

Credible Interval Estimates of the Size and Legal Composition of the US Foreign-Born Population*

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Abstract

Government agencies and academic researchers typically report the size and legal composition of the foreign-born population as point estimates. As these estimates are generally produced using survey data, they are impacted by both sampling and nonsampling error. This paper considers nonsampling error due to item nonresponse in the estimates of the size and legal composition of the foreign-born population produced using the American Community Survey. The standard practice to deal with item nonresponse is to impute values under the assumption that nonresponse is conditionally random. We follow a procedure that allows us to form credible interval estimates that make no assumptions about the values of missing data by taking into account all uncertainty due to item nonresponse. Without any assumptions on the distribution of citizenship status among non-respondents, the size of the foreign-born population in the US falls somewhere between 40.4 and 59.4 million as of 2019 compared to the Census estimate of 44.9 million. When taking into account item nonresponse from all questions used in the imputation procedure to assign legal status, the size of the undocumented population fall between 7.3 and 23.3 million compared to the widely accepted estimates of 11 million undocumented immigrants.

keywords: Imputation, nonsampling error, uncertainty, population estimates

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1 Introduction

It has become widely accepted that, as of 2019, there are 44.9 million foreign-born individuals residing in the US of which 21.7 million are non-citizens.¹ Among the non-citizen population, approximately 11 million are estimated to be undocumented immigrants (Passel and Cohn, 2019; Warren, 2020; Baker, 2021). The estimates of the size of the undocumented population are typically reported as point estimates and usually treated as if they had *incredible certitude* (Manski, 2011) by the media and policy analysts alike. However, because documentation status must be inferred rather than directly measured, these estimates may be sensitive to underlying assumptions. As these estimates predominately use survey data an important underlying assumption is on how to account for nonsampling errors.

One type of nonsampling error that can affect the accuracy of the size and legal composition of the US foreign-born population is caused by survey nonresponse. This can take the form of unit or item nonresponse. The standard, but untested, assumption to deal with survey nonresponse and allow for point estimates to be produced is to assume that nonresponse is conditionally random. That is, conditional on a set of observable covariates, the distribution of legal status among non-respondents is the same as that of respondents. This assumption, often referred to as missing at random (MAR), is made when as weights for unit nonresponse and imputations for item nonresponse.

The assumption of MAR is not valid if nonresponse is a function of characteristics (observed and/or unobserved) not used as part of the matching criteria in the imputation or weighting procedures. This assumption is more likely to fail with sensitive questions such as asking about citizenship status as certain groups may be hesitant to provide information on their immigration status. For instance, undocumented immigrants may be more hesitant than others to provide information or to participate in government administered surveys due to concerns about the data

¹These are the official government statistics produced by the Census using the American Community Survey.

being used for enforcement.² This will lead to a failure of the the assumption that nonresponse is MAR and will bias estimates of the size and legal composition of the foreign-born population.³

Researchers working in the Census Bureau have serious doubt on the validity of this assumption being satisfied for the citizenship question in the American Community Survey (ACS) (Brown et al., 2018). Brown et al. (2018) are able to link the ACS to administrative records that contain citizenship status. Individuals who are identified as being non-citizen in administrative records are significantly less likely to respond to the citizenship question than individuals identified in the administrative records as citizens (naturalized or native-born). They also show Census tracts with noncitizen shares in the top decile have higher levels of unit nonresponse than the Census tracts with noncitizen shares at the bottom decile. Over time, the rate of unit nonresponse has also increased more rapidly among the top decile tracts compared to the bottom decile tracts (Brown et al., 2018). This suggests the imputation procedure used by the Census likely underestimates the size of the non-citizen population in the US and, in turn, leads to an underestimation of the size of the undocumented population.

In this paper, we use the ACS to estimate credible interval estimates of the size of the foreign-born, non-citizen, and the undocumented immigrant populations that takes into account nonsampling error from item nonresponse following the approach in Manski (2016). We focus on item nonresponse in the citizenship question in the ACS as this is the question and survey used to produce official statistics by the Census Bureau and one of the key identifiers used by researchers to assign undocumented status in survey data. Over the years, nonresponse to this question has grown rapidly reaching 7.42% of the sample by 2019 from 2.06% in 2009. The rise of item nonresponse increases the possibility of substantial nonsampling error when it comes to the point estimates of the size and legal composition of the foreign-born population in the US. Particularly, given that nonresponse is rising in areas with high share of non-citizens at a higher rate than areas with high

²While Title 13, U.S.C. prohibits the use of Census data for enforcement purposes, respondents may still have this concern.

³Assuming, reasonably, that undocumented immigrants and legal non-citizens have a higher survey nonresponse than naturalized and native-born individuals the sign of the bias will be negative (i.e. underestimation of the size of non-citizen and undocumented population).

share of citizens [Brown et al. \(2018\)](#).

The Manski approach bounds the estimated parameter by assigning the extreme case values to those individuals who did not respond to the question of interest. This approach produces the maximum degree of uncertainty caused by item nonresponse in the estimates of the size of these populations. The credible interval estimates of the size of these population groups provide the benefit of not requiring the untested assumption that, conditional on a set of observables, the distribution of legal status is the same across respondents and non-respondents.

The most popular method to estimate the size of the undocumented population is the residual method developed by [Warren and Passel \(1987\)](#). In the simplest terms, the residual method estimates the size of the undocumented population by subtracting the estimated number of legal immigrants residing in the US from the estimated number of the total foreign-born population. This method has been expanded to attempt to identify undocumented immigrants at the individual level in survey data. The most prominent government and public policy institutions that use the residual method have estimated the size of the undocumented population to be around 10.5 to 11.5 million people for the years 2017/2018. [Passel and Cohn \(2019\)](#) estimate the undocumented population at 10.5 million in 2017 while [Baker \(2021\)](#) at the Department of Homeland Security (DHS) estimates that 11.4 million undocumented immigrants were living in the US in 2018. [Warren \(2020\)](#) estimates that the undocumented population in the US was 10.5 million in 2018. Differences in the estimates are driven by differences in the underlying assumptions on emigration rates, mortality rates, and survey undercount of the foreign-born and undocumented immigrant population.

Agreement on this number is not universal. Rather than the survey based approach, [Fazel-Zarandi et al. \(2018\)](#) simulates year-over-year population changes by combining separate estimates of population inflows and outflows. [Fazel-Zarandi et al. \(2018\)](#) assume probability distributions around each inflow and outflow component and simulate the model over a range of values. The mean estimate based on the simulation model is 22.1 million undocumented immigrants for the year

2016 or twice the currently accepted estimate. The simulation produced a wide 95% confidence interval of as low as 16.2 million to as high as 29.5 million. This estimate has been highly criticized as being based on flawed assumptions on the rate of emigration by undocumented immigrants (Capps et al., 2018; Baker, 2021).

While we do not make any comment on the accuracy or inaccuracy of the assumptions of Fazel-Zarandi et al. (2018), this debate provides an example of *duelling certitudes* as defined by Manski (2011): Capps et al. (2018) and Baker (2021) question the assumptions asserted by Fazel-Zarandi et al. (2018) for assumptions that they prefer rather than on the methodology used. Recently, Van Hook et al. (2021) measured the uncertainty in the size of the unauthorized population from uncertainty in the underlying assumptions about coverage error (undercount), emigration, and mortality. Uncertainty in all three assumptions lead to a range in the size of the unauthorized foreign-born population between 9.1 and 12.2 million with 95% confidence. Van Hook et al. (2021) does not measure the uncertainty caused by item nonresponse as is done in this paper and which we find to be a more significant source of uncertainty. In this analysis we use the residual method proposed by Borjas and Cassidy (2019) and widely used by researchers which does not require the need to make assumptions on the undercount, rate of emigration, rate of mortality, and rate of deportations.

Disagreement on the size of the undocumented population is more severe among politicians and the general public. In 2016, then presidential candidate Trump told supporters during a rally in Arizona “Honestly we’ve been hearing that number for years. It’s always 11 million. Our government has no idea. It could be 3 million. It could be 30 million.” The media response to this quote demonstrates the level of incredible certitude in current estimates of the size of the undocumented population with PolitiFact labeling this statement as “Pants on Fire” (The statement is not accurate and makes a ridiculous claim). Grigorieff et al. (2020) asked 1,193 people living in the US to estimate the proportion of immigrants and undocumented immigrants in the US.⁴ Survey

⁴This sample of 1,193 people living in the US was obtained as a non-probability quota sample to match the U.S. population in terms of age, gender, and region of residence.

respondents overestimated the percentage of immigrants in the US by more than 20 percentage points from the Census estimates (34.7% vs 13.69%). Survey respondents also believed the undocumented population is 7.7 times larger than the estimates produced by the residual method at 25.4% of the total US population ([Grigorieff et al., 2020](#)). Whatever the true numbers are, there is a clear discrepancy in the perceived number of total foreign-born and undocumented immigrants in the US by the general public and the point estimates produced by government agencies and public policy institutions.

In this paper, we first document the trends and patterns of item nonresponse along with the imputation method used for the citizenship question in the ACS from 2009 to 2019. Item nonresponse has grown rapidly over the past 10 years with the largest increase in 2013. This coincides with the addition of the internet response mode and a reduction in the number of Failed-Edit Follow-Up calls. Nonresponse also varies considerably across the age distribution with item nonresponse is largest among those under the age of 18. While this age group has the largest nonresponse rates, citizenship status can be inferred through logical edits using their parents citizenship response. Roughly a quarter of non-respondents to the citizenship question can have their citizenship status logically edited using the response of their parents in a given sample year.

Individual respondents who did not respond to the mail/internet response but later responded to the phone or in-person interview are about 6 percentage points more likely to be foreign-born than those who responded through mail/internet. Phone or in-person respondents are about 6 percentage points more likely to be non-citizens than those who responded through mail/internet. This shows foreign-born, in particular non-citizens who encompass all undocumented immigrants, are less likely to respond to the ACS and to the citizenship question. The response mode by survey participants provides a measure of difficulty in reaching the respondent where in-person respondents are the most difficult to reach for the Census. The significant discrepancy in immigration status between self-response mode and in-person mode respondents provides suggestive evidence that the MAR assumption is likely invalid as argued in [Heffetz and Reeves \(2019\)](#).

We estimate credible interval estimates of the size of the foreign-born population and across legal status. For each population group, the credible interval widens over time as item nonresponse in the citizenship question increases. The point estimates produced using the Census imputed values are near the lower bound estimate for the foreign-born and non-citizen credible interval estimates. The estimated size of the foreign-born population could be as low as 12.3% or as high as 18.1% of the US population by 2019 compared to the 13.64% estimate produced when including imputed values.⁵ The Census estimates that there are 328 million individuals residing in the US as of 2019. With this total population estimate, the size of the foreign-born population in the US falls somewhere between 40.4 and 59.4 million compared to the Census estimate of 44.9 million. If the upper bound is the true population value, this would mean that as many as 14.6 million individuals may be misclassified as native-born citizens by the Census. At the lower bound, the Census could be overestimating the foreign-born population by 4.4 million.

In regards to the non-citizen population, the upper bound is 5.2 percentage points higher than the point estimates produced assuming nonresponse is MAR at 11.8% of the total US population in 2019. The lower bound of the non-citizen population is at 6.01% of the US population. This shares translate to a credible interval estimate of the size of the non-citizen population that fall between 19.7 and 38.7 million in 2019. This is in contrast to the estimated size by the Census of 21.7 million non-citizens residing in the US.

We next expand on the research estimating the size of the undocumented population by producing credible interval estimates of the undocumented population that take into account nonsampling error caused by item nonresponse in the citizenship question. We use the residual method proposed in [Borjas and Cassidy \(2019\)](#) to identify undocumented immigrants in the ACS. The bounds of the credible interval estimate of the share of the undocumented population in the US are wide, ranging from a lower bound of 2.84% to an upper bound of 4.62% in 2019. This translates to a size of the undocumented population that falls between 9.3 and 15.2 million. In contrast, assuming nonresponse is MAR (i.e.using the Census' imputed values), the Borjas' residual method

⁵The Census value is slightly different than using the IPUMS files at 13.69%.

estimates the size of the undocumented population at 3.1% in 2019 or 10.15 million.⁶

The above credible interval estimates only take into account item nonresponse in the citizenship question. Multiple questions are used in the residual method to impute undocumented status at the individual level in the ACS with each having varying degrees of item nonresponse and different methods in the imputation procedure used to assign a status to item non-respondents. Item nonresponse from each questions exacerbates the issue of nonsampling error leading to wider interval estimates than if only focusing on nonsampling error caused by item nonresponse in the citizenship question. When taking into account item nonresponse from all questions used in the imputation procedure to assign legal status, the size of the undocumented population fall between 7.3 and 23.3 million.

The credible interval estimates can not exclude the possibility that the size of the undocumented population has decreased, stayed flat, or increased over time. This is in contrast to [Passel and Cohn \(2019\)](#), [Warren \(2020\)](#), and [Baker \(2021\)](#) who have estimated a small decrease in the size of the undocumented population after 2008. The credible interval estimates show that, without making the critical and untested assumption that nonresponse is conditionally random, there is significant uncertainty in the estimated size of the undocumented population. Any value within this range is a credible estimate of the size of the undocumented population. Without making any assumptions about the exact distribution of the legal status of non-respondents, we cannot reject the lower end estimates produced by [Fazel-Zarandi et al. \(2018\)](#) whose model based estimates the size of the undocumented population range between 16.2 to as high as 29.5 million.

These results have important implications for all work in the field of the economics of immigration that use survey data such as the ACS. Using the ACS estimates of the size of the foreign-born population or using a sample that includes non-respondents implicitly accepts the MAR assumption underpinning the imputed citizenship values. Error in these estimates and imputed values will bias the estimated effects whether studying the effect of immigration on an outcome of interest

⁶Our 2017 estimate is consistent to that of [Passel and Cohn \(2019\)](#) at 10.46 million compared to their 10.5 million estimate.

or the effect of immigration policy on immigrant outcomes. The issue of nonsampling error from item nonresponse is not just limited to the citizenship question but to all sensitive questions in which the MAR assumption imposed on the data might not be valid.

This paper continues as follows. In Section 2, we detail the degree of item nonresponse in the citizenship question in the ACS and provide suggestive evidence that the conditional random assumption used by the Census to impute missing citizenship data may not be satisfied. In Section 3, we detail the residual method and the version used to identify undocumented immigrants in this paper. The Manski approach used to create the credible interval estimates are described in Section 4. The interval estimates of the size of the foreign-born population, the noncitizen population, and the undocumented population are presented in Section 5. Section 6 concludes and provides policy and empirical recommendations.

2 Item Nonresponse in the American Community Survey

The American Community Survey is the largest representative sample of the US population, sampling 1% of households each year. It provides current demographic, social, economic, and housing information about the communities in the US each year since its full implementation in 2005. The ACS is the predominate survey used by the Census to produce official yearly statistics of the total size of the foreign-born population and its legal composition (naturalized and non-citizen). As the ACS is the key data source used to estimate official government statistics of the size of the foreign-born naturalized and noncitizen population and used extensively to produce estimates of the size of the undocumented population through the residual method ([Passel and Cohn, 2019](#); [Warren, 2020](#); [Baker, 2021](#)), we use the ACS for this analysis.⁷ The publicly available ACS files are sourced from IPUMS ([Ruggles et al., 2020](#)). This analysis focuses on the survey years 2009 to 2019. Survey year 2019 is the most recent year available. Survey year 2009 is the first year where a question on

⁷Prior to the full implementation of the ACS, the most common survey used to estimate the size and legal composition was the Current Population Survey (CPS). Due to differences in the collection mode, the CPS has a significantly lower citizenship question nonresponse rate than the ACS at around 1% each year. While the CPS has lower item nonresponse rates, it has a larger degree of unit nonresponse. As this paper focuses on uncertainty in the estimates from item nonresponse, the paper only focuses on the ACS.

Medicaid participation is asked in the ACS, one of the questions used to identify legal immigrants in the residual method.

Census Sampling and Interview Process

The Census uses standard sampling methods to obtain its data.⁸ The Census Bureau uses its Master Address File, which is composed of all known housing units and group quarters, to identify the household and group quarters that will be chosen for the sample that year. The ACS collects data each month of the year. The ACS yearly data files represent the average demographics of the nation as of July 1st of each year. Each month, the Census sends out requests for response. A household can respond through the paper questionnaire and, as of 2013, through the internet. The Mail and internet response modes are collectively known as the self-response mode. Non-respondents to the self-response modes are then contacted for a computer-assisted telephone interview (CATI) the following month. In the third month, a third of non-respondents to the self-response and CATI modes are contacted in person to complete the ACS through a computer-assisted in-person interview (CAPI).⁹ The ACS has a high survey completion rate at over 95% of those sampled, although the participation rate has been decreasing over the years as with other surveys.

The American Community Survey (ACS) also conducts a follow-up operation to re-contact responding households to try to collect information missing or inconsistent in the mail and internet questionnaires to deal with survey nonresponse (Clark, 2014). This operation is called Failed Edit Follow-up (FEFU) calls. The FEFU calls are only for some households that self-responded to the survey and are conducted by phone interview (Clark, 2014).¹⁰ Coinciding with the introduction of the internet response mode, the Census reduced FEFU operations as a cost cutting measure (Clark, 2014).

⁸For more information on the data collection and ACS sample panels, see [US Census Bureau \(2014\)](#).

⁹In the IPUM files, we cannot differentiate between CATI and CAPI responses or the number of contact attempts made.

¹⁰FEFU are predominately done when mail respondents indicate that there are more than 5 individuals in the household as the mail questionnaire has only room for only 5 individuals (Clark, 2014).

Citizenship Question

The Census uses the citizenship question to distinguish individuals as native-born or foreign-born. As well as to distinguish between naturalized citizens and non-citizens among the foreign-born population. Figure 1 shows the citizenship question in the 2019 ACS. There are 5 options; (1) Yes, born in the United States, (2) Yes, born in Puerto Rico, Guam, the US Virgin Islands, or North Marianas, (3) Yes, born abroad of US citizen parent or parents, (4) Yes, US citizen by Naturalization, (5) No, not a US citizen. Choices (1), (2), or (3) are classified as native-born; while choices (4) or (5) are classified as foreign-born. The IPUMS files do not distinguish between category (1) and (2).

Figure 2 shows the share of the ACS sample that did not respond to the citizenship question. Item nonresponse for this question has more than tripled from 2.07% of the sample in 2009 to 7.42% in 2019. A notable trend break appears in the year 2013. This is driven by changes in the survey collection methodology (addition of the internet response mode) and a reduction in the number of FEFU calls due to budgetary reasons (Clark, 2014).

Figure 3 shows the share of the US population that is foreign-born by response status to the citizenship question.¹¹ The share of foreign-born among respondents has increased slightly from 2009 to 2019. Figure 4 show share of the population that are non-citizens by response status to citizenship question over time. The share of non-citizens among respondents has decreased slightly over time, predominately after 2016. The share of foreign-born and non-citizens drops drastically among non-respondents in 2013 following the methodological changes to the ACS mentioned earlier. This is caused by the Census's 'hot-deck' imputation method that assumes the distribution of citizenship status is conditionally random. If non-response is not MAR and non-citizens have a higher rate of not responding to the citizenship question, the imputation procedure will lead to a higher share on non-respondents to be improperly imputed as natives or naturalized citizens.

From the three figures above, the methodological changes to the ACS by the Census had a clear im-

¹¹When discussing population share estimates, we are using the weighted share. The weights are the person weights provided by the Census.

impact on the degree of nonresponse to the citizenship question and on the share of non-respondents imputed as foreign-born and non-citizen. The methodological changes in 2013 did not have an impact on the response rate of other demographic questions such as race, Hispanic origin, sex, age, nor housing tenure questions (O'Hare, 2018; Clark, 2014). The sharp rise of nonresponse to the citizenship question relative to other demographic questions is suggestive of the sensitive nature of asking about legal status. These questions are asked before the citizenship question so ordering might be an issue on item nonresponse when including sensitive questions on surveys.

We further disaggregate the above statistics by response mode over time. Figure 5 shows the share of the ACS sample by response mode.¹² The IPUMS files do not separate CATI and CAPI interviews. The share of the sample that responds by mail dropped by 40 percentage points after the introduction of the internet response model. As the share of individuals responding to the ACS through the internet mode increase, the share of the sample that responded by both mail and CATI/CAPI has decreased.

Figure 6 shows the share of item nonresponse in the citizenship question by response mode. The share of item nonresponse among mail respondents saw an almost doubling after the reduction in FEFU operations. Internet mode respondents had a slightly higher rate of item nonresponse. This is expected as they are less likely to be chosen for a FEFU call. CATI/CAPI respondents did not see a trend break in 2013 but have seen a near tripling in item nonresponse to the citizenship question from 2009 to 2019. This suggests that asking about citizenship status has become a more sensitive topic. As more individuals respond to the ACS through the internet mode the issue of item nonresponse is likely to worsen.

Figure 7 shows the share of the population that is foreign-born by response status to the citizenship question and response mode. Figure 8 shows the share of the population that is non-citizen by response status to the citizenship question and response mode. Individual respondents who did not respond to the self-response modes and are later chosen to be interviewed by CATI/CAPI

¹²We exclude group quarter respondents.

are about 6 percentage points more likely to be foreign-born than those who responded through the self-response modes. CATI/CAPI respondents are about 6 percentage points more likely to be non-citizens than those who responded through mail/internet. This shows foreign-born, in particular non-citizens who encompass all undocumented immigrants, are less likely to respond to the ACS and to the citizenship question.

Imputation Procedure

The Census does not provide the exact methodology used for imputing citizenship status but has provided this information to IPUMS. For a detailed overview of the imputation procedure provided by the Census and released by IPUMS see Appendix B.¹³ When a survey participant does not respond to the citizenship question the Census imputes a value in one of two ways: A logical editing procedure or a 'hot-deck' procedure. First, the census attempts to logically edit the non-respondents status using information from additional questions in the survey or through parental linkages if at least one parent is present. For instance, if the individual responds to being born in the US by responding they were born in the US in the place-of-birth question, they are logically edited as being native-born. If place-of-birth is also missing but a parent is present and is a native-born, the individual is logically edited as being native-born.

If status can not be logically edited, then the Census performs what they call a 'hot-deck' imputation procedure. The Census imputes a response to a non-respondent based on the citizenship response of a respondent with the same age, race, and ethnicity. The Census also takes into account geography in their 'hot-deck' imputation procedure, choosing a respondent of similarly observables that is also in the same area as the non-respondent (US Census Bureau, 2014).¹⁴

The individuals that can not have their status logically edited is where the assumption that non-response is MAR is used to impute a value. As such, for our credible interval estimates, we will only

¹³We can not be certain that the imputation procedure as released by the IPUMS details the entire procedure used by the Census to impute citizenship status. For instance, the procedure detailed by IPUMS does not include at what geographic level the Census uses for imputation.

¹⁴How granular this area is is unknown to the public. It may be at the Census tract or at the state level.

focus on those that had their status allocated through the 'hot-deck' procedure. Unfortunately, the publicly available files do not distinguish the method used for the imputed values, only that they have been imputed. We perform a simplified logical editing procedure to separate out the logically edited and hot-deck imputed values.

For this analysis, we assign non-respondents as having a logically-edited value in the following way. A non-respondent is assigned as a native-born if there is a parent in the household that responded to the citizenship question as being native-born. We also logically edit native-born status if a person reports being born in the US when asked their place of birth. This procedure assigns a citizenship status to 23.8% of all imputed values.¹⁵ Every other non-respondent is classified here as a 'hot-deck' imputed value. This simplified logical editing procedure will likely miss some of the individuals the Census logically edited. We do not logically edit citizenship status if the parent is not a native-born. Also, it is not clear if the Census uses a parent's imputed citizenship status to logically edit the citizenship status of an individual to ensure logical consistency or if they only use parental links when the parent responded to the citizenship question.

Figure 9 shows the share of the sample with a 'Hot-deck' imputed citizenship response based on the definition in the paragraph above. The Census has been able to logically edit almost the same share of non-respondents over the sample period but the trend in 'hot-deck' imputations has continued to rise. The 2013 trend break is also prominent in the 'hot-deck' imputed values. Logical edits are not enough to deal with the rising trend of nonresponse nor the rise in nonresponse caused by the reduction in FEFUs calls.

As parental linkage is the key method of logically editing citizenship status, this will lead to differential rates of editing based on whether a parent is present or not in the household. Figure 10 shows the item nonresponse rate across the age distribution. Item nonresponse is largest among those under the age of 18. While this age group has the largest nonresponse rates, citizenship

¹⁵A total of 17.26% of non-respondents are assigned nativity based on their mother's nativity while the other 6.54% of non-respondents are assigned nativity based on their father's nativity. No individual was logically edited from their response to the place-of-birth question.

status can be inferred through logical edits using their parents citizenship response leading to this age group having the lowest level of nonresponse that needs to be imputed through the ‘hot-deck’ procedure. More work needs to be done to understand why parents are willing to respond to surveys about their own citizenship status but not when it comes to their children’s citizenship status.

The Assumption that Nonresponse is Missing at Random

The assumption that non-respondents and respondents will have the same legal status distribution conditional on age-race-ethnicity is difficult to accept. For instance, this will require a native-born white Hispanic to have the same probability of not responding to the citizenship question as an undocumented white Hispanics of the same age. Due to the sensitivity of the legal status question, it is quite possible that the undocumented immigrants are less likely to respond to the citizenship question than their native-born or naturalized counterparts.

The MAR assumption can be seen most clearly in Figure 11 and 12. Figure 11 shows the distribution of foreign-born by response status across age for white Hispanics. Response status is now separated between those that responded or could have their citizenship status logically edited versus those that had their status imputed through the ‘hot-deck’ procedure. The distribution of foreign-born across age for non-respondents is similar but slightly higher than among respondents. The distributions do not perfectly match for two reasons. First, the Census imputation procedure takes into account geographic proximity. Item non-respondents are more likely to be in cities that have higher share of immigrants and non-citizens (O’Hare, 2018; Brown et al., 2018). The second reason is the differences in the logical editing procedure between our work and the Census official procedure. Figure 12 shows the distribution of being non-citizen across age for white Hispanics by response status. Both distributions are almost exact after age 15. The differences in the distribution below age 15 may be caused by the incomplete logical editing procedure used in this paper relative to the complete procedure used by the Census. The assumption that nonresponse is conditionally missing at random leads to an interesting outcome among the foreign-born popula-

tion. In figure 13, the ‘hot-deck’ imputed foreign-born are less likely to be assigned as non-citizens relative to those who responded among white-Hispanics of all age groups.

3 Identifying Undocumented Immigrants

A major obstacle in estimating the size of the undocumented population is that large nationally-representative surveys do not ask respondents detailed questions on their documentation status. This has forced researchers and academics to create methods to infer documentation status in these surveys. The most popular of the methods to estimate the size of the undocumented population is the residual method that was first developed by [Warren and Passel \(1987\)](#). The residual method estimates the size of the undocumented population by subtracting the estimated number of legal immigrants residing in the US from the estimated number of the total foreign-born population. The estimates for the total foreign-born population are derived from surveys that ask respondents where they are born such as the ACS. The number of legal immigrants is estimated using administrative data on legal admissions. This method has been further refined over the years to be able to assign undocumented status to individuals in large surveys, such as the ACS, based on demographic characteristics. Using the residual method, the estimated size of the undocumented population was about 10.5 to 11.5 million people for the years 2017/2018 ([Passel and Cohn, 2019](#); [Baker, 2021](#); [Warren, 2020](#)). Estimates derived from the residual method have been widely used and are generally accepted as the best current estimates.

The Pew Research Center use a version of the residual method to identify undocumented immigrants in the ACS ([Passel and Cohn, 2019](#)). As this methodology underlies the “official” estimates reported by the DHS ([Baker, 2021](#)), we focus on detailing the methodology by the Pew Research Center only. There are slight differences in each of the different estimates of the size of the undocumented population. Differences in the method are primarily due to differences in assumptions of the undercount of the foreign-born population and assumptions about mortality and migration rates.

In rough terms, the methodology identifies the foreign-born persons in the sample who are likely to be legal using logical edits based on the individual's demographic, social, economic, and geographic characteristics and then classifies the remainder as likely to be undocumented. [Passel and Cohn \(2019\)](#) then apply a final filter to ensure that the counts from the micro-data agree with the official counts from the DHS of the total legal permanent resident (green card holders) and the official count from the DHS and the Department of State on legal non-permanent population (such as refugees, students with visas, workers with H1B visas, and tourist visas) through probabilistic methods that randomly assign legal or unauthorized status to those identified as potentially unauthorized individuals. Finally, the weights are adjusted to account for the estimated undercount of the undocumented population.

An issue for researchers is that the code underlying the undocumented status identifier is not publicly available. [Borjas \(2017\)](#) and [Borjas and Cassidy \(2019\)](#) “reverse engineered” the residual method by Pew Research Center to create a comparable identifier in all CPS and ACS files to identify likely undocumented immigrants. [Borjas \(2017\)](#) argues that only a few number of characteristics “matter” when it comes to identifying undocumented immigrants. A foreign-born individual is classified as a legal immigrant if any one of the following conditions are met;

1. that person arrived before 1980;¹⁶
2. that person is a citizen;
3. that person receives Social Security benefits, SSI, Medicaid, Medicare, or Military Insurance;¹⁷
4. that person is a veteran, or currently in the Armed Forces;
5. that person works in the government sector;

¹⁶Nearly all undocumented immigrants that arrived prior to 1980 are assumed to be legal as the majority were legalized through the IRCA 1986 reform and are assumed to have had enough time to change their legal status, migrate back to their home country, or died.

¹⁷Medicare and Medicaid information is only available for the years after 2007

6. that person resides in public housing or receives rental subsidies, or that person is a spouse of someone who resides in public housing or receives rental subsidies;¹⁸
7. that person was born in Cuba;¹⁹
8. that person's occupation requires some form of licensing (such as physicians, registered nurses, air traffic controllers, and lawyers);²⁰
9. that person's spouse is a legal immigrant or citizen.²¹

The residual group of all other foreign-born persons is then classified as undocumented. This residual method provides comparable characteristics to those by the Pew Research Center and the "official" count produced by the DHS with the benefits that a researcher does not have to re-weight the data for the estimated undercount mentioned nor use probabilistic random assignment of status to match predetermined estimates. Due to its simplicity and detailed methodology which allow for replication, as well as its wide spread adoption in the academic literature, we identify undocumented immigrants in the ACS using [Borjas and Cassidy \(2019\)](#) residual method.

It is important to note that the validity of the assigned legal status is dependent on the validity of the procedure used to assign an individual's undocumented status in micro-data surveys. The accuracy of the assignment depends on the accuracy of the variables used to identify undocumented individuals. This paper does not focus on whether this method perfectly identifies undocumented immigrants given the logical editing procedure. This paper is focused on estimating the magnitude of nonsampling error in the estimation of the size of the undocumented population caused by item nonresponse in the survey questions used to assign undocumented status under the assumption that the editing procedure of the residual method is accurate.

¹⁸Information on public housing and rental subsidies is only available in the CPS and not the ACS.

¹⁹Practically all Cubans were granted refugee status through the Cuban Adjustment Act of 1966 and the wet feet, dry feet policy in 1995.

²⁰[Borjas \(2017\)](#) does not detail exactly which occupations are used for this condition.

²¹For children living at home, this condition is expanded to include the parent's legal status as US laws allows under-aged children to have the same legal status as their legal parents.

This is also just one, albeit the most popular, method to assign legal status. Another method uses a donor sample that contains a legal status identifier to assign legal status in a larger survey that does not contain said identifier. This two sample approach is usually referred to as the multiple imputation approach. A popular donor survey is the Survey of Income and Program Participation (SIPP) to assign legal status larger surveys such as the ACS and CPS. [Ro and Van Hook \(2021\)](#) compares the Borja's residual method with the multiple imputation procedure using the restricted version of the SIPP. [Ro and Van Hook \(2021\)](#) find notable demographic differences across both methods. While this method is not a focus of this paper, it will also be plagued by nonsampling error from item nonresponse. In fact, it will be more severe as item nonresponse from both samples will need to be taken into account.

The Borjas' residual method produces an estimate of the size of the undocumented population of 3.1% or 10.15 million as of 2019. Figure 14 displays the share of the US population that is identified to be undocumented by their citizenship response status. As with the foreign-born and non-citizen populations, the share of undocumented immigrants among the item nonresponse group drops drastically in 2013 following the methodological changes to the ACS mentioned earlier. The share of undocumented immigrants for non-respondents is lower compared to the share of undocumented immigrants among only respondents for 2013 and beyond. As with the foreign-born and non-citizen shares in the non-respondent group, this is caused by the Census's imputation method assuming the distribution of citizenship status is MAR. This is counter to the intuition that undocumented immigrants are the least likely to respond sensitive questions on legal status and participate in surveys.

Figure 15 shows the share of the undocumented population by response mode and response status to the citizenship question. The share of the population identified as undocumented that responded to the citizenship question is very different across response modes. Citizenship question respondents are twice as likely to be identified as undocumented if they responded by internet compared to if they responded by mail (2% of internet respondents vs 1% of mail respondents). Among CATI/CAPI respondents, about 5.5% of those that responded to the citizenship question

are identified as being undocumented. In all, undocumented immigrants seem hesitant to participate in the ACS. Without phone or in-person follow up of self-response non respondents, the ACS would significantly underestimate the undocumented population.²²

Because of the methodology of the ACS, response mode is a proxy of the difficulty in reaching a respondent. The wide differences in the citizenship share across response mode provides suggestive empirical evidence that MAR fails as argued by [Heffetz and Reeves \(2019\)](#). It also suggest that surveys with large unit nonresponse or that lack adequate follow-up operations are likely to miss a significant share of the undocumented population.

4 Manski's Interval Estimation Method

Nearly all imputation models, including those used by the Census, assume nonresponse is MAR. In the case of the citizenship question in the ACS, conditional on a small set of observables (age, race, and ethnicity), the distribution of the foreign-born population among non-respondents is the same as respondents. While this assumption allows point estimates to be produced, this assumption is a strong one in the context of citizenship status. Without assuming the distribution of foreign-born status among non-respondents, only an interval estimate can be produced. Below we detail how the interval estimates are produced for the foreign-born, non-citizen, and undocumented population following [Manski \(2016\)](#).

For simplification, suppose that all population units are sample members. By the Law of Total Probability the share of the US population that are foreign-born can be defined as:

$$P(F) = P(F|R = 1) \cdot P(R = 1) + P(F|R = 0) \cdot P(R = 0) \quad (1)$$

where $F=1$ (or 0) signifies the population unit is foreign-born (or native-born). $R = 1$ (or 0) if a population unit did (or did not) report citizenship status. The empirical evidence identifies

²²The wide discrepancy between the share of undocumented immigrants in the self-response mode and the in-person response mode may help explain why the CPS has significantly lower citizenship item-nonresponse rates (roughly 1%) as the first interview the CPS conducts with a household is an in-person interview.

$P(R)$ and $P(F|R = 1)$. There is no empirical information on $P(F|R = 0)$. Without assuming the exact distribution of foreign-born status among non-respondents $P(F|R = 0)$ can take any value between 0 and 1. This yields the following sharp bounds:

$$P(F|R = 1) \cdot P(R = 1) < P(F) < P(F|R = 1) \cdot P(R = 1) + P(R = 0) \quad (2)$$

To estimate the lower bound, one supposes that $F = 0$ for each sample member with missing data in the citizenship question. To estimate the upper bound, one likewise supposes that $F = 1$ whenever observation is missing. Thus, the estimation of the bounds simply requires two extreme imputations of each case of missing data. The point estimate of the share of the foreign-born when using the Census imputed values that assume MAR will lie between the upper and lower bounds.

The same procedure can be used to create interval estimates for the share of non-citizens. The interval estimates can be written as:

$$P(NC|R = 1) \cdot P(R = 1) < P(NC) < P(NC|R = 1) \cdot P(R = 1) + P(R = 0) \quad (3)$$

where $NC = 1$ (or 0) if the population unit is a non-citizen (or not a non-citizen). $R = 1$ (or 0) if a population unit did (or did not) report citizenship status. At the upper bound of the estimates, all individuals who did not respond to the citizenship question are assigned as non-citizens. This also corresponds to where all non-respondents are foreign-born. In the lower bound, all non-respondents are allocated as not being non-citizens. This may correspond to either all non-respondents being either native-born or naturalized foreign-born citizens. We allocate the non-residents as native-born so that the lower bound of the non-citizen interval estimates also corresponds to the lower bound of the foreign-born estimates.

There are additional steps to produce the interval estimates of the size of the undocumented population. The residual method uses multiple questions to assign legal status to each individual. The method also assigns legal status based on the legal status of an individual's spouse or parent

if they are present in the household.

For simplicity, we first focus on item nonresponse of the citizenship question. To create a lower bound we assign all citizenship question non-respondents as native-born and run the residual method procedure. To create an upper bound we assign all non-respondents as non-citizens and run the residual method procedure.²³

This is better than assigning all non-respondents as either undocumented or not undocumented if they did not respond to the citizenship question. For example a non-respondent to the citizenship question may have responded that they are currently in the armed forces. Assigning undocumented status to that individual would be improper. The above procedure ensures that the individual is logically edited as being documented regardless if assigned as a non-citizen.

We then produce interval estimates of the undocumented population taking into account non-sampling error caused by nonresponse to all questions used in the assigning procedure. At the lower bound we assign non-respondents an answer to all imputed questions that would logically edit the individual as being documented through the residual method. At the upper bound we assign non-respondents an answer to all imputed questions that would fail to logically edit the individual as a documented immigrant.

Assumptions

The key benefit of producing interval estimates is that we do not need to make assumptions about the non-response process and we are able to estimate the maximum nonsampling error caused by item nonresponse. Even so, as we are only focusing on nonsampling error from item nonresponse only, we must make key assumptions.

²³An alternative method to create interval estimates is to use the basic form of the residual method. That is, to subtract the lower and upper bound estimates of the foreign-born population from the estimated legal foreign-born population produced using administrative data. This would require assumptions to be made on the quality of the estimates from the administrative data. As the goal is to minimize the number of untestable assumptions made, we do not perform such exercise.

First, we do not take into account unit nonresponse. Instead, we assume the census weights accurately deal with unit nonresponse and use the census weights provided to create the interval estimates. As census does not use citizenship status, the MAR assumption leads to demographically comparable native-born and undocumented immigrants to have the same person weight. Since unit and item nonresponse is greatest in areas with the highest share of non-citizens (Brown et al., 2018), there is likely nonsampling error in the weighting procedure as well. Taking into account unit nonresponse will lead to larger bounds than those estimated here.

Second, we accept respondents answers as accurate. It has been documented that recent immigrants misreport their citizenship status (Van Hook and Bachmeier, 2013). Brown et al. (2018) shows non-citizens are significantly more likely to falsely report being citizens (both naturalized and native-born). In the 2016 ACS, 34.7% of respondents that are identified in administrative records as being non-citizens claim to be citizens. Brown et al. (2018) also show misreporting among all immigrants regardless of years in the US unlike Van Hook and Bachmeier (2013) that looked at differences in aggregate estimates. Of those that misreport their citizenship status, approximately 15.9% report being citizens from birth. Among respondents in the ACS linked to administrative records using Individual Taxpayer Identification Numbers (most likely to be undocumented), 11% said they were US citizens and 6.6% said they were native-born (Brown et al., 2018). There was virtually no misreporting among ACS respondents that had been identified as citizens in administrative records.

The logical editing procedure used by the Census magnifies misreporting error within households if one parents falsely reports being a citizen as all non-responding children in the household would be assigned their parents' citizenship status. This is also the case for the editing procedure in the residual method. This can cause major issues in the interval estimates produced here as we only study item nonresponse for those who's citizenship status cannot be logically edited - those assigned a citizenship status only through the assumption that nonresponse is conditionally random. The interval estimates produced here will therefore most likely be shifted down than if all individuals responded truthfully to the citizenship question. Given the evidence provided

in [Brown et al. \(2018\)](#), the true size of the foreign-born, non-citizen, and undocumented populations would likely be closer to the upper bound and may even possibly exceed the upper bounds estimated here depending on the degree of error in the weighting procedure and degree of misreporting.

5 Credible Interval Estimates

5.1 Foreign-Born Estimates Recognizing Item Nonresponse

As discussed in Section 4, without making an assumption on the distribution of legal status among item non-respondents, only interval estimates can be produced. Figure 16 shows the credible interval estimates of the share of the US population that are foreign-born. The long-dash line represents the upper bound of the share of foreign-born in the population where all 'hot-deck' imputed values are assigned as foreign-born. The short-dash line represents the lower bound of the share of foreign-born in the population where all MAR imputed values are assigned as native-born. The solid line represents the share of foreign-born in the population using the imputed values from the Census under the assumption that nonresponse is MAR. All population estimates produced in this section use the Census population weights.

The estimated size of the foreign-born population by 2019 could be as low as 12.3% or as high as 18.1% of the US population compared to the 13.6% estimate produced with Census imputed values. This is a significant degree of uncertainty and any value within these bounds can not be rejected without further making assumptions of the distribution of foreign-born among non-respondents. With an estimated 328 million individuals residing in the country, the upper bound would indicate a size of the foreign-born population at 58 million. If the upper bound is the true population value, this would mean that as many as 14.6 million individuals are misclassified as native-born citizens by the Census. At the other lower bound, there may be only 40.3 million foreign-born individuals in the country or 4.4 million less than Census estimates. The Census estimates produced under the assumption of MAR are closer to the lower bound than

the upper bound. That is due to the Census imputing a distribution of citizenship status among non-respondents that is conditionally the same as for respondents.

In the traditional residual method, the size of the undocumented population is produced by subtracting the estimate of the US total foreign-born population derived from survey data by the estimated total legal foreign-born population derived from administrative counts. As the bounds of the estimated foreign-born population taking into account uncertainty from nonresponse are wide, the traditional residual method will produce considerably large bounds of the undocumented population as well. This is the case even without taking into consideration of the uncertainty in estimates of the legal population that make assumptions on rates of emigration, of mortality, and of deportation.

5.2 Non-citizen Population Estimates Recognizing Item Nonresponse

Figure 17 shows the credible interval estimates of the share of the US population that are non-citizens. The long-dash line represents the upper bound of the share of non-citizens in the population where all MAR imputed values are assigned as foreign-born. The short-dash line represents the lower bound of the share of non-citizens in the population where all MAR imputed values are assigned as native-born. The solid line represents the share of non-citizens in the population using the imputed values from the Census under the assumption that nonresponse is conditionally random.

the upper bound estimate of the non-citizen population is 11.8% of the total US population in 2019. The lower bound of the non-citizen population is at 6% of the US population. The Census estimates 6.6% of the population are non-citizens. These population shares translate to a credible interval estimate of the size of the non-citizen population between 19.7 and 38.7 million in 2019. The point estimate of the size of this population produced by the Census, and which assume MAR, is 21.7 million non-citizens residing in the US as of 2019. Again, the Census point estimates are closer to the lower bound than to the upper bound for the same reason outlined above. The point estimates using the imputed values shows a slight decrease in the size of the non-citizen

population of the sample period. When taking into account the uncertainty of the estimates from item nonresponse, the share of the population that is non-citizen may be increasing, decreasing or have stayed the same.

5.3 Undocumented Population Estimates Recognizing Item Nonresponse

Figure 18 shows the credible interval estimates of the size of the undocumented population taking into account only citizenship question nonresponse. The short dash lines represent the lower bound while the long dash lines represent the upper bound estimates. The bounds of the credible interval estimate of the share of the undocumented population in the US are wide ranging from a lower bound of 2.8% to an upper bound of 4.6% in 2019. This translates to a size of the undocumented population that falls between 9.3 and 15.2 million. Assuming nonresponse is MAR (solid line in Figure 18), the Borjas' residual method estimates the size of the undocumented population at 3.1% in 2019 or 10.15 million.²⁴ The credible interval estimates can not exclude the possibility that the size of the undocumented population has stayed flat, increased, or decreased over time.

The above credible interval estimates only take into account item nonresponse in the citizenship question. Multiple questions are used in the residual method to impute undocumented status at the individual level in the ACS with each having varying degrees of item nonresponse and different methods in the imputation procedure used to assign a status to item non-respondents. Item nonresponse from each questions exacerbate the issue of nonsampling error leading to wider interval estimates than if only focusing on nonsampling error caused by item nonresponse in the citizenship question.

Figures A.20 to A.26 look at the degree of item nonresponse to all other question used in the imputation procedure.²⁵ Panel (A) of each figure looks at the share of the sample that do not respond to each question. We specifically look at the share of nonresponse on a sample composed of in-

²⁴Our 2017 estimate is consistent to that of [Passel and Cohn \(2019\)](#) at 10.46 million compared to their 10.5 million estimate.

²⁵Due to an error in the constructed imputation flag for Medicaid and Medicare produced by IPUMS, We exclude those questions from our analysis.

dividuals that responded in the ACS that are non-citizens and individuals that did not respond to the citizenship question. These are the individuals that compose the bounds for the size of undocumented population. As with the citizenship question, nonresponse to all other questions has grown rapidly over time. A similar spike in nonresponse appears after 2013 coinciding with the methodological changes to the ACS. This means less information is available to deduce documentation status from other questions. More specifically, to assign documentation status the residual method is using the imputed values from the Census. If there is error in the imputation procedure used by the Census in any of these questions, the residual method will be biased when assigning documentation status.

Panel (B) of Figures A.20 to A.26 show the share of the sample that satisfy the condition of interest by the response status to the question of interest. For all except those born in Cuba, the sample with imputed individuals are more likely to be imputed a value that satisfy conditions that would assign them as legal immigrants in the Borjas residual method. Figure A.27 shows the share of the sample that did not respond to at least one of the questions used in the residual method. Again, this is a sample of those that responded as non-citizens or that did not respond to the citizenship questions. Among this sample, around 65% of the sample did not respond to at least one of the questions by 2019. Roughly 50% of those that responded to all the questions used in the residual method are classified as being undocumented immigrants (Panel B). Among the sample that had at least one question imputed, the share undocumented was considerably lower at a little over 10%.

Next, we produce credible interval of estimates of the undocumented population recognizing non-response in all variables as described in Section 4. When taking into account item nonresponse from all questions used in the imputation procedure to assign legal status, the estimated size of the undocumented population fall between 7.3 and 23.3 million. This is a considerable expansion in the size of the bounds. While the bounds are wide, they are of great value as they include all possible uncertainty caused by item nonresponse. Future work is needed to reduce the size of the bounds.

Considerable debate has taken place regarding estimates that deviate from the estimates of 11 million undocumented immigrants residing in the US (Capps et al., 2018; Baker, 2021). The bounds produced here cannot reject the lower range of the estimates produced by Fazel-Zarandi et al. (2018). To reach the upper bound estimates of Fazel-Zarandi et al. (2018) would require a considerable undercount or degree of misreporting that is not taken into account here. A benefit of the bounds produced here is that it is informative in bounding estimates derived from alternative methods. Alternative methods that provide estimates greater than 23 million or lower than 7 million should take caution in the assumptions used to derive those population estimates.

6 Concluding Remarks and Recommendations

Estimates of the size and legal composition of the foreign-born population have been treated with *incredible certitude* by the media and policy analysis alike (Manski, 2016). These estimates contain both sampling and nonsampling error that are occasionally discussed but rarely ever estimated. This paper considers nonsampling error in these estimates caused by nonresponse to the citizenship question in the ACS. Item nonresponse in the citizenship question used to derive these estimates has grown rapidly over the past 10 years, reaching 7.4% of the sample by 2019. This is a considerable issue when estimating the size and legal composition of the foreign-born population as the imputation procedure used to deal with nonresponse assumes that nonresponse is conditionally random. An assumption that has empirically been put into question (Brown et al., 2018).

In this paper, we produced credible interval estimates of the size of the foreign-born, non-citizen, and the undocumented immigrant populations that takes into account nonsampling error from item nonresponse following the approach in Manski (2016). This approach produces the maximum degree of uncertainty in the estimates of these population groups caused from item nonresponse by making no assumption on the distribution of legal status among item non-respondents. Interval estimates of the size of the foreign-born population in the US fall between 40.4 and 59.4 million as of 2019 compared to the Census point estimate of 44.9 million. Interval estimates of

the size of the undocumented population ranges between 9.3 and 15.2 million when taking into account nonresponse to the citizenship question only. These are considerably wide bounds compared to the widely accepted point estimates of around 11 million undocumented immigrants that have implicitly accepted that citizenship nonresponse is MAR. When taking into account item nonresponse from all questions used in the residual method to assign legal status, the size of the undocumented population fall between 7.3 and 23.3 million. Without making the strong assumption that nonresponse is MAR, item nonresponse creates considerable uncertainty in the estimates of the size and legal composition of the foreign-born population.

Recommendations for the Census Bureau: The Census Bureau's decision to reduce FEFU calls is a significant reason for the large increase in item nonresponse documented in the citizenship question. To reduce the rate of nonresponse, the Census will need to increase the rate of FEFU calls. Putting aside the methodological changes, nonresponse to the citizenship question has continued to rise over time, indicating that asking this question has become more sensitive. Increasing FEFU calls will not completely deal with the continued rise in nonresponse nor in dealing with the concern of misreporting. The Census should also consider improving the 'hot-deck' imputation method by adding more covariates and or replacing responses with administrative records when appropriate. More research needs to be done in understanding the causes and patterns of nonresponse to be able to produce accurate and less uncertain estimates of these hard to reach populations.

Recommendations for Researchers: All work that uses Census data as given implicitly accepts the MAR assumption that the non-respondent's citizenship status has the same distribution as respondents conditional on a set of observables. Using the Census estimates to estimate the effect of the size of foreign-born population on an outcome of interest may bias estimates. Using a sample that includes citizenship question non-respondents to estimate the effect of immigration policy on immigrant outcomes may also lead to biased estimates. Given that the distribution of legal status across non-respondents is unknown, these results suggest work using the citizenship question should use bounding estimates to fully take into account the uncertainty of the estimates. Aside from producing estimates using the given Census values, researchers could produce estimates us-

ing the lower and upper bound by assigning the extreme cases to the imputed values to capture this uncertainty.

While this paper focused the impact of item nonresponse in the citizenship question in estimating population counts, the issue of nonsampling error affects all sensitive questions asked in surveys. Measuring the degree of uncertainty and the pattern of nonresponse to a sensitive question of interest, as is done here, will be informative on the validity of the MAR assumption implemented and on the accuracy of the population counts and policy parameter estimates derived when using survey data. It is also important for researchers to note the methodology in which the survey is conducted. Whether the survey is conducted through self-response interview, in-person interviews, or a mix of both, will important implications on the demographics of the respondents.

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Figures

Figure 1: ACS Citizenship Question

8 **Is this person a citizen of the United States?**

Yes, born in the United States → *SKIP to question 10a*

Yes, born in Puerto Rico, Guam, the U.S. Virgin Islands, or Northern Marianas

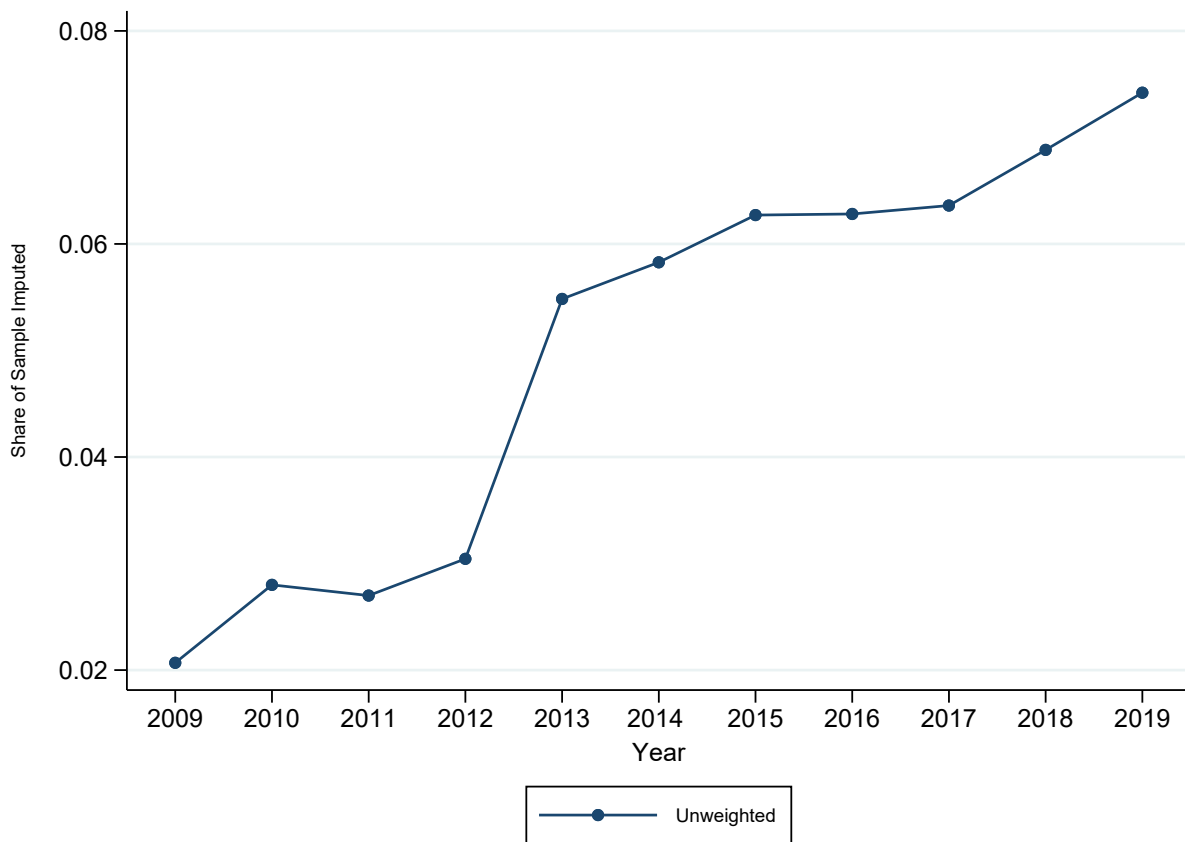
Yes, born abroad of U.S. citizen parent or parents

Yes, U.S. citizen by naturalization – *Print year of naturalization* ↙

No, not a U.S. citizen

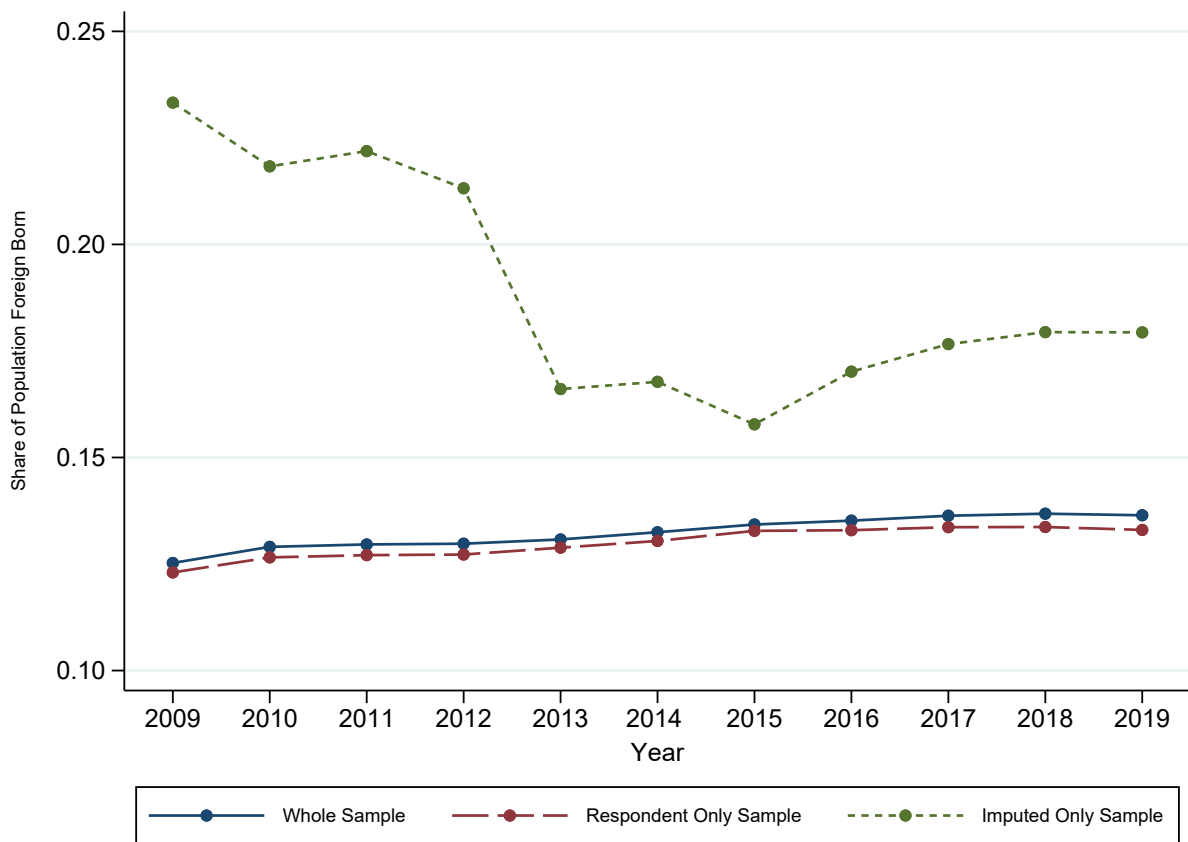
Source - 2019 American Community Survey Questionnaire

Figure 2: Share of Sample with Imputed Citizenship Question



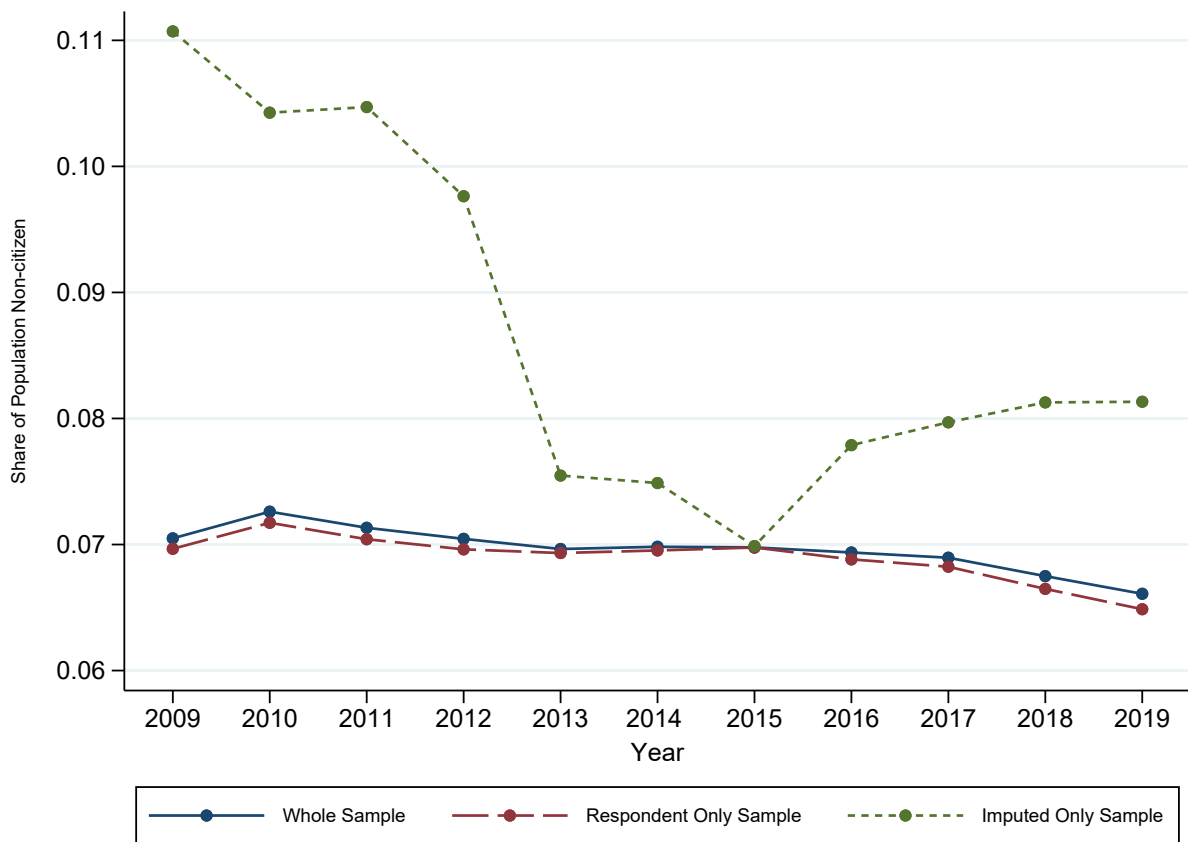
Source - Authors own calculations using the American Community Survey. Shares are the unweighted raw totals.

Figure 3: Share of Population Foreign-Born by Response Status



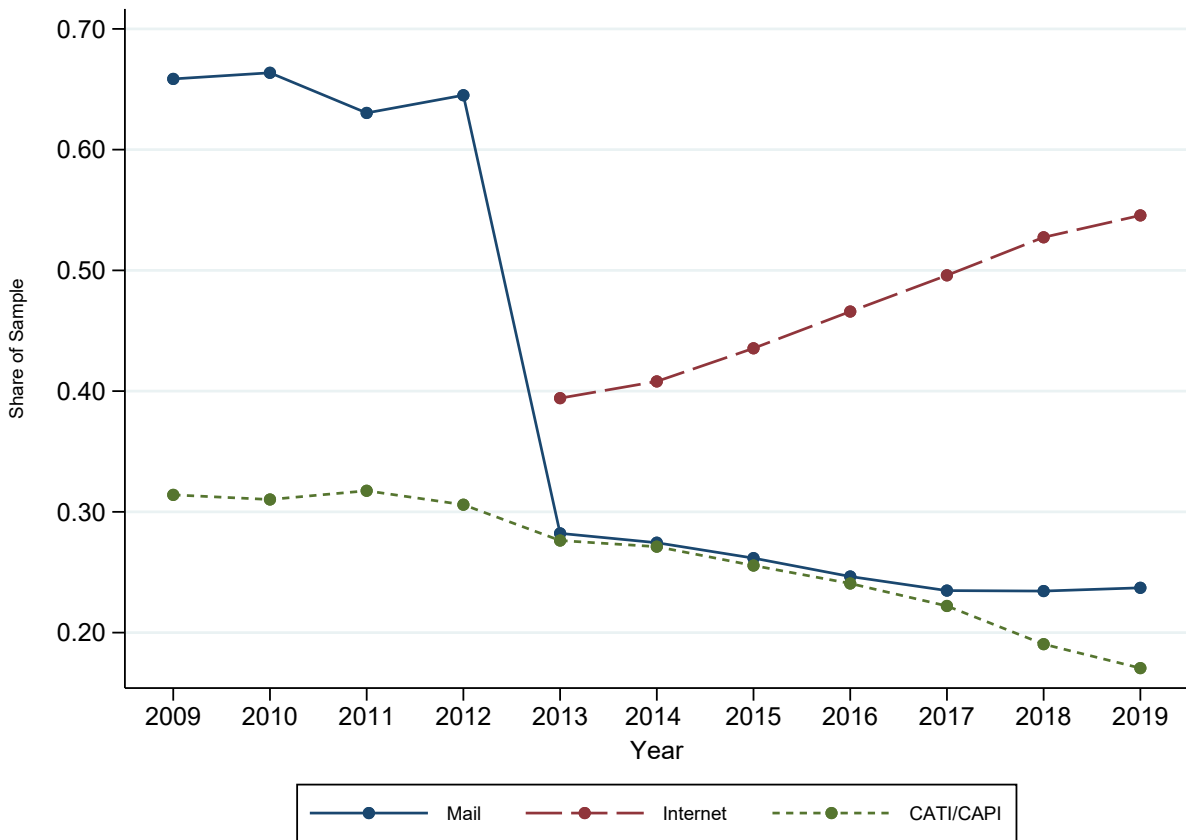
Source - Authors own calculations using the American Community Survey. Weights used are person weight provided by Census.

Figure 4: Share of Population Non-Citizen by Response Status



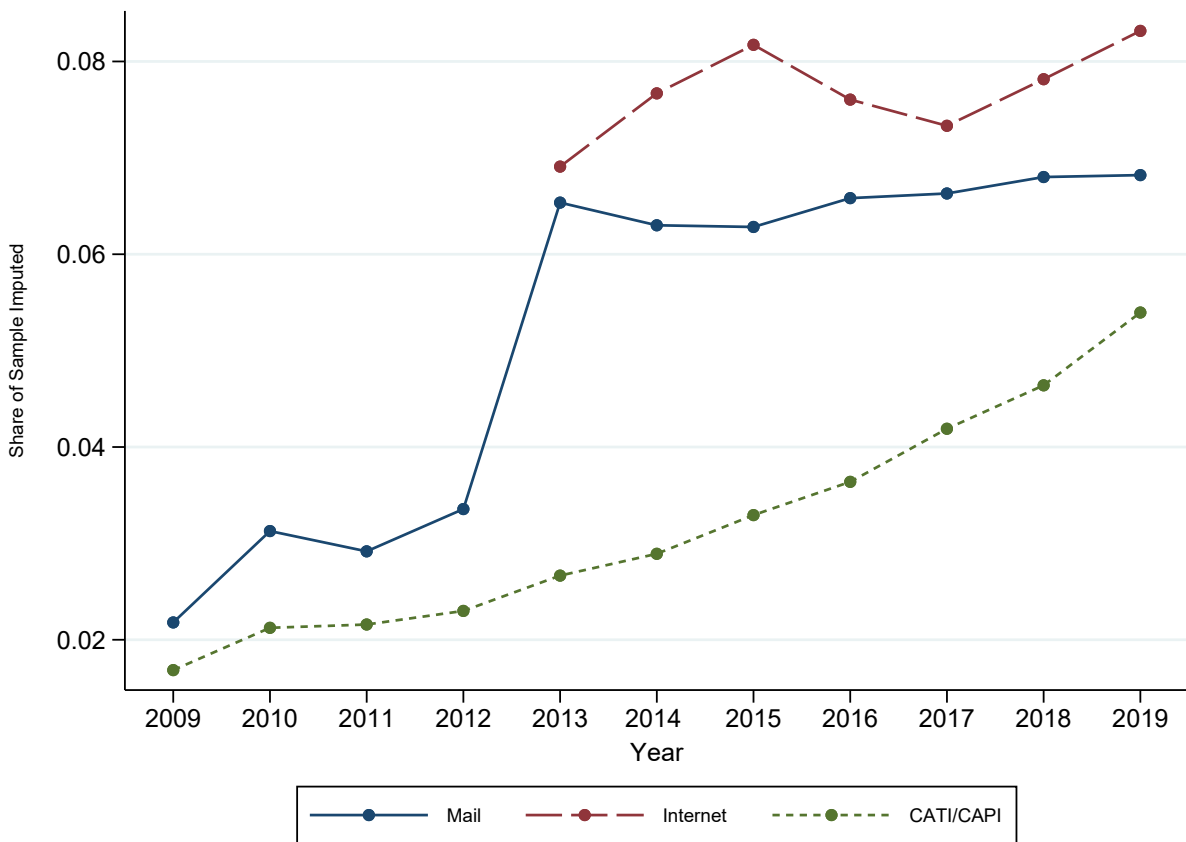
Source - Authors own calculations using the American Community Survey. Weights used are person weight provided by Census.

Figure 5: Share of Sample by Response Mode



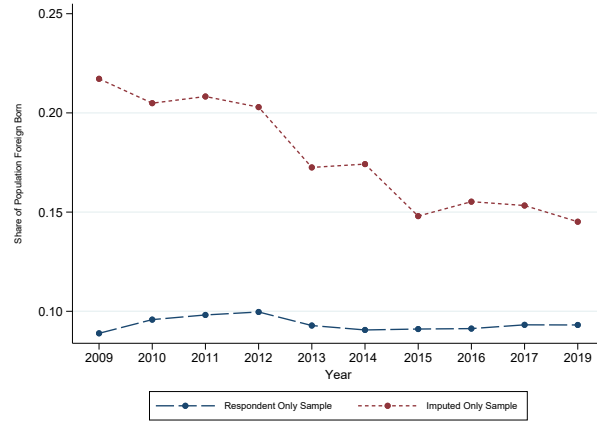
Source - Authors own calculations using the American Community Survey. Shares are the unweighted raw totals.

Figure 6: Share of Sample with Imputed Citizenship Question by Response Mode

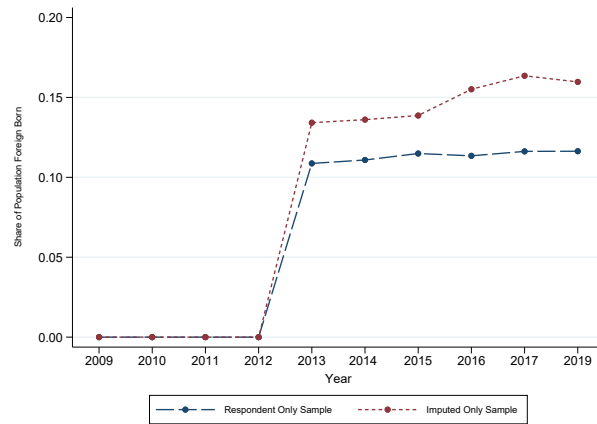


Source - Authors own calculations using the American Community Survey. Shares are the unweighted raw totals.

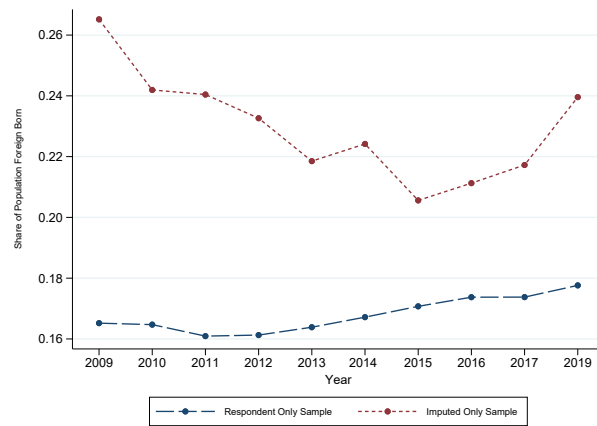
Figure 7: Share of Population Foreign-Born by Response Mode



(A) Responded by Mail



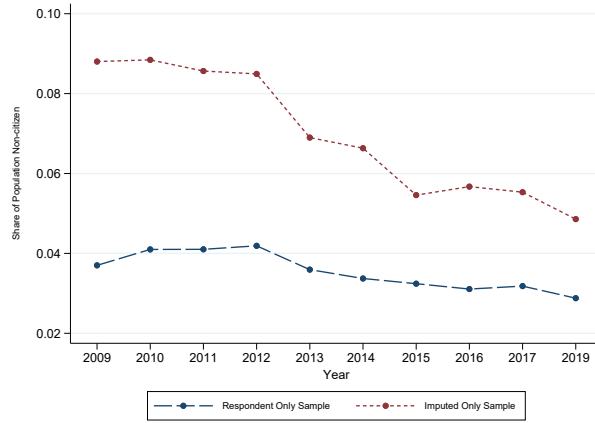
(B) Responded by Internet



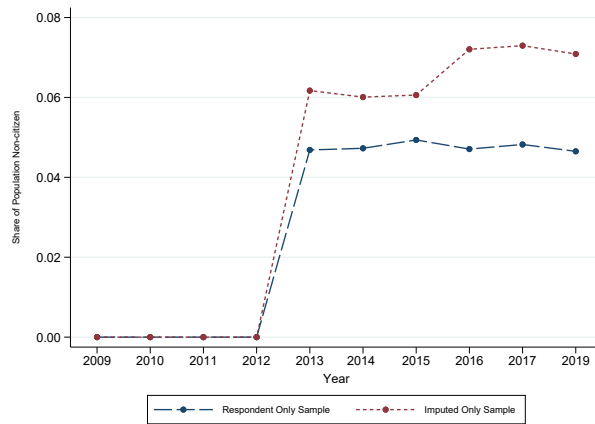
(C) Responded by CAPI/CATI

Source - Author's own calculations using the American Community Survey. Shares are calculated using census person weights.

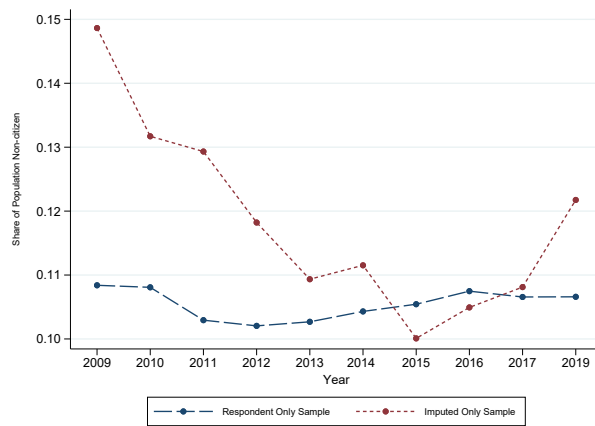
Figure 8: Share of Population Non-citizen by Response Mode



(A) Responded by Mail



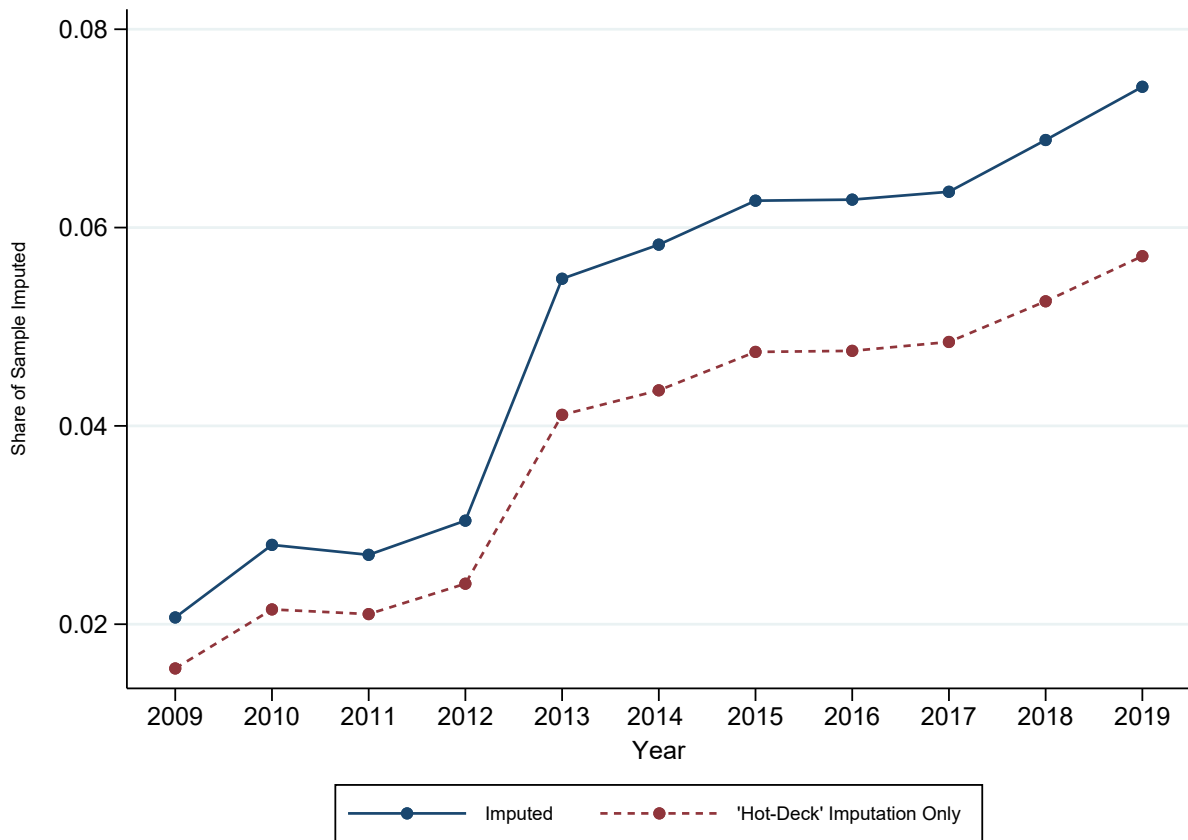
(B) Responded by Internet



(C) Responded by CAPI/CATI

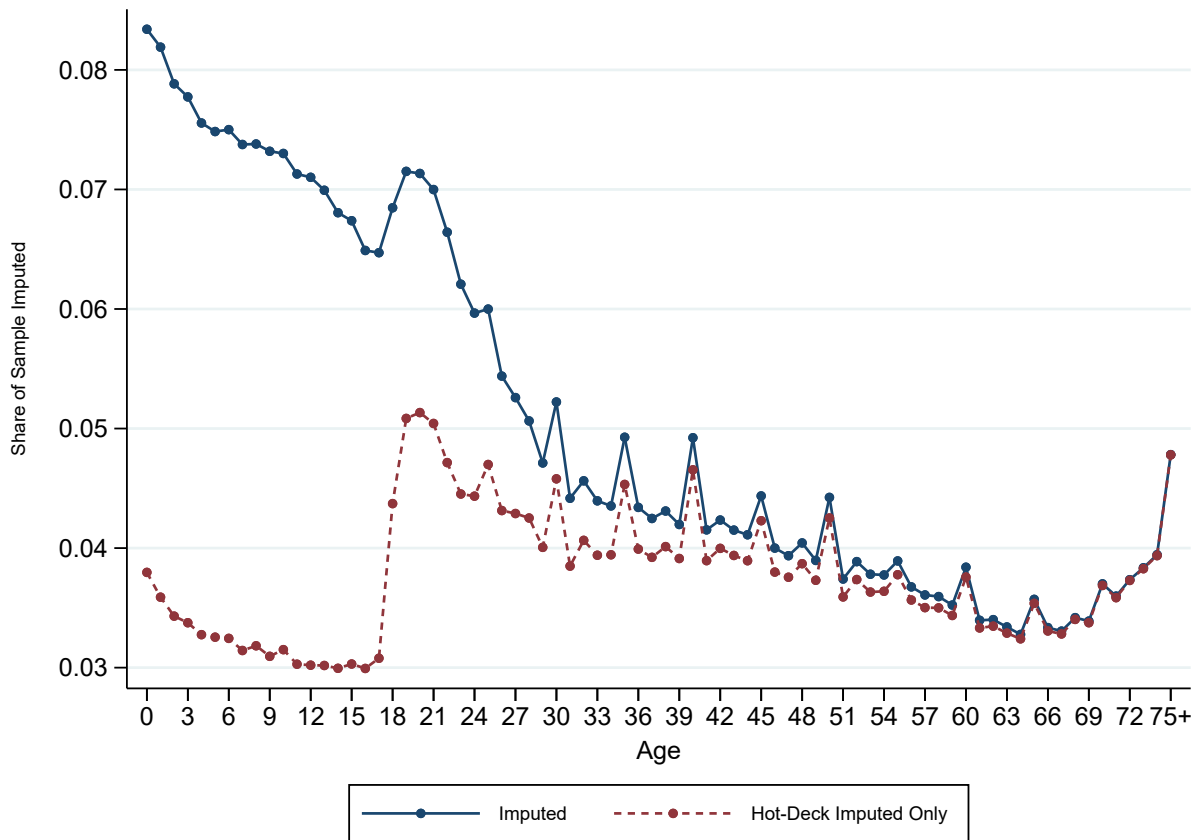
Source - Author's own calculations using the American Community Survey. Shares are calculated using census person weights.

Figure 9: Share of Sample with 'Hot-Deck' Imputed Citizenship Question



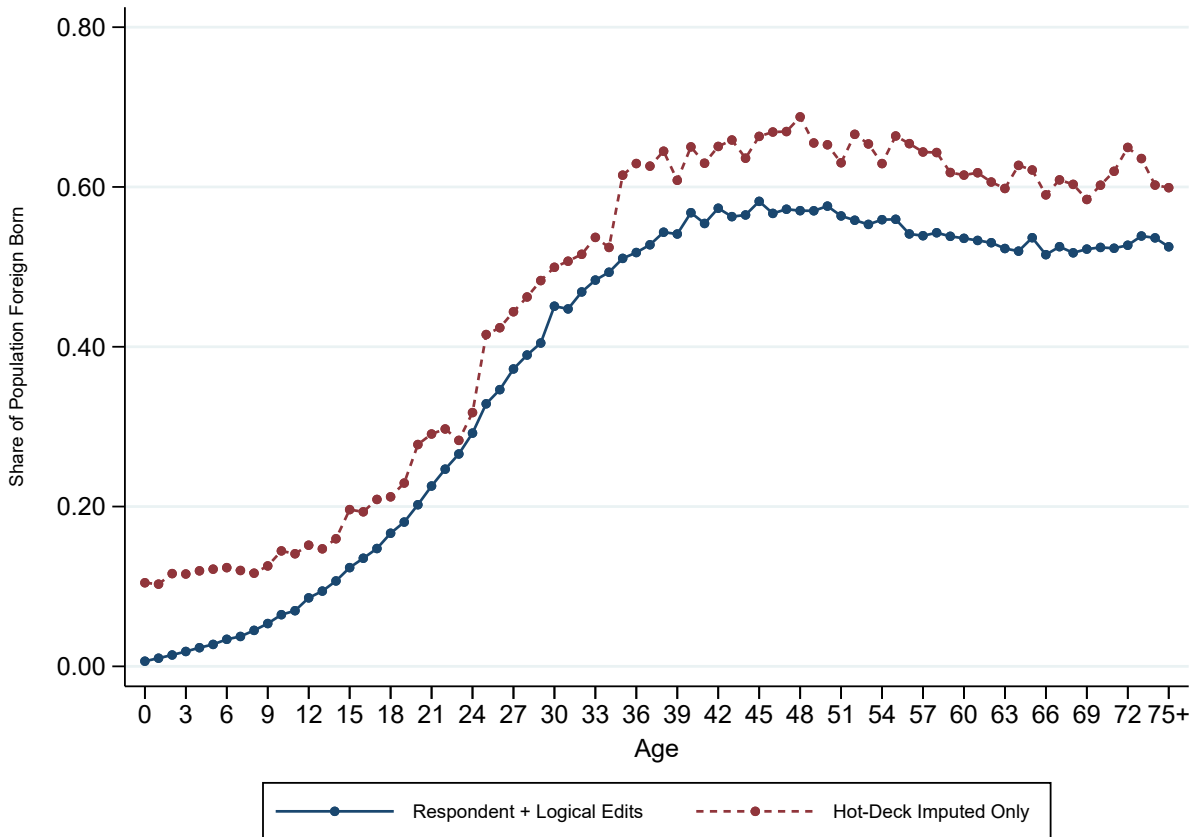
Source - Authors own calculations using the American Community Survey. The solid blue line is the share of the sample that are flagged as not responding to the citizenship question. The dashed red line is the share of the sample where citizenship could not be logically edited from additional data in the survey. Both shares are the unweighted raw totals.

Figure 10: Item Nonresponse in Citizenship Question Across Age



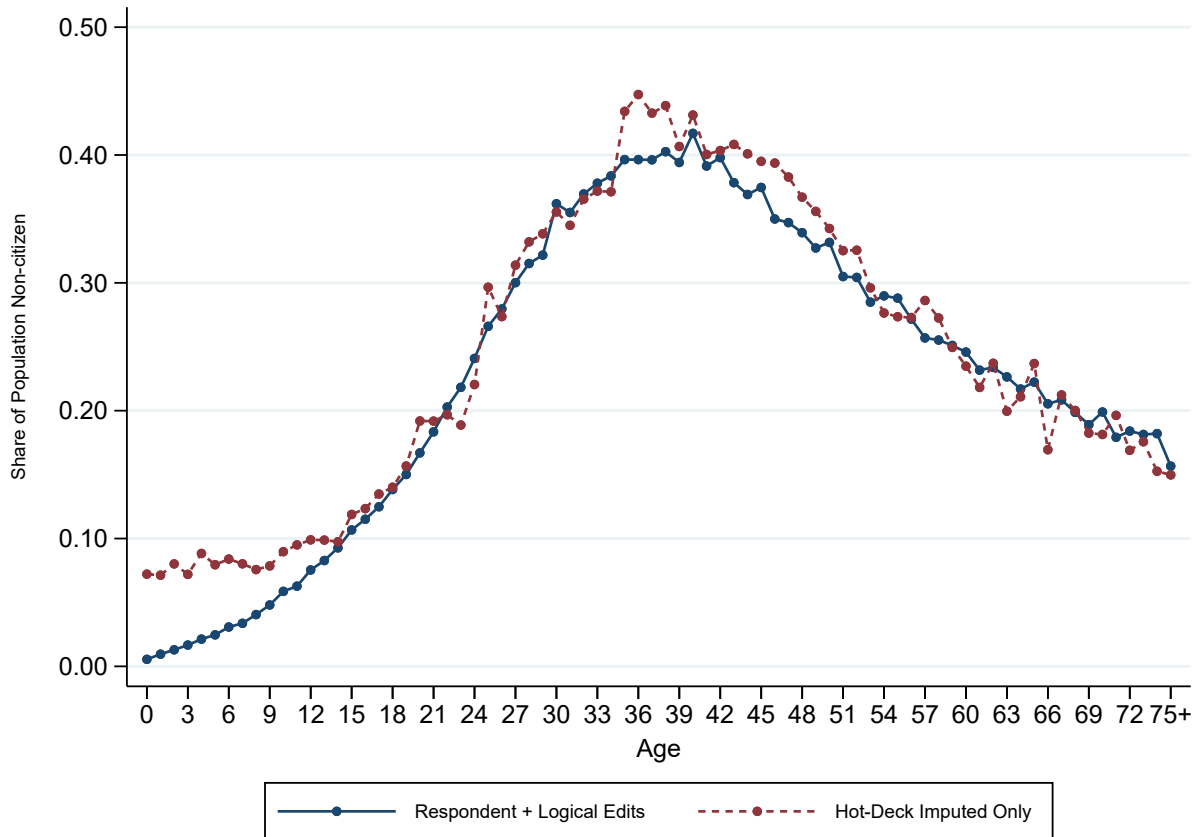
Source - Authors own calculations using the American Community Survey. Figure combines the sample years 2009 to 2019. The solid blue line is the share of the sample that are flagged as not responding to the citizenship question. The dashed red line is the share of the sample where citizenship could not be logically edited from additional data in the survey. Both shares are the unweighted raw totals.

Figure 11: Share Foreign-Born by Response Status Across Age



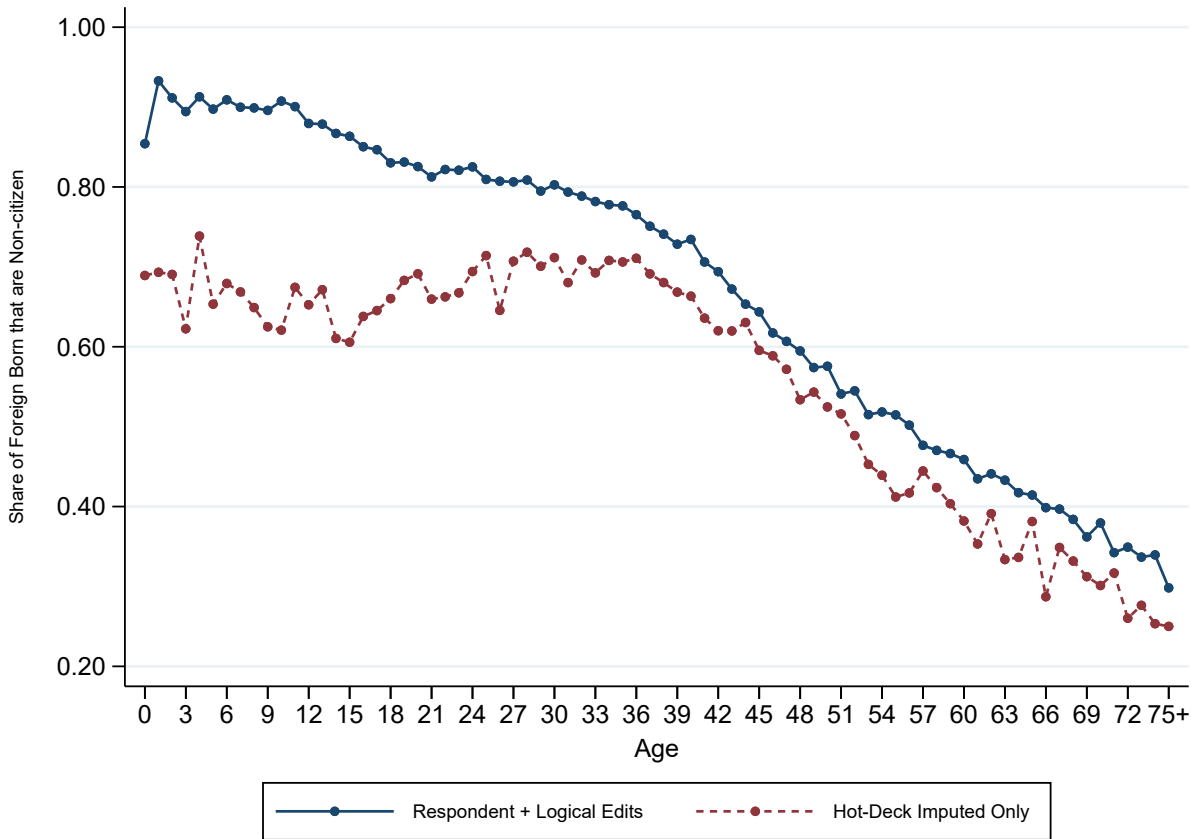
Source - Authors own calculations using the American Community Survey. Figure combines the sample years 2009 to 2019. Sample restricted to white Hispanics. The solid blue line is the share of the sample that are flagged as not responding to the citizenship question. The dashed red line is the share of the sample where citizenship could not be logically edited from additional data in the survey. Both shares are the unweighted raw totals.

Figure 12: Share Non-Citizen by Response Status Across Age



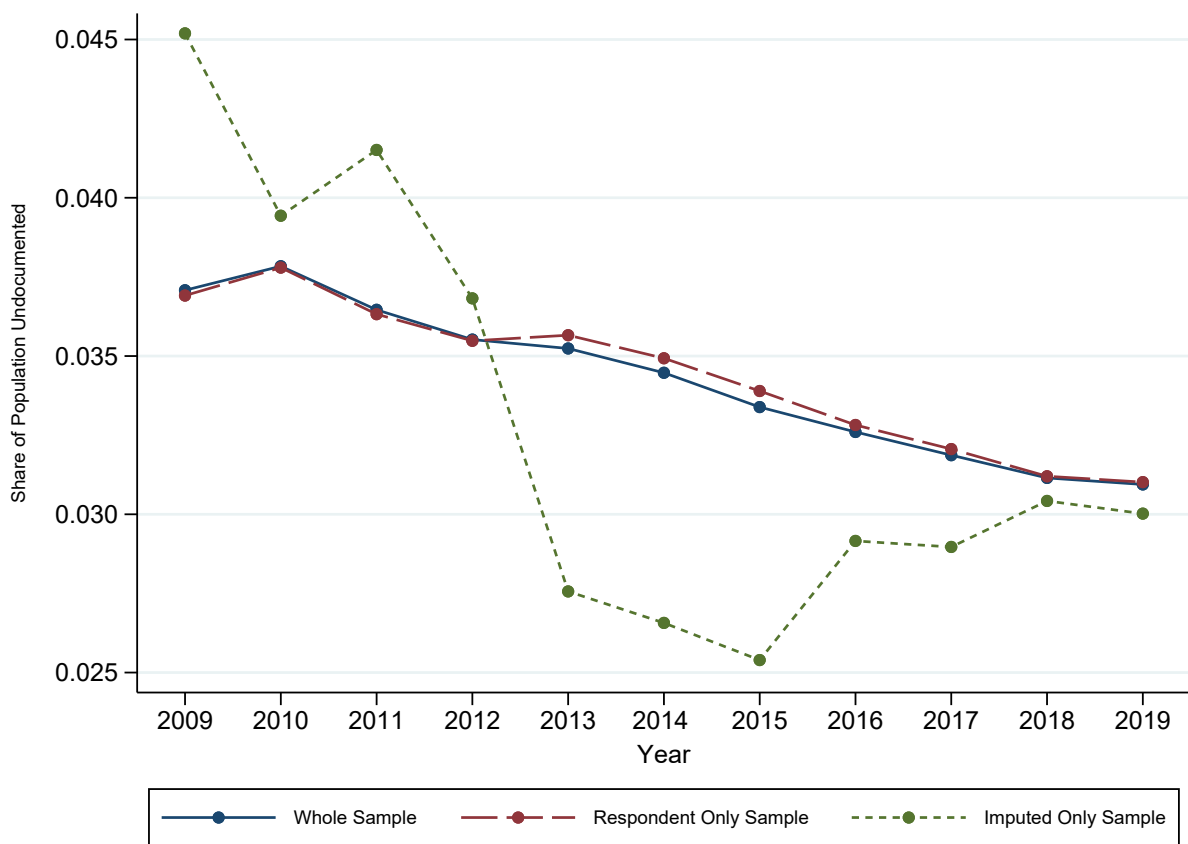
Source - Authors own calculations using the American Community Survey. Figure combines the sample years 2009 to 2019. Sample restricted to white Hispanics. The solid blue line is the share of the sample that are flagged as not responding to the citizenship question. The dashed red line is the share of the sample where citizenship could not be logically edited from additional data in the survey. Both shares are the unweighted raw totals.

Figure 13: Share Foreign-Born That is Non-Citizen by Response Status Across Age



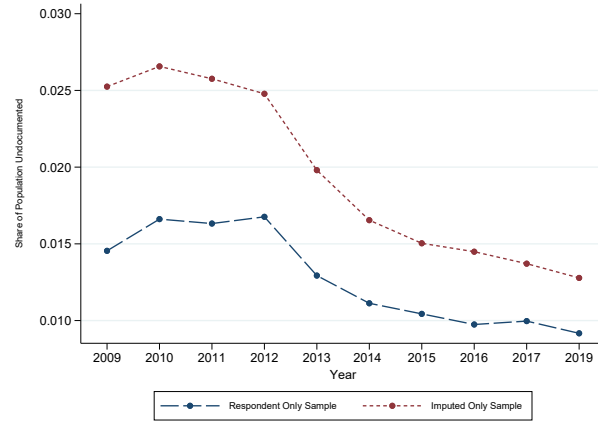
Source - Authors own calculations using the American Community Survey. Figure combines the sample years 2009 to 2019. Sample restricted to white Hispanics. The solid blue line is the share of the sample that are flagged as not responding to the citizenship question. The dashed red line is the share of the sample where citizenship could not be logically edited from additional data in the survey. Both shares are the unweighted raw totals.

Figure 14: Share of Population Undocumented by Response Status

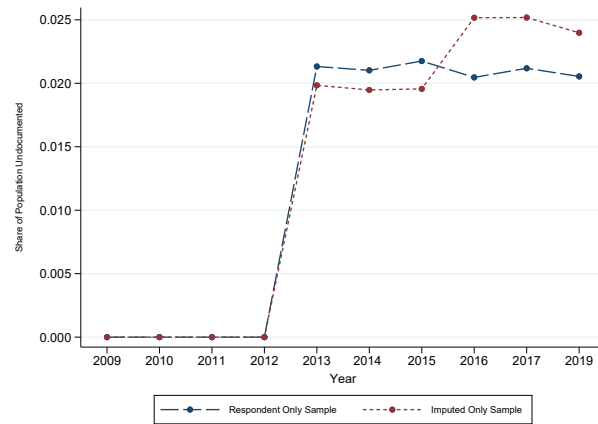


Source - Authors own calculations using the American Community Survey. Weights used are person weight provided by Census.

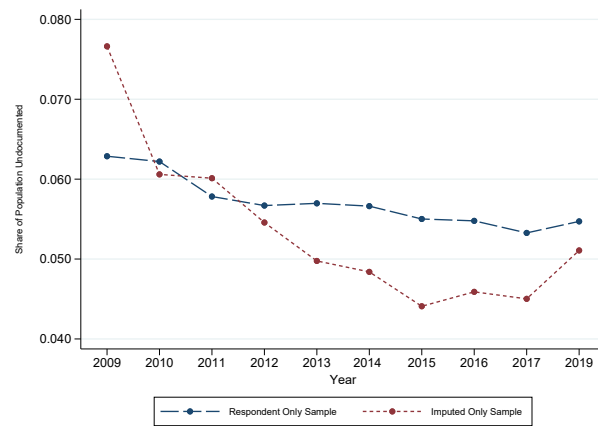
Figure 15: Share of Population Undocumented by Response Mode



(A) Responded by Mail



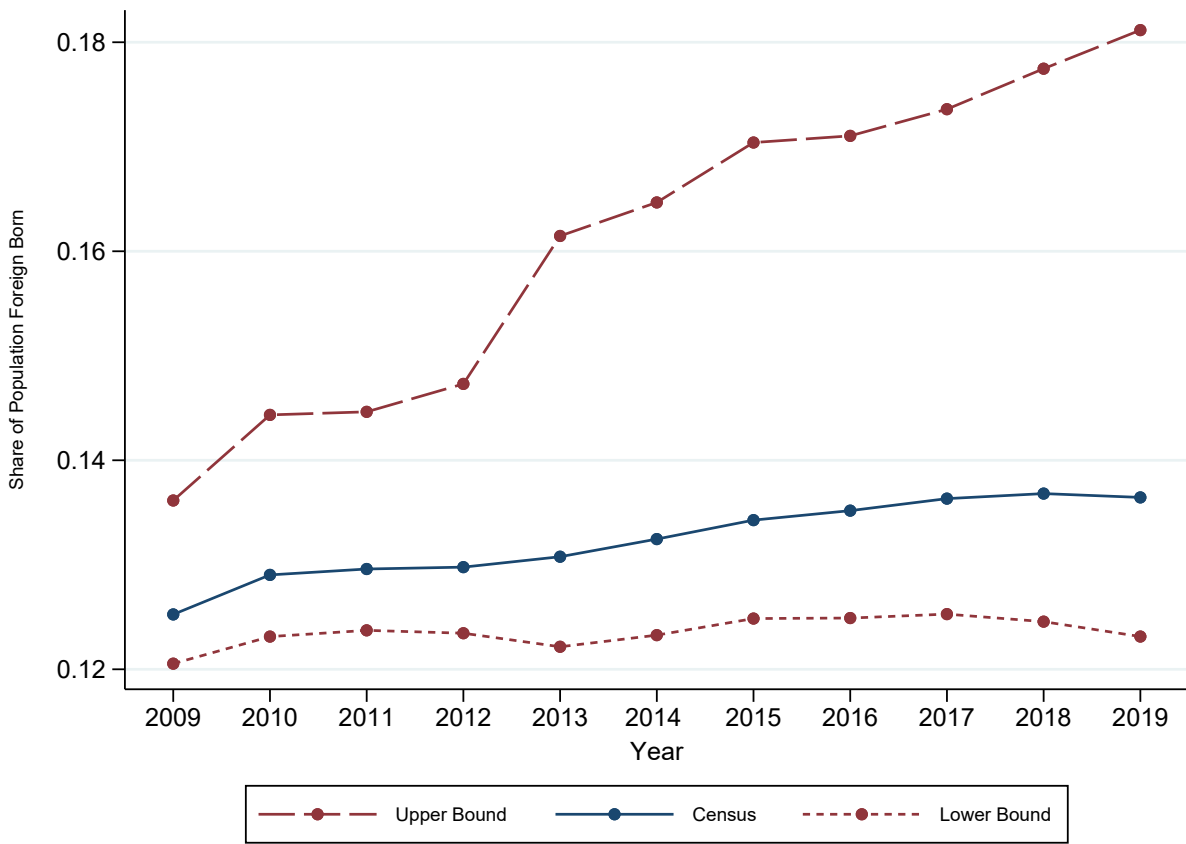
(B) Responded by Internet



(C) Responded by CAPI/CATI

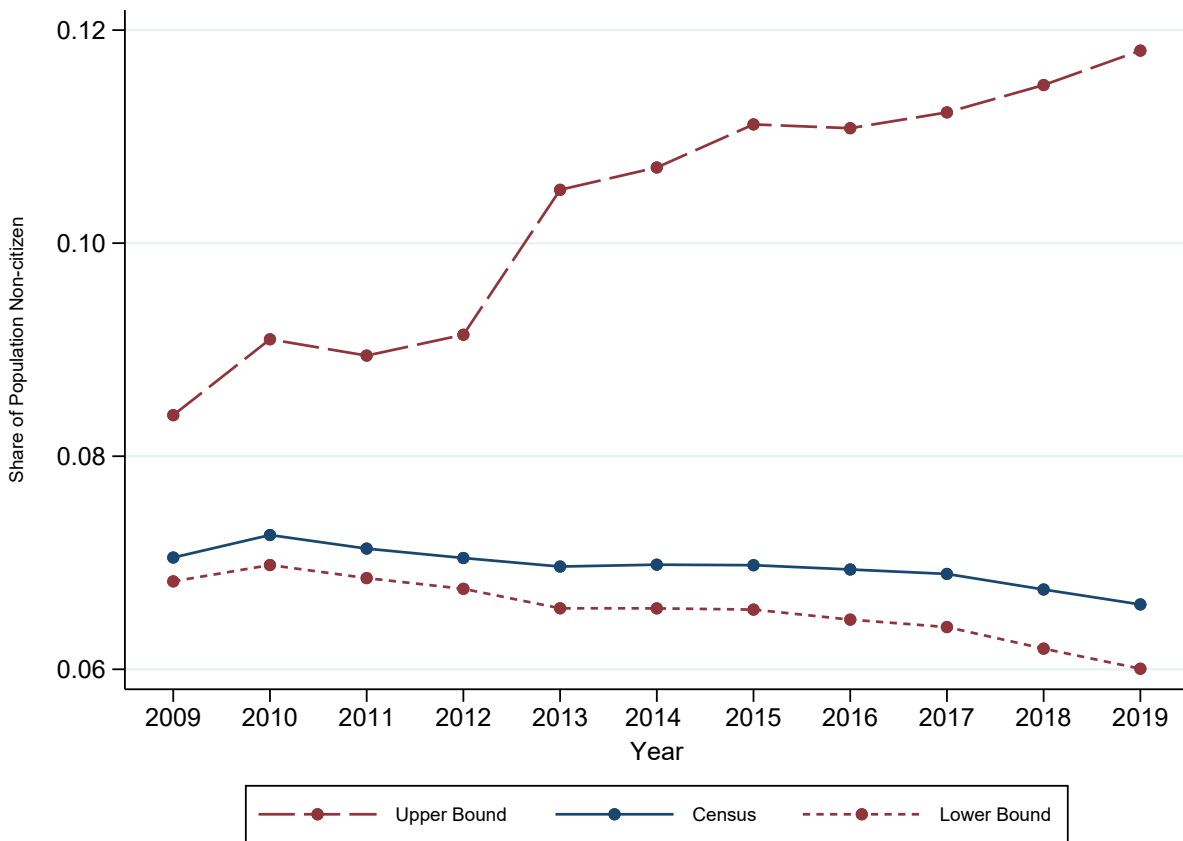
Source - Author's own calculations using the American Community Survey. Shares are calculated using census person weights.

Figure 16: Interval Estimates of the Share of Population that is Foreign-Born



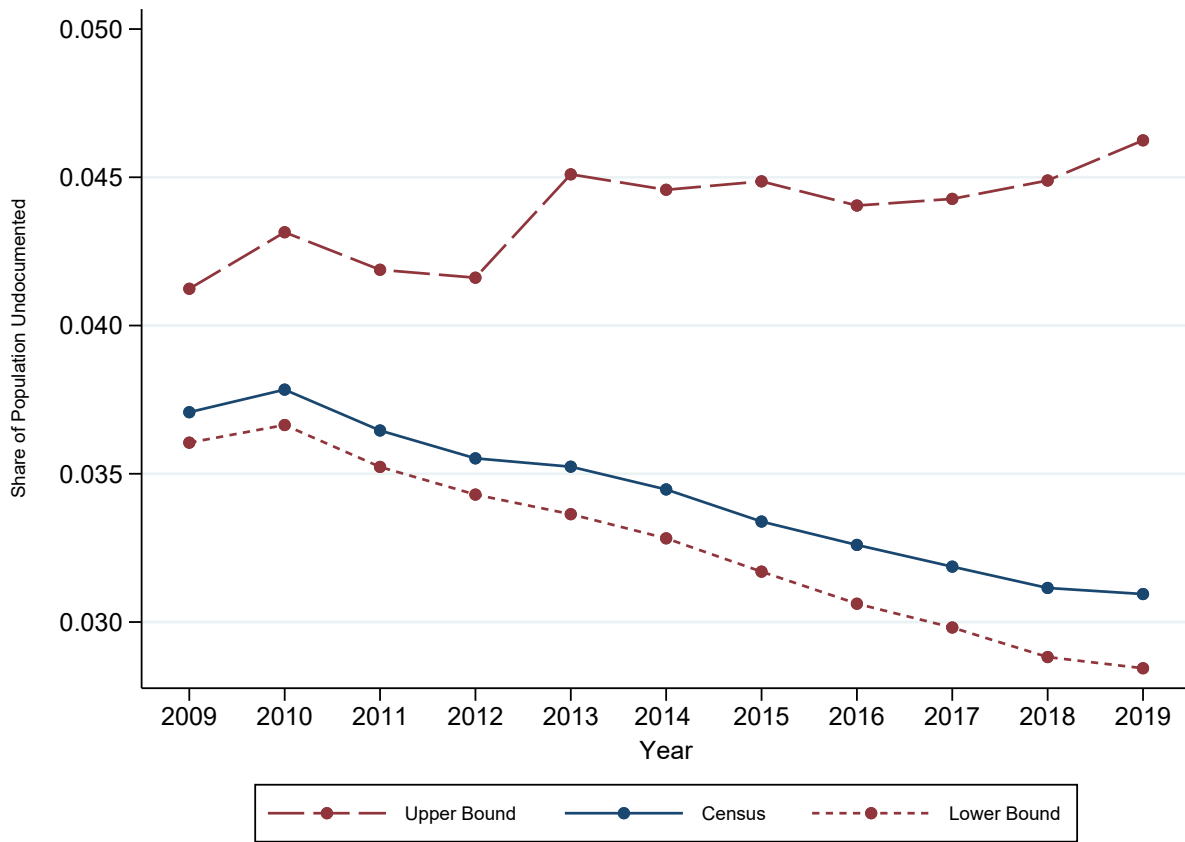
Note - The long-dash line represents the upper bound of the share of foreign-born in the population where all imputed values are assigned as foreign-born. The short-dash line represents the lower bound of the share of foreign-born in the population where all imputed values are assigned as native-born. The solid line represents the share of foreign-born in the population using the imputed values from the Census under the assumption that nonresponse is conditionally random. Estimates are weighted using Census person weights.

Figure 17: Credible Interval Estimates of the Share of Population that is Non-citizen



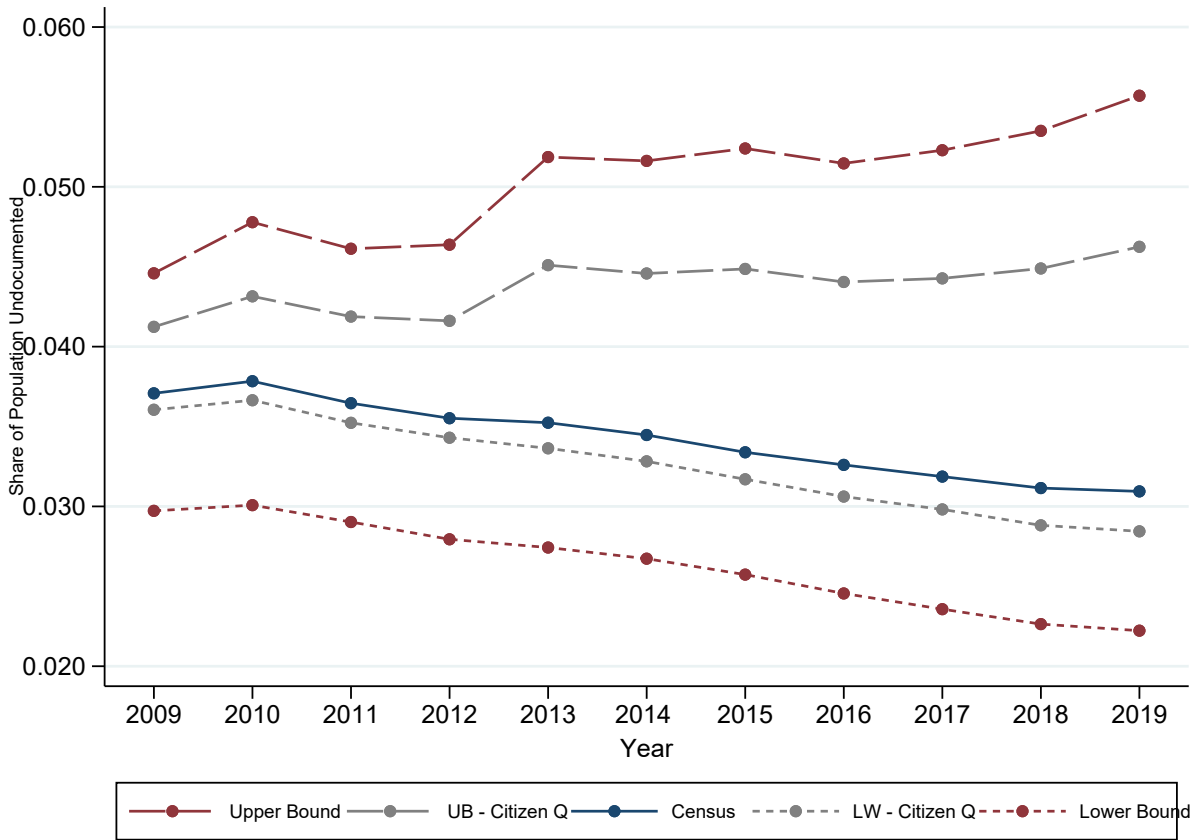
Note - The long-dash line represents the upper bound of the share of non-citizens in the population where all imputed values are assigned as non-citizens. The short-dash line represents the lower bound of the share of non-citizens in the population where all imputed values are assigned as native-born. The solid line represents the share of non-citizens in the population using the imputed values from the Census under the assumption that nonresponse is conditionally random. Estimates are weighted using Census person weights.

Figure 18: Credible Interval Estimates of the Share of Population that is undocumented



Note - The long-dash line represents the upper bound of the share of undocumented immigrants in the population where all imputed values are assigned as non-citizens. The short-dash line represents the lower bound of the share of non-citizens in the population where all imputed values are assigned as native-born. The solid line represents the share of non-citizens in the population using the imputed values from the Census under the assumption that nonresponse is conditionally random. After assignment the residual method procedure is conducted to create the estimates at each bound. Estimates are weighted using Census person weights.

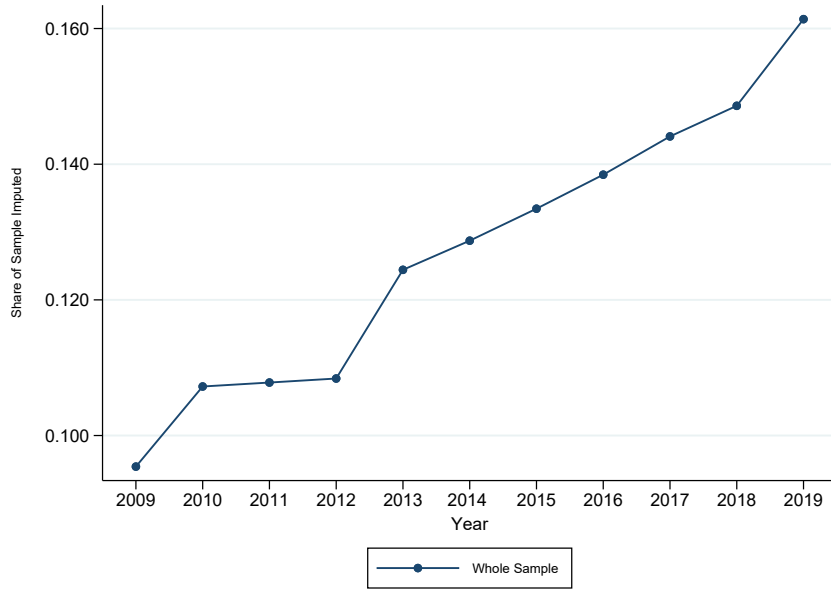
Figure 19: Credible Interval Estimates of the Share of Population that is undocumented



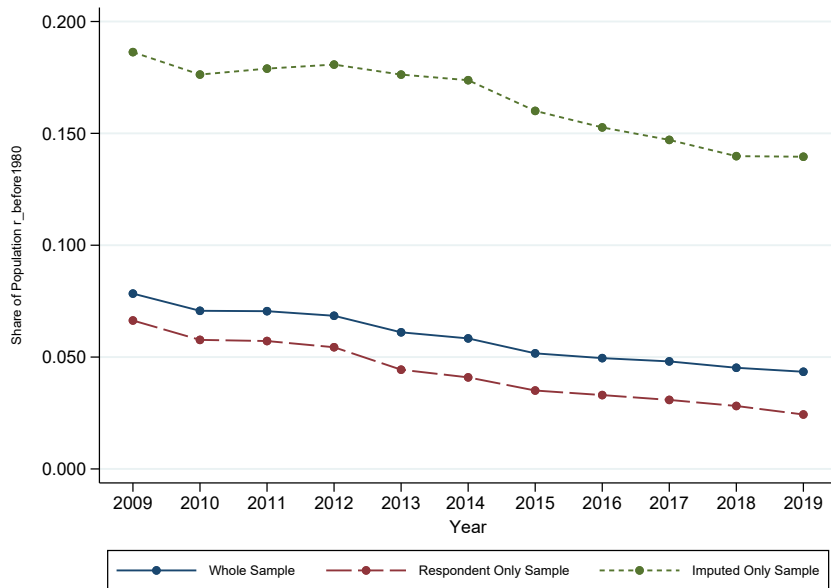
Note - The long-dash line represents the upper bound of the share of undocumented immigrants in the population where all imputed values are assigned as non-citizens. The short-dash line represents the lower bound of the share of non-citizens in the population where all imputed values are assigned as native-born. The solid line represents the share of non-citizens in the population using the imputed values from the Census under the assumption that nonresponse is conditionally random. After assignment the residual method procedure is conducted to create the estimates at each bound. Estimates are weighted using Census person weights.

A Supplementary Figures

Figure A.20: Year Immigrated Condition



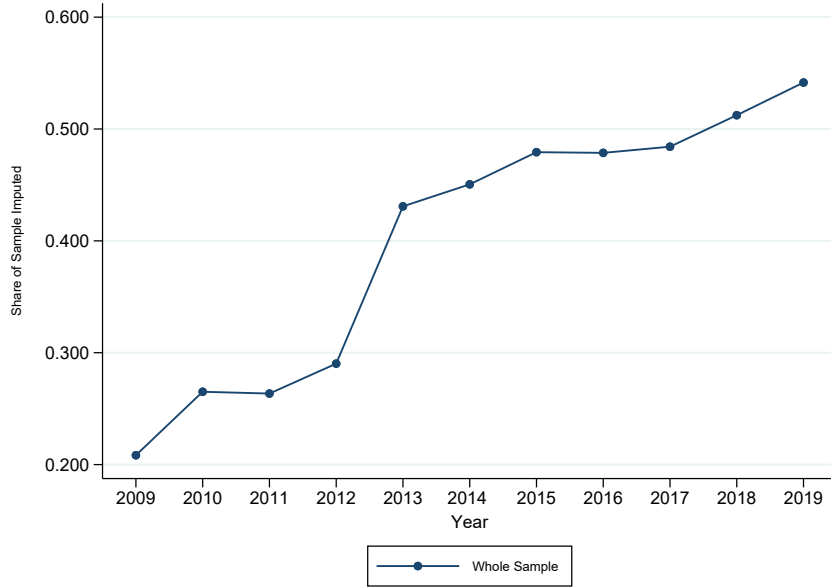
(A) Share of Sample with Imputed Year Immigrated Question



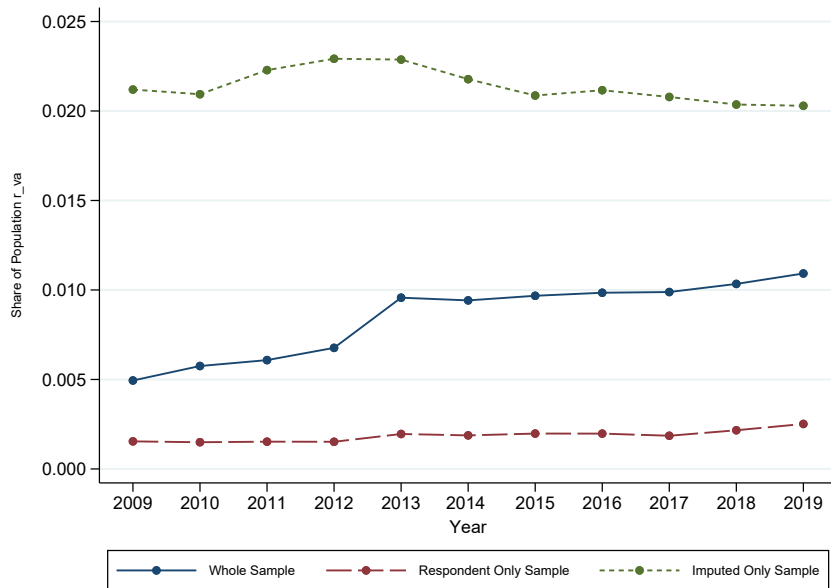
(B) Share of Sample that Satisfy condition by Question Response Status

Source - Author's own calculations using the American Community Survey. Sample is composed of all individuals that responded to the citizenship question as non-citizens and that those that did not respond to the citizenship question. Share of sample imputed is unweighted. Share of population by question response status are calculated using census person weights.

Figure A.21: Veteran's Insurance Condition



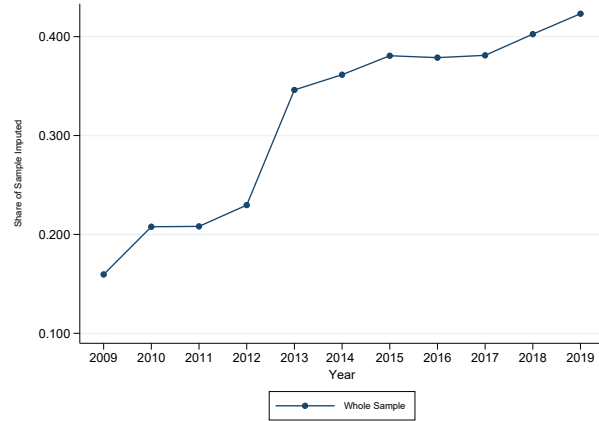
(A) Share of Sample with Imputed Veteran's Insurance Question



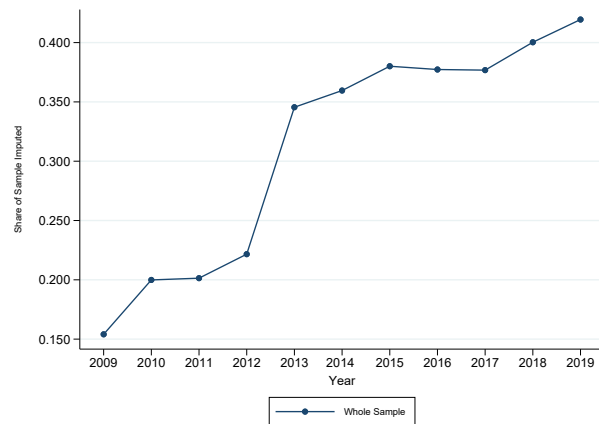
(B) Share of Sample that Satisfy condition by Question Response Status

Source - Author's own calculations using the American Community Survey. Sample is composed of all individuals that responded to the citizenship question as non-citizens and that those that did not respond to the citizenship question. Share of sample imputed is unweighted. Share of population by question response status are calculated using census person weights.

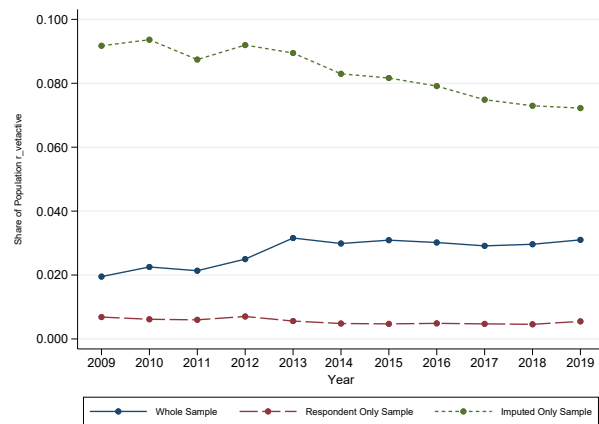
Figure A.22: Active Military or Veteran Condition



(A.1.) Share of Sample with Imputed Employment Status Question



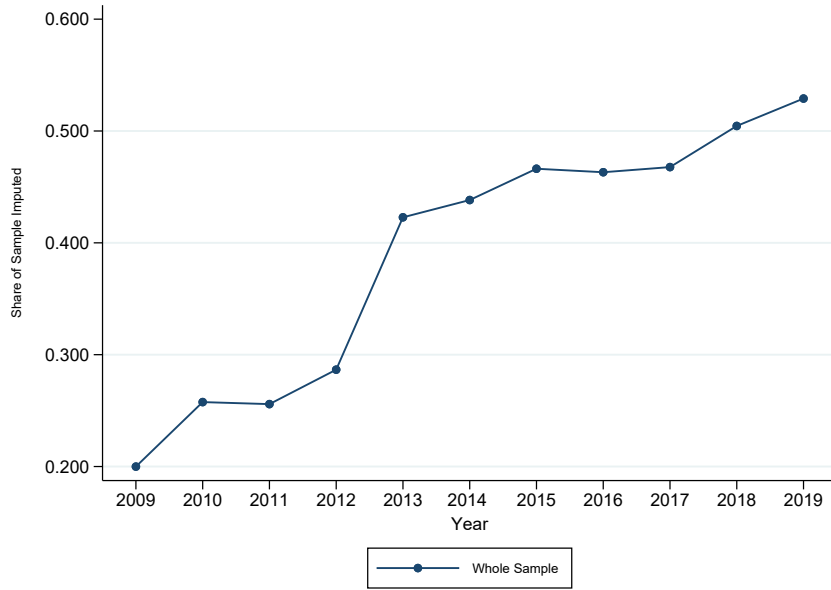
(A.2.) Share of Sample with Imputed Veteran Status Question



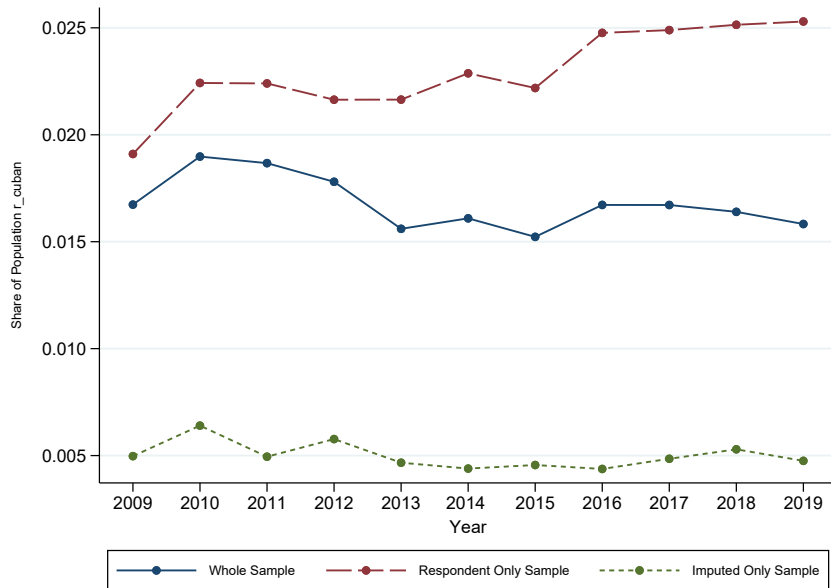
(B) Share of Sample that Satisfy condition by Question Response Status

Source - Author's own calculations using the American Community Survey. Sample is composed of all individuals that responded to the citizenship question as non-citizens and that those that did not respond to the citizenship question. Share of sample imputed is unweighted. Share of population by question response status are calculated using census person weights.

Figure A.23: Born in Cuba Condition



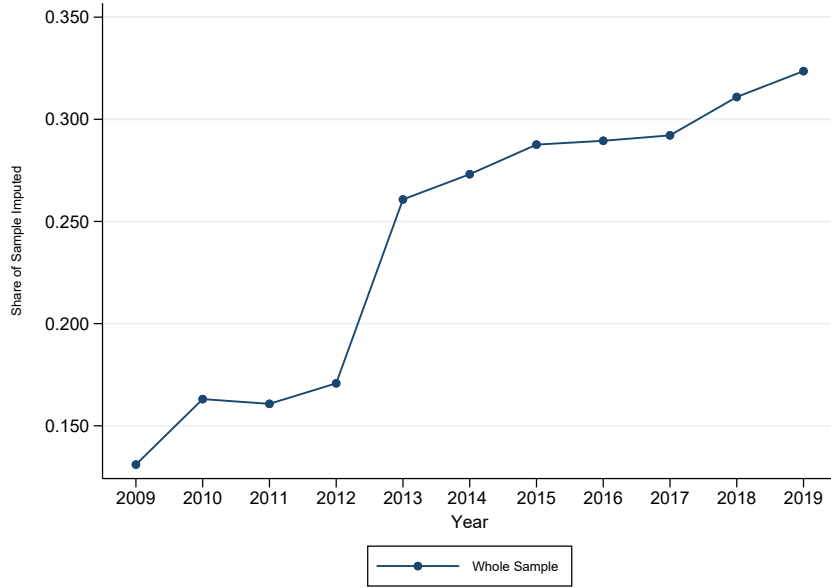
(A) Share of Sample with Imputed Place-of-Birth Question



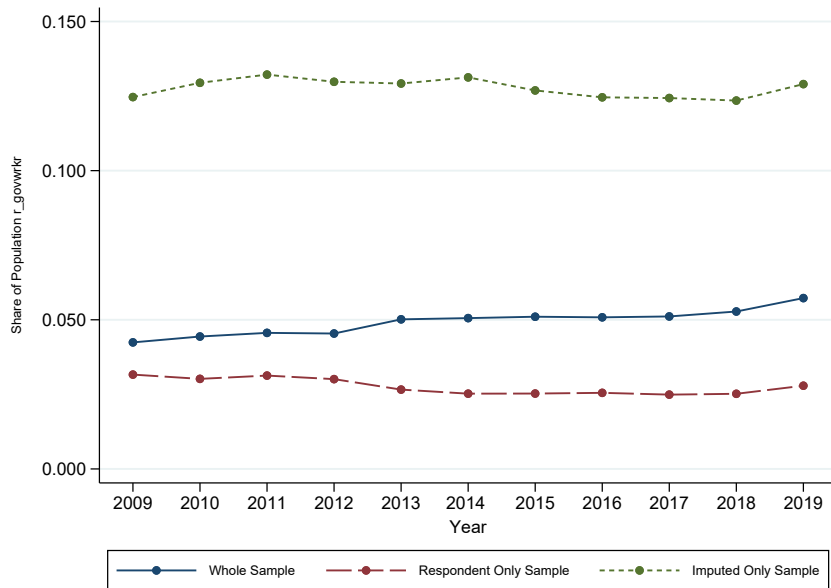
(B) Share of Sample that Satisfy condition by Question Response Status

Source - Author's own calculations using the American Community Survey. Sample is composed of all individuals that responded to the citizenship question as non-citizens and that those that did not respond to the citizenship question. Share of sample imputed is unweighted. Share of population by question response status are calculated using census person weights.

Figure A.24: Government Employee Condition



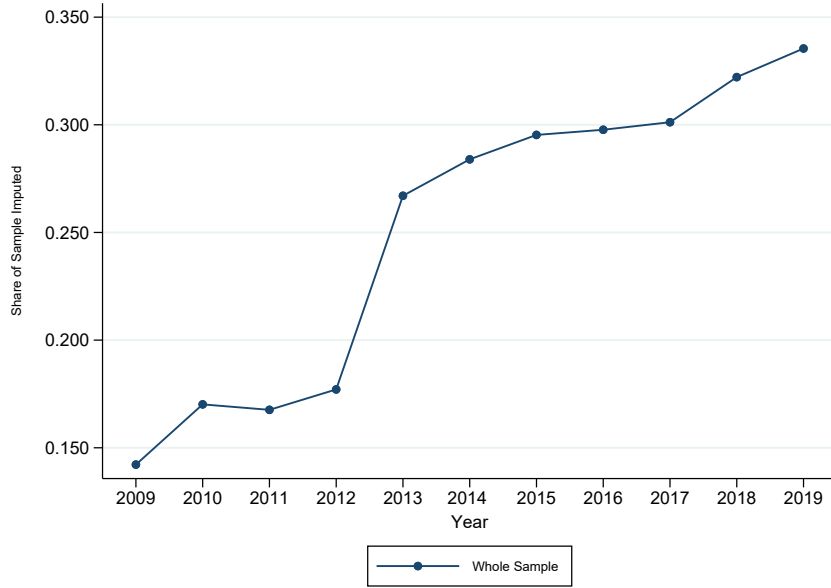
(A) Share of Sample with Imputed Class of Worker Question



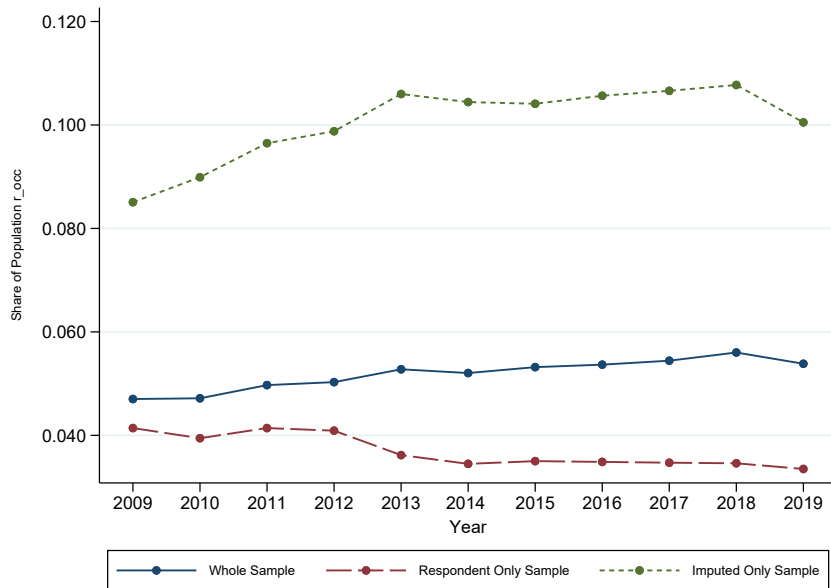
(B) Share of Sample that Satisfy condition by Question Response Status

Source - Author's own calculations using the American Community Survey. Sample is composed of all individuals that responded to the citizenship question as non-citizens and that those that did not respond to the citizenship question. Share of sample imputed is unweighted. Share of population by question response status are calculated using census person weights.

Figure A.25: Type of Occupation Condition



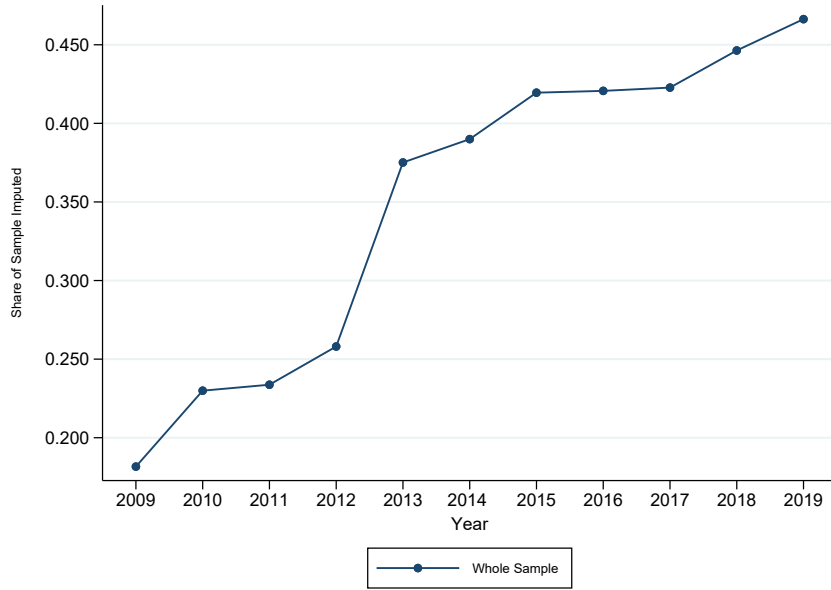
(A) Share of Sample with Imputed Occupation Question



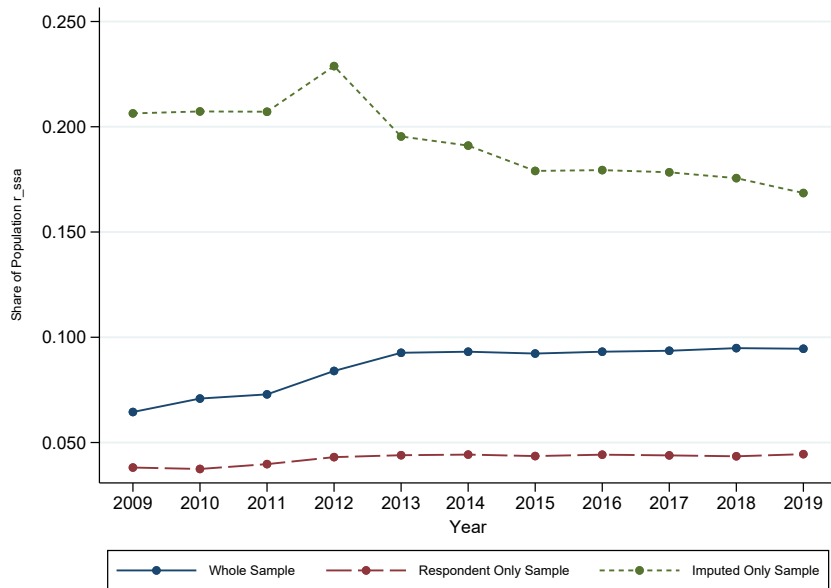
(B) Share of Sample that Satisfy condition by Question Response Status

Source - Author's own calculations using the American Community Survey. Sample is composed of all individuals that responded to the citizenship question as non-citizens and that those that did not respond to the citizenship question. Share of sample imputed is unweighted. Share of population by question response status are calculated using census person weights.

Figure A.26: Social Security Income Condition



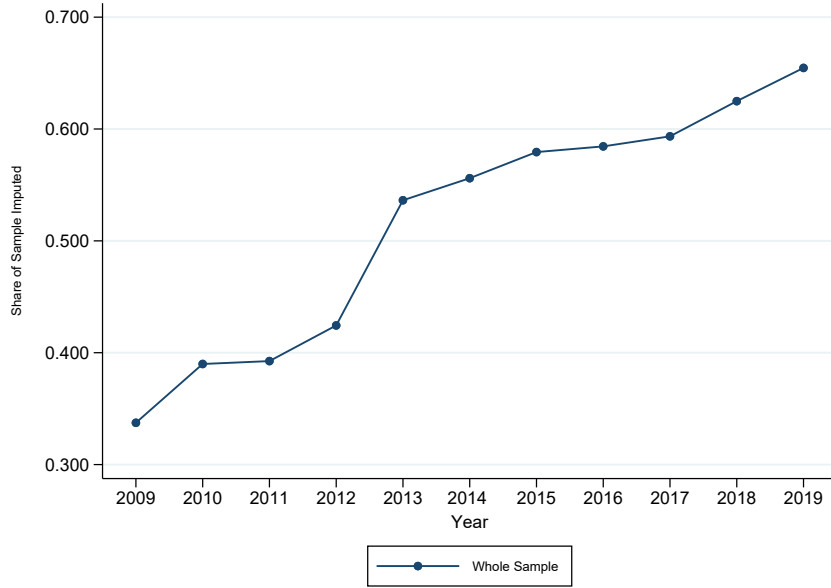
(A) Share of Sample with Imputed Social Security Income Question



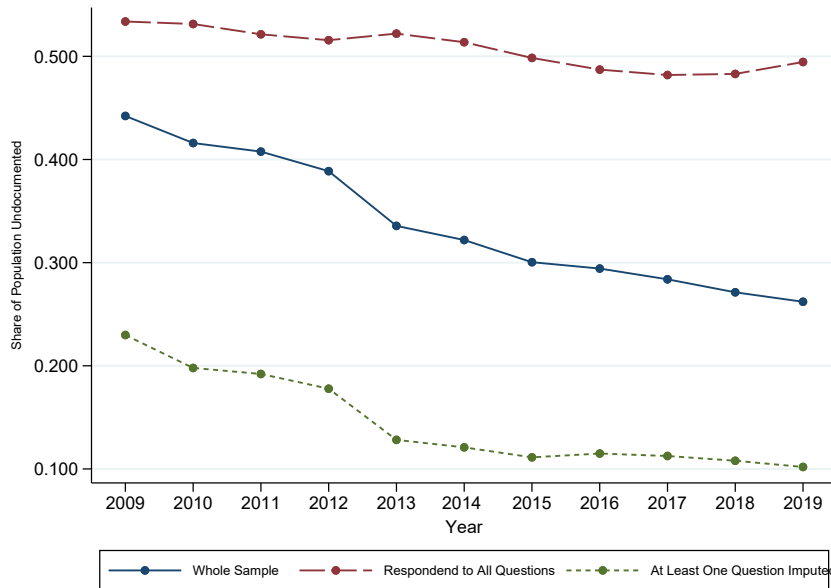
(B) Share of Sample that Satisfy condition by Question Response Status

Source - Author's own calculations using the American Community Survey. Sample is composed of all individuals that responded to the citizenship question as non-citizens and that those that did not respond to the citizenship question. Share of sample imputed is unweighted. Share of population by question response status are calculated using census person weights.

Figure A.27: All Conditions



(A) Share of Sample with at least one imputed Question



(B) Share of Sample Undocumented by Questions Response Status

Source - Author's own calculations using the American Community Survey. Sample is composed of all individuals that responded to the citizenship question as non-citizens and that those that did not respond to the citizenship question. Share of sample imputed is unweighted. Share of population by response status are calculated using census person weights.

B ACS Imputation Procedure for Citizenship Question

This section details the imputation procedure as provided by the Census to IPUMS. This imputation procedure is likely incomplete. The Census uses geographic information for the hot-deck imputation procedure of demographic information which is not mentioned here. As the Census does not provide a publicly available document detailing every step of the imputation procedure, it is not possible to know what or if any additional steps are taken by the Census in imputing item nonresponse in the citizenship question.

The Census imputation procedure provided to and released by IPUMS for citizenship, year of immigration, and year naturalized in the ACS is as follows:

- If a person reports being born in the United States when asked their birthplace (BPL) but reports not being born in the U.S. when asked if they are a U.S. citizen (CITIZEN), CITIZEN will be replaced with "Born in the U.S." When this happens, QCITIZEN will show the value is allocated.
- If year of immigration (YRIMMIG) is one year after the survey year, YRIMMIG will be replaced with the survey year.
- If a person reports being born in Puerto Rico, Guam, Northern Marianas, or the Virgin Islands when asked their birthplace (BPL) and either does not have a response for when asked about their citizenship, says they are a citizen but does not specify what type, says they were born in the U.S., or says they are not a citizen, CITIZEN will be replaced with "Born in the Puerto Rico, etc." When this happens, QCITIZEN will show the value is allocated.
- If a person is foreign-born (BPL) and either does not have a response for when asked about their citizenship, says they are a citizen but does not specify what type, says they are a citizen who was born in the U.S., or says they are a citizen who was born in Puerto Rico (CITIZEN), CITIZEN will be allocated based on their parents citizenship. If the person has a parent in

the household who is US-born, CITIZEN will be replaced with "Born abroad of American parents." If the parent is a naturalized citizen, CITIZEN will be replaced with "Naturalized citizen." If the parent is not a citizen, CITIZEN will be replaced with "Not a citizen." When this happens, QCITIZEN will show the value is allocated.

- RELATE is used to determine parents: A person with value of "parent" in RELATE is the parent to the reference person or brother/sister. The reference person and spouse are the parents to the son/daughter or foster child. The son/daughter or foster child of the reference person are parents to grandchildren of the reference person.
- If after the previous edits, a person still has a value of "Yes" for being a citizen, but does not specify which type of citizen or is missing (CITIZEN), and year of immigration is equal to or after the year they were born, CITIZEN will be allocated - the allocated value will be drawn from another person with the same age, race, and ethnicity. If year of immigration is also missing or is prior to when a person was born, CITIZEN and YRIMMIG will be allocated jointly - these values will be drawn from another person with the same age, race, and ethnicity. When this happens, QCITIZEN and/or QYRIMM will show the values are allocated.
- If after the previous edits, a person indicates they are a citizen who was born in the U.S. or Puerto Rico but lists a foreign birthplace (BPL), and year of immigration is equal to or after the year they were born, CITIZEN will be allocated - the allocated value is drawn from another person of a similar age, race, and ethnicity. If year of immigration is also missing or is prior to when a person was born, CITIZEN and YRIMMIG will be allocated jointly from another person with a similar age, race, and ethnicity. When this happens, QCITIZEN and/or QYRIMM will show the values are allocated.
- If a person reports being born in Puerto Rico, Guam, Northern Marianas, or the Virgin Islands when asked their birthplace (BPL) and says they are a citizen who was born abroad

to American parents or says they are a naturalized citizen, CITIZEN will be replaced with "Born in the Puerto Rico, etc." When this happens, QCITIZEN will show the value is allocated.

- If after the previous edits, a foreign-born (BPL) person still indicates being a naturalized citizen (CITIZEN), and year of immigration is after they[the] year they were born and either the same year as the survey year or the year before the survey year, CITIZEN will be replaced with "Not a citizen." When this happens, QCITIZEN will show the value is allocated.
- If a person reports being a citizen and born in the U.S. and they current live in one of the 50 states (STATE) or they report being a citizen who was born in Puerto Rico and they currently live in Puerto Rico, YRIMMIG will be replaced with "Not in universe."
- For respondents who are in universe for having a year of immigration, if YRIMMIG is not reported or if it is before the year a person was born, YRIMMIG will be allocated from another person with a similar age, race, and ethnicity. When this happens, QYRIMM will show the value is allocated.
- Beginning in 2008, if a person reports their year of naturalization as prior to 1883, reports being a naturalized citizen but leaves the year blank, reports a year of naturalization before they were born, or reports a year of naturalization after the survey year, YRNATUR will be allocated from someone else with a similar age (AGE), race (RACE), and ethnicity (HISPAN).
- Beginning in 2008, if a person reports not being a U.S. citizen or being born in the U.S., U.S. territories, or abroad to U.S. parents (CITIZEN) and reports a value for year of naturalization, YRNATUR will be replaced with a missing value.