Puerto Rican Exodus: One Year Since Hurricane Maria

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One year since Hurricane Maria made landfall in Puerto Rico on September 20, 2017, nearly 160,000 residents of the island have relocated to the United States. This exodus represents one of the most significant movements of Puerto Ricans to the U.S. mainland in the island's history in terms of both volume and duration. The new emigration estimates — of 159,415 with an upper bound confidence interval of 176,603 — is as high as the net migration flow in the previous two years combined (144,801).[1]

However, measuring population movement in real time, especially after a natural disaster like Hurricane Maria, continues to be a major undertaking that presents various methodological challenges. The need for migration estimates drew attention in states that experienced an influx of Hurricane Maria evacuees, which included both states of traditional Puerto Rican settlement as well as those in which Puerto Rican settlement is relatively recent.[2]

This research brief presents findings from a new alternative methodology to estimate the emigration from Puerto Rico to the United States using a combination of school enrollment data from Puerto Rico's Department of Education and U.S. Census Bureau's American Community Survey (ACS). This new methodology is then compared with traditional methodologies used to estimate past migration patterns that have used the net movement of passengers (NMP), the Population Balance Equation (PBE), or ACS.

MIGRATION ESTIMATES PRE- AND POST-HURRICANE MARIA
Data Sources and Availability

Prior estimates of the magnitude of the population movement between Puerto Rico and the United States post-Hurricane Maria continue to be based on the net movement of passenger, mobile telephone data,[3] or projections based on recent migration trends from Puerto Rico to the U.S. Immediately following the storm, alternative data sources were not available to measure the magnitude of the net migration. Generally, social scientists — such as demographers, sociologists and economists — rely on a few methods and data sources to estimate Puerto Rican migration. These are:[4]

1. Demographic balancing equation[5] (PBE), using data from the Puerto Rico Department of Health and the U.S. Census Bureau Population Estimates.

2. Net Movement of Passengers (NMP), using data from the U.S. Bureau of Transportation Statistics.

Figure 1. Estimated MIgration Flows from Puerto Rico to the U.S., 1941-2016
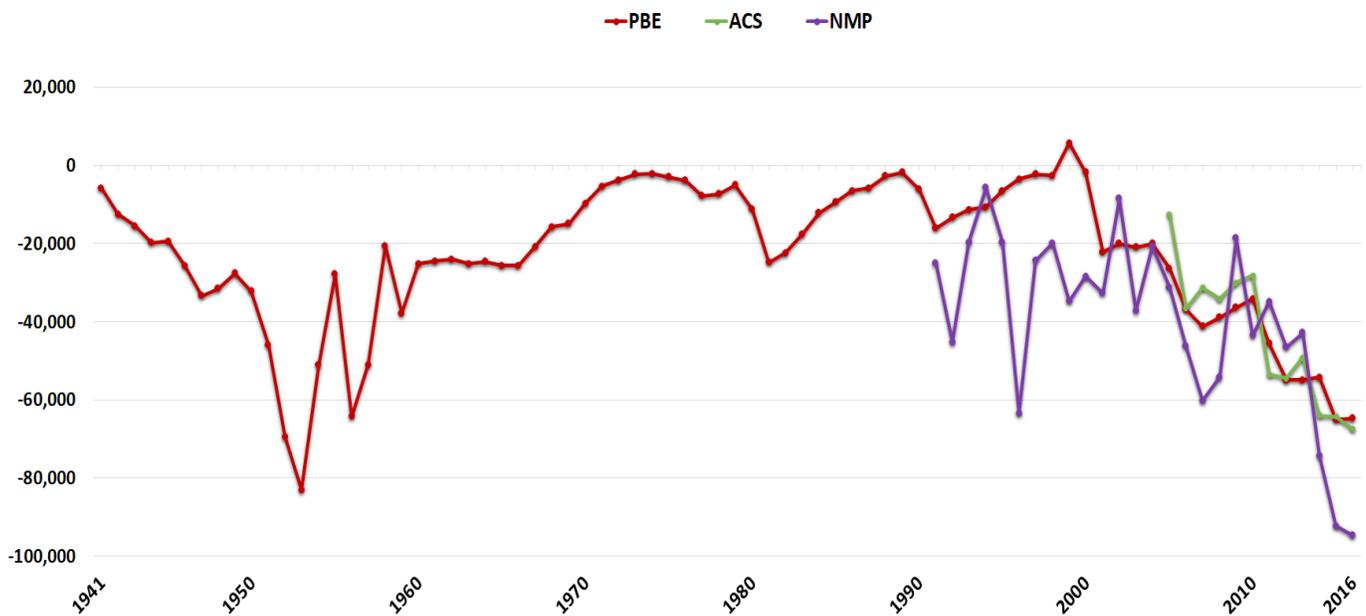
Source: 1941-2016 Department of Health and U.S. Census Bureau Population Estimates; 1991-2016 Bureau of Transportation Statistics; 2005-2016 American Community Survey.

3. Data from the American Community Survey (ACS) of the U.S. Bureau of the Census.

However, these methods are not conducive to estimate Puerto Rican migration in the short term, especially in the aftermath of Hurricane Maria. As shown in Figure 1, the estimates produced by these measures tend to converge over long periods of times, even though the NMP tends to show more volatility (i.e., wider variation) than the estimates derived from the ACS or the PBE. The main issue with the three available data sources and methods to estimate migratory flows from the island to stateside is their ready availability. The PBE relies on population, mortality, and birth data that are typically reported annually for the prior year fiscal year (ending on June 30). Therefore, there is a lag in time capturing current conditions. Similarly, the ACS data is based on a random survey of the population and the data is published between twelve and eighteen months after the end of the year it is collected. The NMP data is an indirect method to estimate migration and typically would lag about six months after it is collected. Because the duration of travel for a significant portion of passengers tends to be short and traveling is by nature frequently seasonal, NMP is more volatile than other available

data and is generally interpreted primarily as an early indicator of migration flows. These time-lag issues are compounded by the fact that Hurricane Maria struck in Puerto Rico September 20, 2017, and migration data collected by the ACS for the last quarter of 2017 will be combined with the data for the previous eight months of that year, diluting the impact of the storm on migration over the entire twelve-month period, leading to lower estimates. Using data collected from these sources would therefore reduce the actual magnitude of the post-hurricane exodus.

Since Hurricane Maria made landfall in September 2017, data collection and estimate quality for the recently released 2017 ACS conducted both in the U.S. and Puerto Rico[6] do not precisely reflect post-Hurricane Maria actual impact at present.[7] First, the U.S. Census Bureau's 2017 Population Estimates for Puerto Rico is a population count as of July 2017, two months prior to Hurricane Maria.[8] Thus, by implication the migration estimates based on the PBE for the fiscal year that ends on June 30 of 2017 would exclude the impact of Hurricane Maria. Second, the 2017 ACS population estimates in the United States, which measure household interstate mobility, include households surveyed

from January to December of 2017. This survey would include a representative sample of the population in Puerto Rico collected after September 2017 when Hurricane Maria struck Puerto Rico and induced a massive emigration from the Island. Yet, according to the U.S. Census Bureau survey protocols, evacuees from Puerto Rico would only be counted as emigrants in the 2017 survey if they had arrived in the U.S. prior to the hurricane's landfall or planned to stay in the U.S. for two or more months. Therefore, population and migration figures reported for 2017 are likely to underestimate actual changes in residence between Puerto Rico and the U.S. in 2017, and by implication total population and migration estimates. Furthermore, the U.S. Census Bureau will not release the results of the 2018 American Community Survey, which should reflect demographic, social, and economic profile of Puerto Rico post-Hurricane Maria, until 2019.

NEW ESTIMATES: DATA AND METHODOLOGY

To estimate the number of migrants from Puerto Rico to the United States post Hurricane Maria, we have developed an alternative method using student population losses reported by Puerto Rico's Department of Education as source of data, data that is available at the beginning of each semester and thus offers the opportunity to estimate an early indicator of emigration to the U.S. The Commonwealth's Department of Education reports the total number of students registered in public schools in Puerto Rico as of August of the current school year as well as in January, during the same school year. Our estimates, using the change in student population from Puerto Rico's public school as a suitable indicator of migration from Puerto Rico to stateside,[9] show a substantial increase in emigration in aftermath of the hurricanes that struck Puerto Rico in 2017. We use these reported school enrollment figures to estimate the School Enrollment Migration Index (SEMI) defined as:

$$SEMI = \Delta SE_{0,1} \times (A/C),$$

where $\Delta SE_{0,1}$ refers to the change in student enrollment between period 0 and 1, and (A/C) *is the ratio of the total adult migrant population (19 years and over) and non-school-age children (4 years or less) relative to school-age children (5 to 18 years old).*

To establish the "A/C" ratio, we calculate the averages for Puerto Rican school-age children and total adult migrants using data from the yearly surveys of the American Community Survey from the U.S. Bureau of the Census between 2013 to 2016. This ratio is then used to estimate the total migration that corresponds to the number of children assumed to have relocated stateside.[10] In other words, the data on public school enrollment change from Puerto Rico's Department of Education is extrapolated to estimate the total post-Hurricane Maria exodus from Puerto Rico on a yearly basis. Our current estimate of 159,415 and up to 176,603 emigrants from the island was derived by using Puerto Rico's Department of Education's student matriculation loss in public schools between 2017 and 2018 (the academic year when Hurricane Maria made landfall in Puerto Rico) and the present academic year, 2018–2019. Between both academic years, there was a reported public school student population loss of nearly 40,000 students, from 346,096 students from 2017–2018 to 306,652 students.[11]

MIGRATION ESTIMATE: A COMPARISON

This section presents findings from our new estimation method for the Puerto Rican pre- and post-disaster relocation to the U.S. mainland relative to other estimation methods currently in use. Figure 1 illustrates the net migration estimates between 2005 and 2017 based on observable available data from the U.S. Census Bureau's American Community Survey and the Puerto Rican Community Survey (2005 to 2017), the U.S. Bureau of Transportation Statistics (2005-2018), and Puerto Rico Department of Health (2005-2017). The present report introduces school enrollment data as an indicator of migration from Puerto Rico to the U.S. Based on school enrollment data from the Commonwealth of Puerto Rico Department of Education, we estimate that 159,415 (and up to 176,603) Puerto Ricans relocated to the United States in the year since Hurricane Maria made landfall in Puerto Rico.

## Figure 2. Estimated MIgration Flows from Puerto Rico to the U.S., 2005-2017
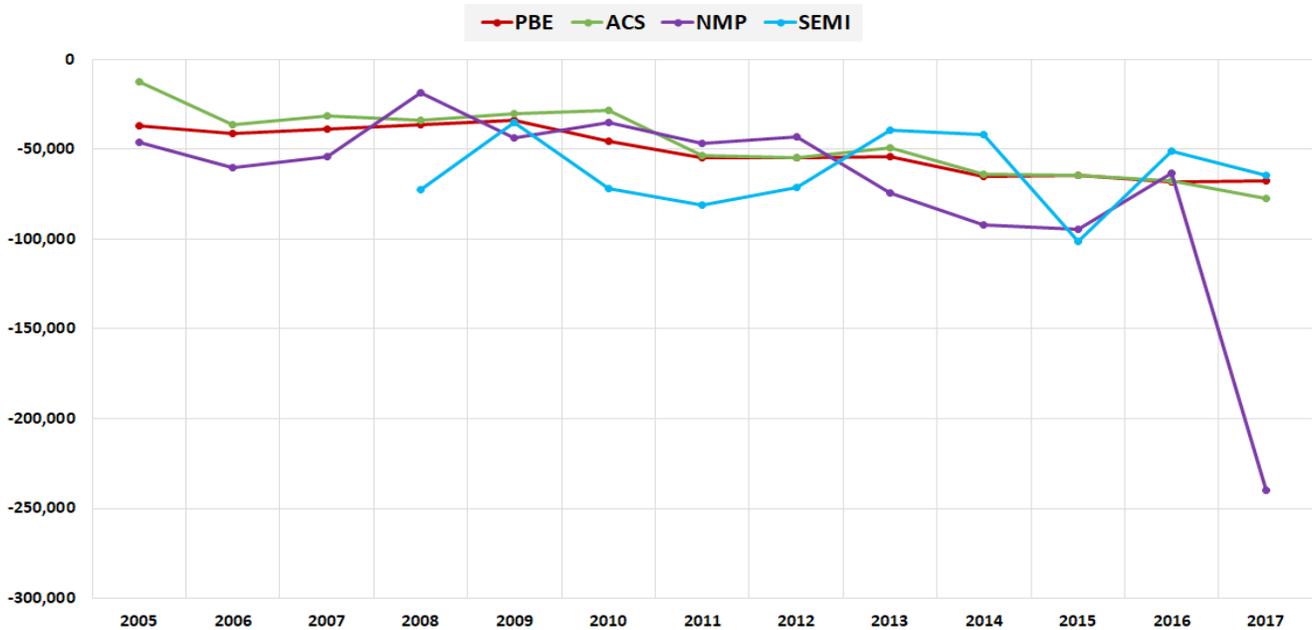
As shown in Figure 2, prior estimates of the magnitude of this exodus were based on movement of passengers or projections based on recent migration trends from Puerto Rico to the U.S. Our migration estimates parallel to some extent the NMP downward (negative) migration trend observed in the number of passengers exiting the island relative to those who arrive, a trend that indicates that the exodus from the island continues over time in the aftermath of the cyclones. The blue shaded trend line represents our school enrollment migration (SEMI) estimates compared to net migration estimates from PBE (red line), NMP (purple), and ACS (green line) (see Figure 2). Overall, similarly to the NMP (purple line) our SEMI estimate (blue line) shows volatility, at times over- or under-estimating migration figures relative to the ACS and PBE. As shown in Figure 2, between 2005 and 2017, both PBE and ACS data showed similar net migration trends throughout the years. The 2017 ACS net migration estimates were obtained using Table 07204 (for both ACS and PRCS). These estimates show the net migration estimates in 2017 were higher than in past years.

According to the 2017 ACS and the PRCS, 97,488 migrants from Puerto Rico relocated throughout the U.S. and 20,167 returned to Puerto Rico for a net migration

of -77,321 people (a negative number indicates that more people left the island, 'out-migration', than arrived or moved to the island, 'in-migration'). This is an increase in emigration from the prior three years when net migration from Puerto Rico reached an average of 65,000 people. However, this indicator for 2017 under-estimates the actual net migration, as some families and individuals who relocated to the U.S. post-Hurricane Maria were probably not counted as movers if surveyed between late-September 2017 and December 2017. Furthermore, this may not consider families who relocated to hotels sponsored by FEMA's Transitional Shelter Assistance program or stayed with relatives or friends. The NMP trend also showed significant volatility at times higher or lower net migration estimates relative to ACS and PBE.

In 2017, the net movement of passengers (NMP) estimate was the highest it has ever been in the past 12 years, with a net migration of -239,992, reflecting the impact of Hurricane Maria. To better ascertain the impact of Hurricane Maria, we use available NMP monthly data from a year prior, from August 2016 to August 2017, and from September 2018 until March 2018. Figure 3 depicts NMP data for both pre- and post-Maria periods. As shown in figure 3, the net movement of passengers

Figure 3. Observed Puerto Rican Migration Indicators Pre- and Post-Hurricane Maria
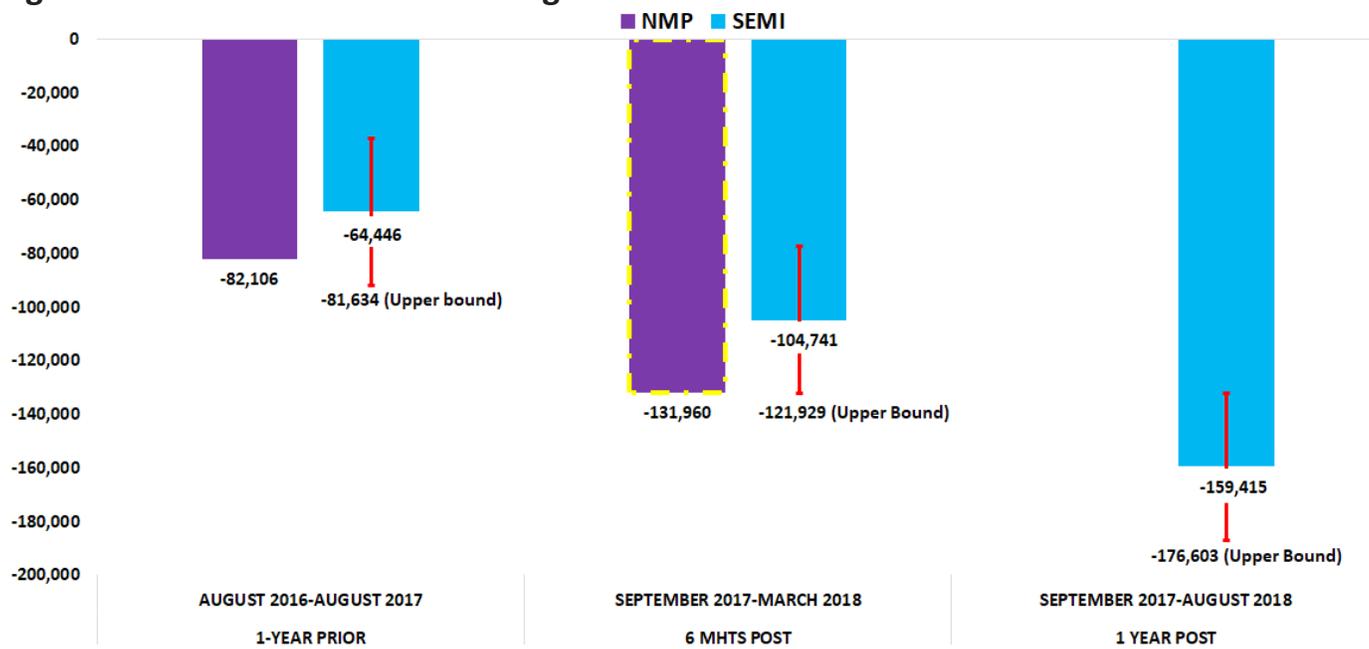
Source: August 2016–March 2018 Bureau of Transportation Statistics; 2013–2017 American Community Survey; 2016–2018 Puerto Rico's Department of Education.

increased from -82,106 the 12 months prior to Hurricane Maria to -131,960 during the six months after Hurricane Maria.

School enrollment estimates between 2008 and 2017 show a similar trajectory, though with high volatility of net migration estimates from Puerto Rico to the U.S. relative to the PBE, ACS, and NMP. For 2008, for example, our school enrollment estimate (-72,575) overestimates the migration flow relative to PBE (-36,349) and ACS (-34,128). However, the NMP figures (-18,569) underestimate the flow in the same year. During the same year (2008), student population loss in Puerto Rico's public schools was the third highest in a 10-year span.[12] In 2009, school enrollment migration estimate (-35,140) showed similar migration patterns compared PBE estimates to (-34,158) and ACS estimates (-29,966), while NMP (-43,460) exhibited a higher net migration estimate. Between 2010 and 2012, school enrollment migration estimates showed higher estimates relative to other three measures. In 2013 and 2014, school enrollment estimates (-39,563 for 2013 and -41,684 in 2014) were within similar ranges as the PBE (-54,259 for 2013 and -65,089 for 2014) and the ACS (-49,194 for 2013 and -64,073 for 2014), but much lower compared to NMP (-74,339 for 2013 and -92,310 for 2014). In 2015,

ACS (-64,238) and PBE (-64,757) showed similar estimates; however, PBE (-94,735) and our school enrollment estimate (-101,575) overestimated the emigration. Moreover, in that same year, Puerto Rico's experienced the second highest loss of student population (-32,931) between the previous school year (2014) and 2015. Therefore, the school enrollment migration estimate is able to capture such significant change, and as a result shows a comparable estimate to the NMP (-94,735). In 2016, our school enrollment estimate (-50,853) showed a lower migration estimate relative to PBE (-68,262), ACS (-67,480), and NMP (-63,508). Relative to PBE and ACS, the 2017 annual NMP total captures the months of October, November, and December immediately following Hurricane Maria, and as a result, migration estimate for the calendar year spiked to -239,992,[13] whereas ACS and PBE annual data do not reflect post-Hurricane Maria migration flow. Yet, school enrollment based on August 2017 data yields an indicator (-64,446) that approximates ACS (-77,321) and PBE (-67,500) migration estimates for 2017.

To date, the Net Movement of Passengers (NMP) provided by the U.S. Department of Transportation, is the only indicator (compared to ACS and PBE) reflecting post-Hurricane Maria migration flows. However, this

Figure 4. Monthly Net Movement of Passengers, Pre- and Post-Hurricane Maria
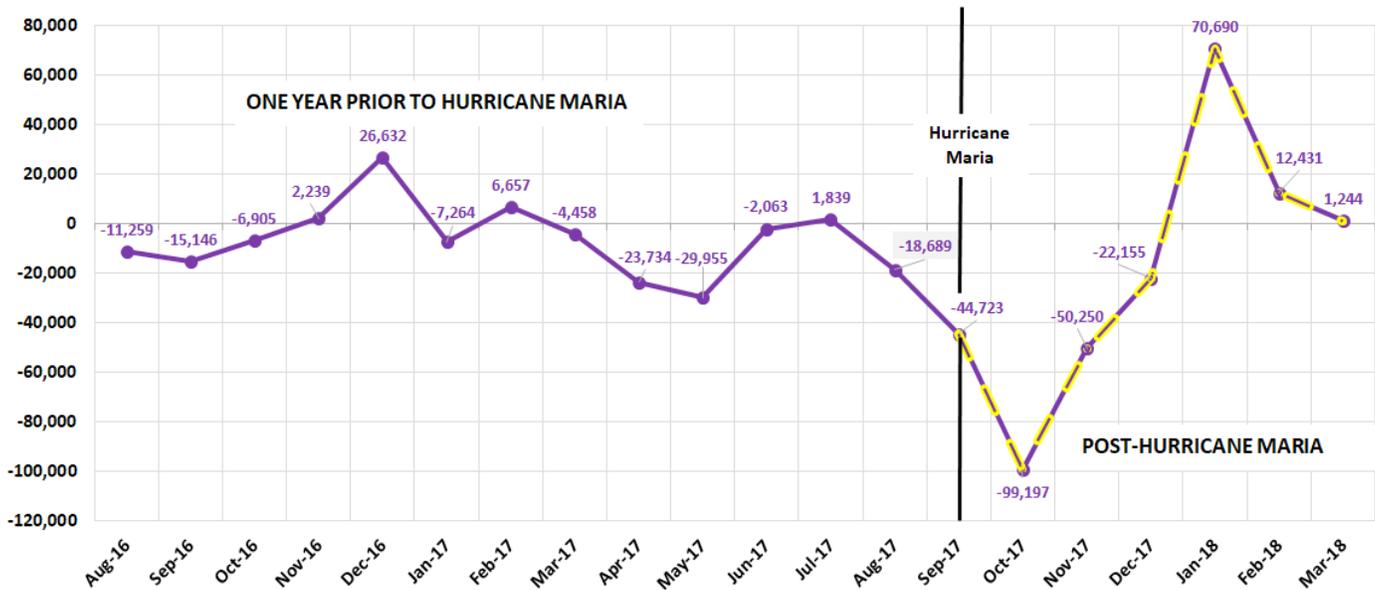
Source: August 2016–March 2018 Bureau of Transportation Statistics.

indicator does not reflect relatively permanent or long stay migration patterns, such as the PBE and ACS. As shown in Figure 4, one year (August 2016 to August 2017) before Hurricane Maria made landfall, NMP estimated an outflow of -82,106 from Puerto Rico to the U.S., and within this same time period, our estimate shows -64,446, with an upper bound of -81,634, emigrants relocated to stateside. During the post-Hurricane Maria period from September 2017 to March 2018 (six month post-Hurricane Maria), NMP reported an outflow of -131,960 while school enrollment migration estimate indicates an outflow of -104,741, with an upper bound estimates of -121,929. Lastly, the school enrollment indicator for one year post-Hurricane Maria estimate is -159,415 islanders relocating to stateside, with an upper bound of -176,603. In all, our revised school enrollment estimates can be used as an indicator for migration estimates post-Hurricane Maria for both time periods and six months and one year post Hurricane Maria).

As shown in figure 2, the -239,000 migration estimate from the NMP aggregates January 2017 through December 2017 net movement. The impact of Hurricane Maria heightened the outflows between September 2017 through November 2017, pulling the net movement to such a high volume (see figure 4). For example, as

illustrated in Graphic 3, the NMP jumped from -18,689 in August 2017 (one-month prior to Hurricane Maria) to -99,197 in October 2017 (one month post-Hurricane Maria). This spike is reflective in the NMP annual average in 2017 (-239,992, as depicted in figure 2). However, between December 2017 through March 2018, the NMP estimate shows a return migration spike (more so in January, February, and March of 2018), and this is attributed to the holiday season. As shown in the previous year, between November 2016 and February 2017, there was a similar return migration spike shown, however, not as prominent as the month's holiday period during post-Hurricane Maria (see figure 4).

CONCLUSIONS

The advent of Hurricanes Irma and Maria and the significant spike in migration from the island stateside induced a quest for finding empirical data to gauge the extent of the island's population loss. The exodus of Puerto Rico residents has significant implications for both the island's economy and for those families and individuals that have relocated stateside, for many of them for the first time under pressing circumstances. To the island the migration exodus reinforces a pattern of depopulation that has induced austerity and the decline

Figure 5. Puerto Rican Population in Puerto Rico and the United States
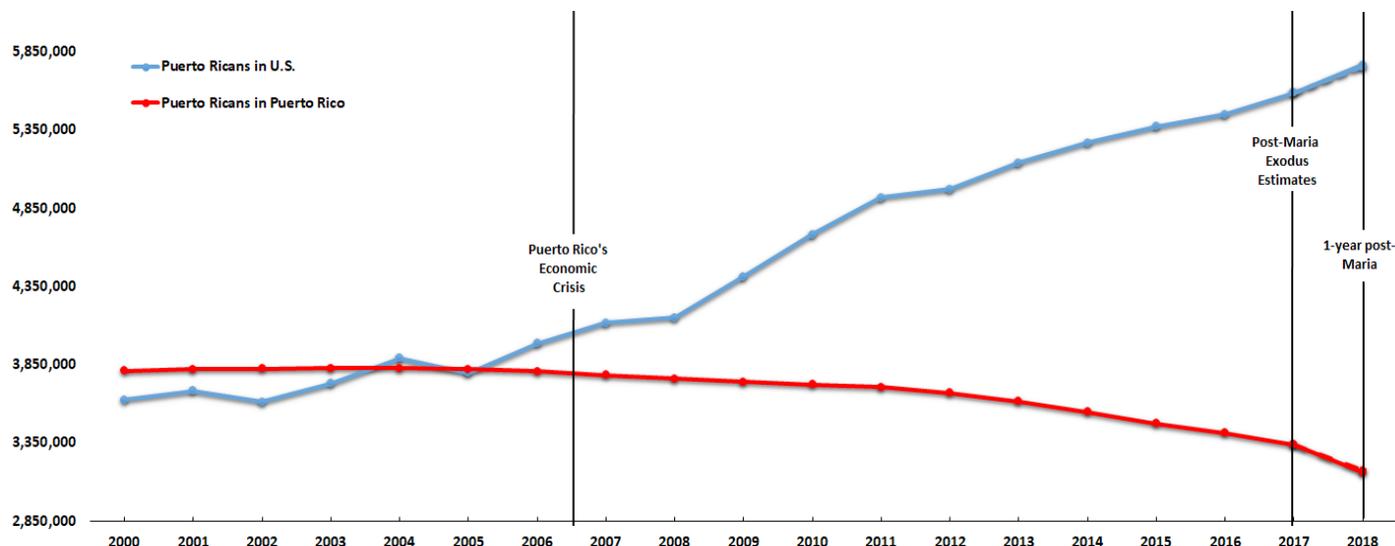
Source: American Community Survey, Various Years.

in government services and employment, the closing of schools, increased poverty among the most disadvantaged such as families with children and the elderly, among other unfolding consequences of sudden population losses. Those that relocate have the challenge of finding jobs, housing, medical services, and schools. Measuring population movement in real time, especially after a natural disaster like Hurricane Maria, continues to be a major undertaking. In this report, we use available, observable data to develop estimates of migration post-Hurricane Maria. In addition to the Net Movement of Passengers data, we use school enrollment data from the Puerto Rico Department of Education to estimate a migration index. The School Enrollment Migration Index allow us to estimate migration using data that is available at the beginning of each semester. Though further

research is required to refine this index, we are confident that school enrollment provides a reliable indicator of migration patterns.

The new emigration estimates — of 159,415 with an upper bound confidence interval of 176,603 — indicate a significant spike in out-migration flow from the island to the United States when compared to prior years. Both empirical indicators, the NMP and the SEMI, suggest that migration post-Hurricane Maria has doubled when compare to the prior year as a baseline. This recent exodus represents one of the most significant historical movements of Puerto Ricans to the U.S. in terms of both volume and duration.

Notes

1. Source: 2016-2017 American Community Survey (1-year estimates).

2. See Jennifer Hinojosa and Carlos Vargas Ramos's Introduction of *The Almanac of Puerto Ricans in the United States, issued on March 2017* for further reading.

3. Source:https://www.citylab.com/environment/2018/05/watch-puerto-ricos-hurricane-migration-via-mobile-phone-data/559889/

4. An additional data source, the Survey of Travelers (or *Encuesta Sobre Información del Viajero*, in Spanish) was conducted by the Puerto Rico Planning Board (PRPB) from 1982 to the 1988 and from 1991 to 2002.The main objective of the PRPB survey was to collect information about the volume and characteristics of travelers from Puerto Rico to the United States. The so-called "ramp" survey was based on a sample drawn from all the commercial flights leaving or entering Puerto Rico from the Luis Muñoz Marín International Airport in San Juan, and subsequently from the Rafael Hernández airport in Aguadilla. This study was discontinued for lack of funding.

5. Demographic balancing equation is defined as $P2 = P1 + (B - D) + (I - E)]$, where P2=the number of individuals in a population at time 1; P1= the number of individuals in that population at some later time 2; B= the number of births in the period from time 1 to time 2; D= the number of deaths from time 1 to time 2; I= the number of people entering as immigrants; and E= the number of people leaving as emigrants.

6. The Puerto Rico Community Survey (PRCS) is an island wide a customized version of the American Community Survey (ACS) designed to provide data every year for Puerto Rico communities.

7. Refer to https://www.census.gov/programs-surveys/acs/technical-documentation/user-notes/2018-02.html

8. The 2017 American Community Survey (1-year estimates) data released on September 13, 2018 used the same total population count (3,337,177) as estimated by the 2017 Population Estimates for Puerto Rico. This does not reflect post-Hurricane Maria population in Puerto Rico (3,337,177) due to data collection postponement as a result of both Hurricane Irma and Maria in September 2017. For further information, refer to: https://www.census.gov/programs-surveys/acs/technical-documentation/user-notes/2018-02.html

9. We are assuming a) that the decline in student enrollment reflects families moving stateside; b) that the death rate among children, student transfers between private and public schools in Puerto Rico, and school dropout rates are negligible; and c) that a stateside move is likely to last at least one semester thus meeting the minimum threshold of time required to define a migrant. This threshold is of two months in the ACS and of three months in the PRPB Survey of Travelers — the so-called "ramp survey." All of the aforementioned factors induce volatility in the reported migration estimates.

10. In a prior survey of enrollment of students from Puerto Rico in stateside school districts after Hurricane Maria we found a close proximity of the number of student loss reported by the Puerto Rico Department of Education and the number of enrollees in stateside schools. See Jennifer Hinojosa, Nashia Román, and Edwin Meléndez, "Puerto Rican Post-Maria Relocation by States Research Brief," issued March 2018, Centro RB2018-03. https://centropr.hunter.cuny.edu/sites/default/files/PDF/Schoolenroll-v4-27-2018.pdf.

11. An alternative hypothesis to the reduction in enrollment in public schools in Puerto Rico may be that those students are enrolling in private schools. However, data indicate that between 2005 (the year before the economic crisis began in Puerto Rico) and 2017 (the last year for which data are publicly available) the enrollment in private schools declined every single year at a rate of tens of thousands of students. This decreased enrollment in private schools may not be unexpected given the magnitude, depth, and long-term duration of the economic crisis in Puerto Rico. While many students may have transferred from public schools to private schools as the public education system deteriorated, many students were likely to similarly transfer from private schools to public schools as many parents may have been unable afford the costs of private schooling. In any event, the trend for school-age children in Puerto Rico is clear: the enrollment in private and public schools on the island has declined over the past five to ten years.

12. Between 2007-2008 and 2008-2009 school year, Puerto Rico's public school student enrollment declined from 526,565 to 503,635 students, a loss of -22,930. This was the third highest student loss between 2007 and 2019 school years.

13. January 2017 through December 2017 are the months NMP includes for the annual migration estimates of -239,992 for 2017.

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