this paper, we look at the role of UAA by considering patterns and consistencies in the assignment of UAA reasons. We discuss possible techniques for accounting for inconsistencies in UAA assignments across mailings such as including Cohen's kappa coefficient for agreement as a covariate for modeling housing unit status. This paper also considers changes in the national UAA assignment rate over time and its implications for our rate of vacancy assignment.

Key words: 2020 Census; Administrative Records; Undeliverable-as-Addressed Mail; Address Based Sampling

1. Introduction

The U.S. Census Bureau is researching and testing new methods to reduce the cost of the 2020 Census while maintaining data quality. One of the costliest components of the 2010 Census was Nonresponse Followup (NRFU). In this operation, enumerators conducted in-person interviews at addresses that did not return a census questionnaire by mail. In 2010, 50 million addresses fell into the NRFU universe, and received at least one visit from an enumerator (Walker et al., 2012). Current research aims at reducing the NRFU workload by using Administrative Records (AR) to assign a housing unit status to a portion of the NRFU universe (Morris et. al., 2015, Mule and Keller, 2014). If a housing unit is determined to be occupied, AR are used to enumerate the persons in the household as well as assign them characteristics. If a housing unit is determined to be vacant, the address is removed from the NRFU workload and assigned a vacant status. Similarly, if a housing unit is determined to be nonexistent, the address is removed from the NRFU workload and assigned a nonexistent status. (U.S. Census Bureau, 2017)

¹ This paper is released to inform interested parties of research and to encourage discussion. The views expressed are those of the author and not necessarily those of the U.S. Census Bureau.

In 2010, the Census Bureau sent three rounds of mail to all addresses that it believed to be housing units in its Mail-Out/Mail-Back (MOMB) universe. The United States Postal Service (USPS) marked any mail it could not deliver with an Undeliverable-as-Addressed (UAA) code. Examples of undeliverable reasons include vacant, refused, and no such number. This information was also collected for mailings for the 2015 National Content Test (NCT) as well as the 2014, 2015, and 2016 Census Tests. Through the Census Bureau’s AR Modeling Team research for each of these tests as well as for the 2010 Census, we have found that one of the strongest predictors of both vacant and nonexistent housing units is the presence of a UAA code for an address. Thus, this paper seeks to explain what UAA mail is as well as trends in its national distribution, and how to account for any inconsistencies of its assignment in our AR modeling. The paper also investigates the relationship between UAA mail from the 2010 Census and subsequent census tests, and national vacancy rates, as estimated by the National Housing Unit Survey.

2. Data

2.1 Undeliverable-as-Addressed Data

The UAA data used in this research are considered in two ways: at the reason level, and at a group level. In 2010, there were 15 UAA reasons that could be associated with a mailing. In 2015, there were 12 UAA reasons that could be associated with a mailing. For some of the analysis that follows, we group together UAA reasons that may be associated with each other. The specific reasons and associated analysis groups are shown in the following table.

Table 1: UAA Analysis Groups and Corresponding Reasons

Analysis Group (Census-created)	UAA Reason (USPS-assigned)
Attempted - Not Known (ANK)	Attempted - Not Known
Nonexistent (NE)	In Dispute
	Insufficient Address
	No Mail Receptacle
	No Such Number
	No Such Street
Unable to Forward (UTF)	Deceased
	Unable To Forward
Vacant (VAC)	Vacant
Unknown (UNK)	Illegible
	More than one UAA Code*
	Refused
	Temporarily Away*
	Unclaimed
	Other*
Delivered	Deliverable

*This flag not present after 2010

The UAA data in 2010 were received in detail for three mailings: an advance letter, an initial questionnaire, and a reminder card. The universe that received the advance letter and

reminder card was slightly larger from that which received the initial questionnaire. The advance letter and reminder card were sent to units classified as MOMB, military, and Update/Leave (U/L)² while the initial questionnaire was only sent to MOMB and military units. Thus, our 2010 UAA analysis is restricted to the advance letter and reminder card for consistency. This universe of the 2010 MOMB, military and U/L units totaled 128.8 million units. The advance letter was sent on March 17, 2010 and the reminder card was sent on March 31, 2010. Both mailings were sent prior to Census Day, April 1, 2010.

The UAA data from the 2015 NCT are from a nationally representative sample of about 1.2 million housing units. The first two mailings of the 2015 NCT were an internet invitation letter and reminder card, and were sent on August 24, 2015 and August 31, 2015, respectively. Census Day in the 2015 NCT was September 1, 2015. The first two NCT mailings encouraged an internet response, and therefore did not include the questionnaire. The third and fourth mailings for the NCT were paper forms, and were limited to housing units that had not responded. These mailings are not included in this analysis. Since the 2015 NCT was a sample, the values associated with UAA are weighted totals. The total expected housing unit count in 2015 was roughly 132.8 million, which does not include Puerto Rico.

2.2 2010 Census Vacancy Rates

2010 Census vacancy rates cited in this report are determined based on the total number of units identified as vacant in 2010 divided by the total number of units determined to be housing units in the 2010 Census. Nationally, the total number of housing units was about 131.7 million, which does not include Puerto Rico.

3. UAA Trends

In the 2010 Census, about 14 million mail pieces per mailing were returned to the USPS with a UAA code. The most common code associated with undeliverable mail was the *Vacant* UAA code, a strong predictor for true housing unit vacancy³. Other commonly used codes were *No Mail Receptacle*, *No Such Number* and *No Such Street*. These last three codes are often associated with addresses that did not represent housing units. The UAA reasons *Unable to Forward* and *Deceased* should not be associated with the 2010 Census mailings -- these codes are associated with the status of a specific named resident, rather than an address. Since the Census Bureau addresses its decennial mailings to "Current Resident," these codes should not apply. However, they are often assigned to census mailings. Table 2 provides the distributions of UAA reasons assigned to the advance letter and the reminder card in 2010.

² For Update/Leave areas, a census worker updated the address list and delivered questionnaires to each address on the updated list. Respondents were to return the form by mail.

³ In the 2010 Census, if a unit received a *Vacant* UAA code in the first mailing, there was a 64.6% chance they would receive a *Vacant* status assignment from a Census fieldworker.

Table 2: Distribution of UAA Reasons in 2010 Census Mailings

	Advance Letter		Reminder Card	
	Number	Percent of Total	Number	Percent of Total
Attempted – Not Known	379,984	0.3	432,234	0.3
Deceased	1,722	0.0	61	0.0
In Dispute	10,960	0.0	8,085	0.0
Insufficient Address	566,784	0.4	991,020	0.8
Illegible	84,974	0.1	86,399	0.1
More than one UAA Code	4,848	0.0	1,486	0.0
No Mail Receptacle	2,369,568	1.8	3,336,580	2.6
No Such Number	1,311,411	1.0	1,504,675	1.2
No Such Street	529,295	0.4	625,522	0.5
Other	24,594	0.0	640	0.0
Refused	167,988	0.1	205,487	0.2
Temporarily Away	304,933	0.2	288,975	0.2
Unclaimed	106,575	0.1	124,155	0.1
Unable To Forward	1,360,000	1.1	1,602,094	1.2
Vacant	6,822,840	5.3	7,140,179	5.5
Delivered	114,765,790	89.1	112,464,674	87.3
	128,812,266	100.0	128,812,266	100.0

Considering that these mailings were sent only 14 days apart from each other, one would expect a certain amount of consistency between the UAA reasons assigned. For example, a piece of mail that was undeliverable due to an address containing a street that is marked as *No Such Street*, a separation of 14 days should not change this reason being assigned in most cases. However, the transition matrix in Table 3 shows otherwise. Separated into the six groups outlined in the Data section of this report, this table shows how frequently a UAA code group remained the same or shifted to another UAA code group between two mailings. Of the mail pieces marked as *Vacant* on the first mailing, 66.9 percent were also marked *Vacant* on the second mailing and 19 percent were deliverable.

Table 3: Transition Matrix for UAA Groups across Mailings in 2010

UAA Group: First Mailing	UAA Group: Third Mailing						Total (thousands)
	ANK	NE	UNK	UTF	VAC	Delivered	
ANK	23.9	14.6	1.7	7.1	28.3	24.5	380
NE	1.2	70.0	1.4	6.0	9.8	11.5	4,788
UNK	0.8	7.4	39.1	4.8	25.7	22.2	694
UTF	2.0	20.5	2.0	33.9	24.0	17.5	1,362
VAC	1.7	5.7	2.2	4.5	66.9	19.0	6,823
Delivered	0.1	2.0	0.2	0.4	1.3	96.0	114,766
Total (thousands)	432	6,466	707	1,602	7,140	112,465	128,812*

*Total may not equal sum due to rounding

Since UAA code assignment in 2010 was not entirely consistent, both mailings are included as covariates in our AR modeling determinations. Considering that the UAA reason is highly correlated with our determination for both vacant and nonexistent status, we were interested in assessing whether this UAA transition is unique to 2010.

Table 4 shows the transition matrix between the first two mailings in the 2015 NCT. The behavior is similar to that in 2010, and is demonstrative of a steady state in the transition of UAA codes. In both tables, the NE UAA group remains across mailings over 70 percent of the time, and the ANK, UNK, and UTF groups remain across mailings between 23.9 and 39.7 percent of the time. *Vacant* UAA codes are assigned to mail pieces in both mailings between 58.6 and 66.9 percent of the time, and the delivered rate across mailings is at least 96 percent.

Table 4: Transition Matrix for UAA Groups across Mailings in 2015

		UAA Group: Second Mailing					Delivered	Total (thousands)
		ANK	NE	UNK	UTF	VAC		
UAA Group: First Mailing	ANK	33.7	12.8	1.0	9.7	12.7	30.1	922
	NE	1.9	76.0	0.5	5.8	3.1	12.7	3,511
	UNK	3.6	10.4	31.3	8.8	20.7	25.2	245
	UTF	3.5	13.6	0.9	39.7	16.3	26.1	2,429
	VAC	2.9	6.6	1.2	9.3	58.6	21.4	5,054
	Delivered	0.3	1.2	0.1	0.6	0.9	97.0	120,650
	Total (thousands)	932	4,900	267	2,460	4,679	119,573	132,811

Determinations through AR for vacant and nonexistent units are dependent on accuracy in UAA assignment. If a certain region or zip code area tends to have more consistency in its assignment of UAA codes in short periods of time, then the information in that physical area could be more reliable for our use. One statistic that can be used to measure UAA consistency is Cohen’s kappa coefficient. Cohen's kappa coefficient is a statistic that measures agreement across categorical variables. The formula accounts for agreement-by-chance, so tends to be considered more robust than just percent agreement for an area.

$$\kappa = \frac{p_o - p_e}{1 - p_e}$$

Where: p_o = percent of agreeing cases in an area

p_e = probability of matching by chance

For our purposes, we calculated a Cohen’s kappa coefficient for each zip code in the U.S. By using a kappa coefficient in our model at the zip code level, we are likely to capture agreement by post office. However, a limitation is that this level may not assess the agreement for a particular mail carrier.

Guidelines on whether there is no agreement up through substantial agreement between assignments are outlined in Table 5. In our model, the coefficient was included as a continuous predictor of housing unit status.

Table 5: Kappa Score Ranges and Agreement Levels (Mchugh, 2012)

Range	Interpretation
< 0.2	No Agreement
0.21-0.39	Minimal Agreement
0.40-0.59	Weak Agreement
0.60-0.79	Moderate Agreement
0.80-0.90	Strong Agreement
> 0.90	Almost Perfect Agreement

With the incorporation of the Cohen's kappa statistic into our AR model, we can account for more than just the interaction of UAA codes, but also an assessment of the quality of information by zip code.

4. Undeliverable-as-Addressed Mail and Vacancy Rates

One of the challenges in modeling removals from the NRFU universe based on data in 2010 is not knowing whether housing units will be detected as vacant at the same quantity and quality in 2020. In 2010, the U.S. was still suffering from a recession and housing crisis that contributed to higher vacancy rates than in previous years. Based on studies of the 2010 data, our team can remove 10.78 percent of the NRFU universe as vacant or nonexistent with 78.6% agreement (Keller and Konicki, 2016). However, considering that the economy may be in a better state in 2020 than in 2010, the vacancy rates and UAA rates could drop. This would impact the rate at which we could remove units through our model. To estimate the impact in a reduction of vacancy rates on our AR determinations, one research question we developed was: How well do UAA rates correspond with vacancy rates?

We considered overall UAA rates in the 2010 Census as compared to 2010 Census vacancy rates. Nationally, the 2010 Census vacancy rate was 11.4 percent. The average 2010 Census UAA assignment rate for MOMB, military, and U/L units was 12.7 percent. In Table 6, the rates are displayed by regional divisions. With the exception of the Mid-Atlantic, East North Central, and South Atlantic divisions, Census vacancy rates are slightly lower than average UAA rates. Overall, the two rates only differ by between 0.1 and 2.0 percentage points across the divisions.

Table 6: UAA Rates and Vacancy Rates in the 2010 Census by Division

Region and Divisions	UAA Rate: Adv. Letter	UAA Rate: Rem. Card	UAA Rate: Average of Two Mailings	Census Vacancy Rate
Northeast				
New England	12.2	13.5	12.9	11.8
Mid-Atlantic	9.0	9.8	9.4	9.7
Midwest				
East North Central	10.4	11.8	11.1	11.2
West North Central	10.0	14.1	12.0	10.8
South				
South Atlantic	12.9	14.1	13.5	13.9
East South Central	13.8	14.0	13.9	11.9
West South Central	10.1	13.7	11.9	11.2
West				
Mountain	12.3	16.9	14.6	13.4
Pacific	9.1	9.9	9.5	8.6

Figure 1 shows a similar comparison, but for every state in the nation. UAA rates tend to be slightly higher than vacancy rates in the 2010 Census, but the trends in each are still well correlated ($R^2 = 0.63$).

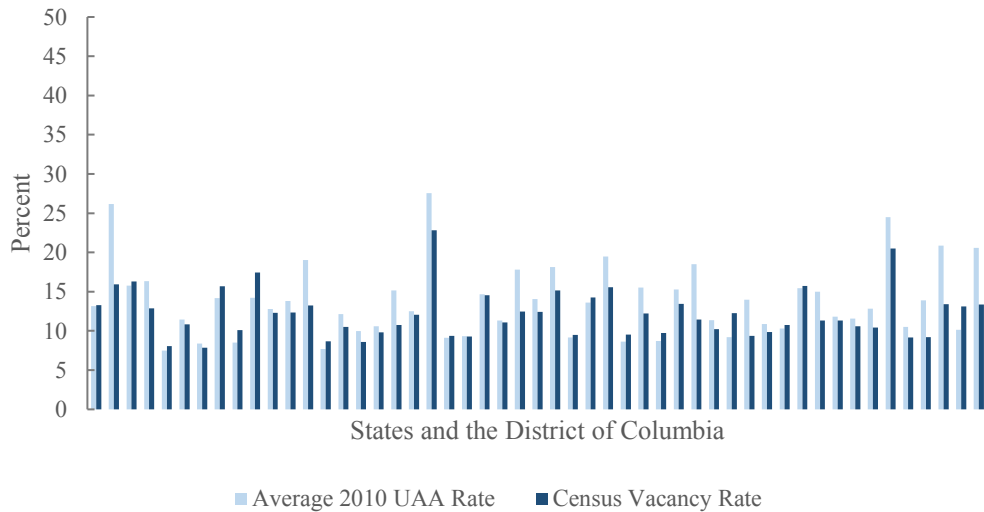


Figure 1: 2010 Census Vacancy Rates and Average UAA Rates by State and the District of Columbia

In 2010, the Census vacancy rates and average UAA rates followed a similar trend across regional divisions of the country as well as across states. Since the vacancy rates are associated with the average UAA rates, our team uses differences in UAA rates from 2010 to more recent data from tests to estimate how vacancy may change between 2010 and 2020. Should the vacancy rates decrease from 2010 to 2020, the rate at which the AR modeling team removes units from the NRFU universe with a vacant or nonexistent determination would also decrease.

To study the changes in UAA rates, we consider two categories: the existence of any UAA reason, and the existence of a UAA *Vacant* reason. If a unit received any UAA code in the first mailing in 2010, it was found to be vacant 51.4 percent of the time and nonexistent 13.9 percent of the time. If a unit was marked with a *Vacant* UAA code in the first mailing in 2010, it was found to be vacant 64.6 percent of the time and nonexistent 12.6 percent of the time. Since the vacant reason is closely tied with the Census vacant units and represents the majority of UAA codes assigned in 2010, its rate fluctuations are of interest. We consider changes from 2010 to mid-decade Census tests that took place in 2014 (Montgomery County, MD and Washington, D.C.), 2015 (Maricopa County, AZ), and 2016 (Los Angeles County, CA and Harris County, TX). In order to draw an accurate comparison of rates, the 2010 Census numbers cited pertain to just the sample areas that were mailed to in each given test.

A comparison of the 2014, 2015, and 2016 Census Tests to the 2010 Census shows that in both the 2015 and 2016 sample areas, there is a decrease in both the overall and *Vacant* UAA rates from 2010. Similarly, the 2014 sample areas show a decrease in the overall UAA rate from 2010 to 2014. The numbers are below in Tables 7, 8, and 9. Note that Census 2010 and site-specific test rates do not have standard errors.

Table 7: UAA Rate Change from 2010 to 2016

	Census 2010 Rate (2016 Blocks)	2016 Test Rate	Percent Change
UAA, All Codes	6.1	4.7	-22.5
UAA, Vacant	4.0	2.5	-38.6

Table 8: UAA Rate Change from 2010 to 2015

	Census 2010 Rate (2015 Blocks)	2015 Test Rate	Percent Change
UAA, All Codes	13.8	10.2	-26.0
UAA, Vacant	8.8	5.5	-37.3

Table 9: UAA Rate Change from 2010 to 2014

	Census 2010 Rate (2014 Blocks)	2014 Test Rate	Percent Change
UAA, All Codes	4.8	3.1	-35.7
UAA, Vacant	1.5	1.7	12.3

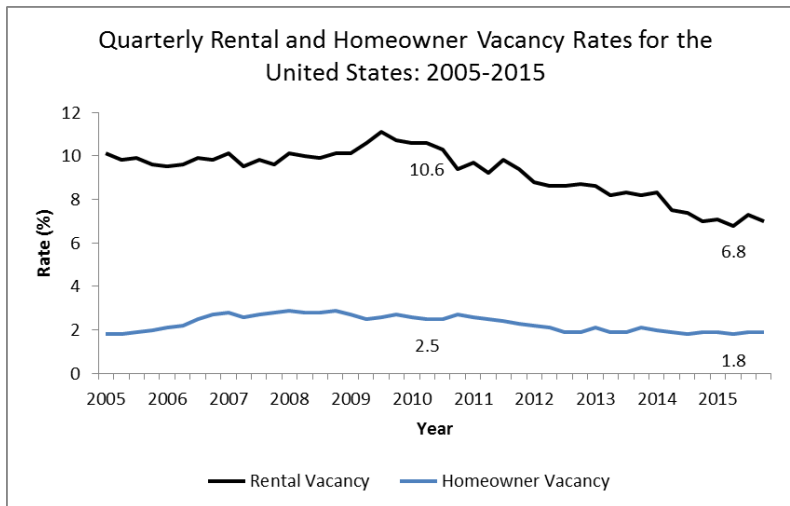
Table 10 provides a national look at the average UAA Rates for the 2010 Census as compared to the 2015 NCT. As in the trends from the Census tests shown in Tables 7, 8, and 9, the overall UAA rates decrease by over 13 percent in the 5-year span, and the *Vacant* UAA rates decrease by over 30 percent in the 5-year span.

Table 10: National UAA Rate change from 2010 to 2015

	Census 2010 Rate	2015 NCT Rate	2015 NCT Standard Error	Percent Change
UAA, All Codes	11.8	10.2	0.009	-13.7
UAA, Vacant	5.5	3.7	0.010	-33.6

Since the NCT is nationally representative, nationally there is about a 13.7% decrease in the overall UAA rates from 2010 to 2015. At the *Vacant* UAA level, there is about a 33.6% decrease from 2010 to 2015. The rate decreases are significant at the 95 percent confidence level. Both nationally and regionally, there is a mostly consistent decrease in UAA rates from the 2010 Census to the middle of the decade.

Furthermore, the Social, Economic and Housing Statistics Division of the Census released national vacancy rates in a July 2016 press release that further corroborate the trends in UAA assignment rates. As shown in the chart below, there is evidence of a downward trend in rental and homeowner vacancy rates from 2010 to 2015.



Source: <http://www.census.gov/housing/hvs/files/currenthvspress.pdf>

Figure 2: Quarterly Rental and Homeowner Vacancy Rates

Labeled in Figure 2 are the second quarter vacancy rates from both 2010 and 2015. In the five-year span, the rental vacancy rate and homeowner vacancy rate decreased by about 36% and 28%, respectively. These values are of a similar scale to the decrease we observe in UAA mail. The downward trend from 2010 to 2015 paired with a similar downward trend in vacancy rates is evidence of overall lower amounts of vacancy rates in 2020, and potentially fewer administrative records removals of vacant and nonexistent units.

5. Conclusion

Mail that is marked as Undeliverable-as-Addressed by a mail carrier is valuable to our team for several reasons. The nature of the existence of UAA codes – that a piece of mail cannot be delivered to an address – leads to it being a strong predictor of vacancy and nonexistence of housing units listed on the Census enumeration universe. However, there are nuances to the consistency of UAA reasons from week to week that can affect the determination of a

housing unit's status. Therefore, our team has implemented the use of a Kappa coefficient for interrater agreement into our modeling. A second benefit of UAA is that its rates track with Census vacancy rates. Though often slightly higher than vacancy rates in the Census, the two are correlated. With this relationship, we can use trends in UAA assignment rates from 2010 to present day to estimate a potential decrease in vacant and nonexistent housing units in 2020. A decrease in the presence of these units would also be associated with a decrease in the potential reduction of the NRFU universe through the use of AR.

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