Alternative Method for Projecting Foreign-Born Emigration

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ABSTRACT

Foreign-born emigration rates calculated using a residual method based on data for the period 2000 to 2010 were used to project emigrants from 2012 to 2060 in the U.S. Census Bureau's 2012 National Projections. This method is limited in that it produces average annual levels of emigration by the average age over the period. This paper examines an alternative method that estimates emigration using consecutive American Community Survey (ACS) files from 2006 to 2012. Because estimates produced this way are rough due to sampling and non-sampling error in the ACS, we smooth the estimates with the penalized least squares method on two dimensions: time (year of estimate) and age. This method will improve our ability to examine annual variation in foreign-born emigration levels as well as making them more precise by age.

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INTRODUCTION

The U.S. Census Bureau currently estimates emigration of the foreign-born population by estimating a set of emigration rates for the present and then applying those rates to the foreign-born population. For the 2012 National Projections, the Census Bureau estimated rates of foreign-born emigration using a residual method based on data for the period from 2000 to 2010. A limitation inherent to the residual approach is its lack of sensitivity to variation across time. Calculations of emigration between 2000 and 2010 produce the average level of emigration by the average age across the period. The severity of this issue increases as variation across time or by age increases. For example, let us assume that all emigration between 2000 and 2010 for the cohort aged 20 in 2000 (10,000) occurred at age 28 in 2008. The residual method estimates the value for this group as the total value averaged over the 10 years (10,000 / 10 = 1,000 per year) and attributes it to the average age of the cohort during the period (age in 2010 minus 5 = 25).

In this paper, we propose an alternative method to estimate rates of foreign-born emigration using a single-year approach. By estimating rates of emigration for single-year periods, rather than a ten-year period, we are better able to measure variation in annual levels and age of the foreign born emigrating from the United States. We will compare the two approaches by using the rates generated by each method to project foreign-born emigration, which also entails projecting the foreign-born population, for the period from 2012 to 2060. We will assess the magnitude of the difference in the emigration rates as well as the projections of foreign-born emigration and the foreign-born population. The results will provide insight to the method we will use to produce Census Bureau's next set of national population projections.

DATA AND METHODS

Foreign-born emigration is projected using emigration rates derived from two methods of estimating foreign-born emigration: a residual method and a single-year approach. In both

methods, the foreign-born emigration rates are produced and applied by arrival cohort, age, sex, and Hispanic origin. Rates are produced for three arrival cohorts: (1) immigrants who arrived in the past 0-9 years, (2) immigrants who arrived in the past 10-19 years, and (3) immigrants who arrived 20 or more years ago.

Calculating Emigration Rates Using the Residual Method

The residual rates are estimated using Census 2000 as the base population and the 2010 American Community Survey (ACS) as the target population.[1] We first survive forward the 2000 base population and post-2000 immigrants ten years to estimate an expected foreign-born population in 2010. To do this, we start with the foreign-born population on July 1, 2000, add one half of the immigrants that arrived in 2000, multiply the sum by 2000 survival rates, and then add one half of the 2001 immigrant arrivals.[2] This process is repeated for each year until the expected population on July 1, 2010 is achieved. The general equation for calculating an expected foreign-born population in each year between 2001 and 2010 is

$$E_{y+1} = (E_y + 0.5*I_y) * SR_y + 0.5*I_y \qquad\qquad (1)$$

where E_{y+1} is the expected foreign-born population in year *y+1*,
E_y is the expected foreign-born population in year *y* (the process is started with the base foreign-born population in 2000),
I_y is the estimated number of immigrants that arrived in year *y*, and
SR_y is the survival rates for year *y*.

 A residual estimate is calculated by subtracting the 2010 foreign-born population estimated using the 2010 ACS from the 2010 expected population from Equation 1. This estimate of foreign-born

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[1] Data from the ACS are used to estimate the foreign-born population in 2010 because the 2010 Census did not collect data on the foreign born. The ACS data are based on a sample and are subject to sampling variability. For information on confidentiality protection, sampling error, nonsampling error, and definitions see http://www.census.gov/acs.
[2] Due to the continuous nature of migration, with migrants arriving throughout the year rather than all at one point in time, migrants are not at risk of dying for the full year. If we were to add in all of the immigrants at the beginning of the interval and survive them forward by subtracting out deaths to the group, we would overestimate the number of deaths for the immigrant arrivals in that year. Instead, we add half of the immigrants at the beginning of the period and survive them forward to the end of the interval by subtracting out deaths. We then add in the other half of the immigrants, which were not subjected to mortality.

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emigration is converted into an annual emigration rate by dividing the residual estimate by the

estimated number of person years lived during the ten-year period (Equation 2).

$$R_{2000\text{-}2010} = (E_{2010} - P_{2010})/ (\sum E_{y+1})* 1000 \tag{2}$$

> where $R_{2000\text{-}2010}$ is an annual rate of emigration for the years 2000 to 2010, expressed as the number of emigrants per 1,000 population,
> E_{2010} is the expected foreign-born population in 2010 from Equation 1,
> P_{2010} is the estimated foreign-born population from the 2010 ACS, and
> $\sum E_{y+1}$ is the cumulative person years lived between 2000 and 2010, calculated by summing E_{2001} through E_{2010} from Equation 1.

The emigration rates were smoothed using penalized least squares. For the ages where the rates

become negative, they are modeled using mathematical curves between the non-negative points.

Calculating Emigration Rates Using the Single-Year Approach

In our alternative approach, single-year ACS data for the period from 2006 to 2012 are used

to estimate annual rates of emigration for the foreign born from one year to the next. Similar to the

method used to estimate the number of foreign-born emigrants in the residual method, we begin by

estimating the number of foreign-born emigrants for each year from 2007 to 2012. The estimates

for each year are produced by first calculating the expected population for that year. The expected

population is produced by adding half of the immigrants for that year (y) to the initial population in

the previous year (y-1), surviving that population forward to the next year, and then adding the

other half of the immigrants (similar to Equation 1). The estimated population, which is the ACS

estimate of the foreign-born population for that year, is subtracted from the expected population to

provide an estimate of how many foreign-born persons emigrated during that year.

The annual estimates of foreign-born emigration are then converted into a rate by dividing

the estimate by the number of person years lived during that year. The rates are smoothed using

penalized least squares on 2 dimensions: time (year of estimate) and age. Values for ages where the

rates are negative are modeled using mathematical curves between the non-negative points. Values

for the last 5 years will be averaged for the final set of rates. Future projection series will also begin

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with the 2006 ACS data (as it was the first year the ACS was fully implemented), but will add each new year as it becomes available.

Projecting Foreign-Born Population

The foreign-born population is projected by applying the emigration rates generated by each of the methods described above to the foreign-born population. The same set of rates, by arrival cohort, age, sex, and Hispanic origin, are used for all projected years in both series. For example, to estimate the emigration of the foreign born between 2010 and 2011, the foreign-born population is projected for 2011 by aging the foreign-born population from the 2010 ACS forward one year, subtracting out deaths and emigrants, and adding the projected number of immigrants for that year.[3] The rates are then applied to the foreign-born population for 2011 to calculate the number of projected emigrants for that year. The general equation for the projected foreign-born population in a projection year is

$$Pr_{y+1} = Pr_y * SR_y * R_y + Pi_y \qquad\qquad (1)$$

where Pr_{y+1} is the projected foreign-born population in year *y+1*,
Pr_y is the projected foreign-born population in year *y* (the process is started with the estimated base foreign-born population in 2010),
SR_y is the projected survival rates for year *y*,
R_y is the annual rate of emigration calculated using each method described above for year *y*, and
Pi_y is the projected number of immigrants in year *y*.

This process is then repeated each year until 2060.

RESULTS

The alternative methods for estimating foreign-born emigration rates discussed in this paper will allow us to examine annual variation in emigration, whereas the residual method reveals

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[3] Deaths are calculated using the projected survival ratios that were developed for the mortality component of the 2012 National Projections (U.S. Census Bureau, 2012). Mortality rates were developed by age, sex, race, and Hispanic origin. The mortality schedules have not yet been produced by nativity, so the same series of rates are applied to the foreign-born as applied to the total U.S. population in our population projections. Future research will address the feasibility of estimating and projecting mortality rates for the foreign born.

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only average annual levels. It will also us to estimate rates by age rather than average age over a period. This should improve our ability to capture variation from one age to the next.

The residual method and single-year approach will be evaluated by comparing differences in the rates themselves as well as by examining differences in the projections of foreign-born emigration and the foreign-born population for the period from 2012 to 2060.

REFERENCES

U.S. Census Bureau. 2012. *2012 National Projections.*
    <http://www.census.gov/population/projections>.