

The Impact of Hurricane Maria: The US Census Bureau's Experience Combining Survey-Based Estimates and "Big Data" to Produce 2018 Puerto Rico Net Migration Estimates

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The Commonwealth of Puerto Rico



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Puerto Rico Background

- The Commonwealth of Puerto Rico is an unincorporated territory of the United States, located in the northeast Caribbean Sea, 1,600 km from Miami, Florida
- Population of over 3 million persons, declining since 2004
- Puerto Ricans are US Citizens and have the right to free movement between Puerto Rico and the United States
 - The US Census Bureau's Population Estimates Program (PEP) does not include this movement as domestic migration, but rather as part of its net international migration component

Hurricane Background

- On September 20, 2017 Hurricane Maria, a Category 4 hurricane, devastated Puerto Rico, resulting in mass out-migration, primarily to the United States.
- Initial reports varied on the potential "exodus" to the United States.
 - Puerto Rico Governor Ricardo Rossello: "...you will see thousands, if not millions, of Puerto Ricans flocking to the United States."
 - "It will be a massive exodus," predicts Edwin Meléndez, director of the Center for Puerto Rican Studies at Hunter College. "We're talking about 100,000 to 200,000 people."
 - According to the Florida Division of Emergency Management, over 208,000 people from Puerto Rico have landed at airports in Miami, Orlando, and Tampa since October 3rd (NBC News, November 30, 2017).

Other Studies

- These early estimates did not account for potential return migration to Puerto Rico.
 - Other studies¹ indicated that a sizeable number of Puerto Ricans (approximately 225,000 to 238,000) left for the US mainland.
 - These same sources estimated 135,000 to 145,000 Puerto Ricans returned to the island after Hurricane Maria.
 - This accounted for a net out-migration of approximately 90,000 to 93,000.

1- The PEW Research Center, [Jens Manuel Krogstad](#), 2017 - "Puerto Ricans leave in record numbers for mainland US"; [Stefan Rayer](#), 2018 - "Hurricane-Induced Migration"



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ACS/PRCS

- PEP uses the American Community Survey (ACS) to measure migration from Puerto Rico to the United States and the Puerto Rico Community Survey (PRCS) to measure migration from the United States to Puerto Rico
- ACS: Monthly survey with an annual sample of 3.5 million addresses
 - Out-migration from Puerto Rico
- PRCS: Monthly survey with an annual sample of 36,000 housing units across every municipio
 - In-migration to Puerto Rico
- 1-year (national) and 5-year (subnational) files available for both surveys
- Ask the same questions, including "where did this person live one year ago" (Residence one year ago, or ROYA)



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Impact of Hurricane Maria on the 2017 ACS/PRCS

- The PRCS ceased operation from October to December 2017, and did not resume until January 2018.
- ACS did not adjust the weighting procedure for the 2017 PRCS to account for Hurricane Maria's impact.
 - Nine months of population controls were used for the full 2017 PRCS estimate year.
 - PRCS likely overestimated in-migration to Puerto Rico, which would have been minimal from October to December.
- Analysis of monthly ACS data did not show a large influx of migrants to the United States from Puerto Rico from September to December, thus making it likely that the ACS was not picking up hurricane-related migration flows.



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Reasons to Adjust 2017 ACS/PRCS Estimates to Account for Hurricane Maria

- For Puerto Rico, this decade's net migration estimates have been based on the ACS/PRCS, but 2017 ACS data did not reflect hurricane-related movement to the United States.
 - In 2016, ACS/PRCS estimated out-migration of 88,000 people from Puerto Rico to the US, with in-migration of 21,000 from the US, resulting in a net loss of -67,000 people.
 - The 2017 ACS/PRCS estimated out-migration of 97,000 people from Puerto Rico to the US, with in-migration of 20,000 from the US, resulting in a net loss of -77,000 people.
 - This was a change of only 10,000 or (15.0%) between year 2016 and 2017.
- The ACS/PRCS was not designed to pick up sudden mass movements, because ACS and survey-based migration data tend to "lag" actual migration events.
 - An alternative data source is needed.



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“Big Data” Background

- There has been a fair amount of research into the application of “big data” to measure international migration in recent years
 - Social media (Facebook, Twitter, etc.)
 - Cell phone usage (commuting)
 - Advertising data
 - Flight data (tourism)
 - Other commercial data
- These sources raise issues of coverage, measurement, accuracy, access, privacy, cost, etc., ...to name just a few

Alternative “Big Data” Source

- Airline Passenger Traffic (APT) Domestic Data¹
 - Commercial flight data provided by airports/airlines to the Bureau of Transportation Statistics (BTS)
 - Provides data on monthly movements between Puerto Rico and the United States
 - Release of APT data lags 2 months or more and is updated with later releases

1- Bureau of Transportation Statistics, US Department of Transportation. Data Bank 28DS- T-100 Domestic Segment Data - US Air Carriers Traffic and Capacity Data.

APT Data

- APT data include all travelers (migrants, visitors, business travelers, tourists, etc.)
- **The APT can only provide an estimate of “net” migration**
 - Only viable as a potential data source because Puerto Rico is an island without any land borders (movement via ship is minimal)
- Monthly tallies of net migration reflect seasonal patterns due to tourism
 - Year-to-year fluctuations in tourism trends could impact results if fluctuations occurred over two time periods of measurement
- APT data did a better job of measuring net migration to and from Puerto Rico after Hurricane Maria than the ACS/PRCS



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Monthly APT Net Movement for Calendar Years 2015 to 2018

Monthly APT Net Movement	2015	2016	2017	2018
Total Net	-122,084	-108,693	-301,304	88,194
January	-11,663	-15,749	-19,817	66,321
February	-2,931	-8,956	3,228	14,128
March	-20,427	-10,452	-10,566	1,981
April	-31,010	-28,798	-29,671	-8,264
May	-28,130	-36,394	-24,606	-8,949
June	-7,266	1,624	8,287	6,424
July	-2	-1,736	-3,436	-5,213
August	-34,542	-21,861	-28,766	-10,179
September	-18,014	-15,816	-43,144	-16,017
October	2,005	-6,346	-93,177	1,581
November	-5,398	1,227	-43,626	3,984
December	35,294	34,564	-16,010	42,610

Source: US Bureau of Transportation - Airline Passenger Traffic Data



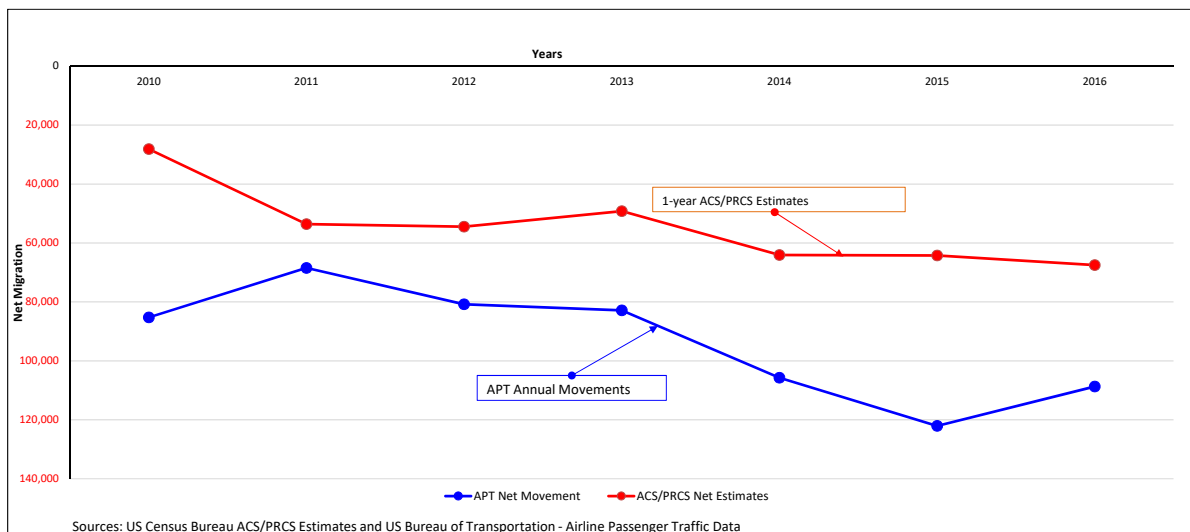
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Results from APT Data

- APT data seem to better reflect the impact of Hurricane Maria on movement to and from Puerto Rico
- Large spike of Puerto Ricans flying to the United States during the latter months of 2017 (September-December), resulting in large net out-migration
- Corresponding return of Puerto Ricans from the United States in the early months of 2018, reflecting return migration
- This return movement (Puerto Ricans returning to Puerto Rico from the United States) dropped during the early months of 2018, returning to net out-migration in April 2018

Net Puerto Rico-to-US Migration: 2010-2016 (prior to Hurricane Maria)



Comparison of APT and ACS/PRCS Flows: 2010-2017

Annual Migration Movement	Air Passenger Traffic Data US/PR Domestic Movement			1-year ACS/PRCS Estimates Migration Distribution		
	Ins	Outs	Net	Ins	Outs	Net
Years						
2010	3,700,263	3,785,500	-85,237	31,732	59,885	-28,153
2011	3,534,030	3,602,480	-68,450	22,649	76,218	-53,569
2012	3,672,341	3,753,135	-80,794	20,044	74,500	-54,456
2013	3,665,767	3,748,616	-82,849	24,652	73,846	-49,194
2014	3,702,073	3,807,775	-105,702	19,771	83,844	-64,073
2015	3,785,132	3,907,216	-122,084	24,762	89,000	-64,238
2016	3,951,359	4,060,052	-108,693	21,196	88,676	-67,480
2017	3,611,199	3,912,503	-301,304	20,167	97,488	-77,321

Sources: US Census Bureau ACS/PRCS Estimates and US Bureau of Transportation - Airline Passenger Traffic Data



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Historical Differences Between ACS and APT Net Flows

- APT data have shown higher net outmigration than ACS for all years
- Converged in 2011, but differences remain for all years since, following similar trends
- Often find differences between survey- and administrative-based migration data
 - Likely due to inherent differences between administrative- and survey-based data: coverage, volume of movement, flight data at time of move/survey data a retrospective/post facto measure of movement
 - More research needed to better understand these differences
- Used APT data to adjust 2017 ACS/PRCS estimates to reflect changes based on the impact of Hurricane Maria



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Methodology

- Data sources: 2015 to 2017 1-year ACS/PRCS net migration estimates and 2015 to 2018 APT flight data
 - While ACS data were only available for 2017, obtained most recent 2018 APT data to reflect Puerto Ricans returning to the Island
- For APT data, used the same time period as ACS (calendar year)
- APT net migration estimates have been consistently higher than ACS/PRCS estimates (perhaps because APT includes all travelers: migrants, visitors and tourists)
 - Restrict to domestic movement between Puerto Rico and the United States
- “Blend” the ACS/PRCS and APT to adjust 2017 APT data to reflect past ACS/PRCS-to-APT trends

Methodology (cont.)

Ratio Method

- Calculate a ratio of ACS/PRCS-to-APT results for net migration over two years: 2015 and 2016
- Apply ratio to APT net Puerto Rico-to-US migration measured for calendar year 2017
- Ratio method should be as methodologically consistent as possible with previous ACS/PRCS-based estimates

ACS/PRCS Net Migration Estimates: 2015 to 2017

Ratio Method of ACS/PRCS to APT: 2015-2017

Net Migration	2015	2016	2017
ACS/PRCS	-64,238	-67,480	-77,321
APT	-122,084	-108,693	-301,304
Ratio	.52618	.62083	
Avg. Ratio	.5735		

Adjusted ACS/PRCS Estimates

ACS/PRCS Net Estimates	2015	2016	2017	2017 adjusted
Total Net	-64,238	-67,480	-77,321	-172,799

Sources: US Census Bureau ACS/PRCS Estimates and US Bureau of Transportation - Airline Passenger Traffic Data



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Ratio Method Results

- The ACS/PRCS measured -77,321 net migrants for the year 2017, not reflecting the impact of Hurricane Maria.
- The APT measured -301,304 net migrants during the calendar year 2017, with -195,957 from the months of September to December, reflecting post-Maria outmigration from Puerto Rico to the United States.
- ACS/PRCS net migration results were 0.5735 lower than the APT during the same two-year period of 2015 and 2016.
- To get an equivalent ACS/PRCS figure for 2017, the APT number is multiplied by the .5735 ratio to yield a figure of -172,799 persons.
- This is equivalent to applying 2017 ACS/PRCS data to the Vintage 2018 estimate year, thus consistent with the methodology for previous net migration estimates for Puerto Rico.



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Final Adjustment to Ratio Method

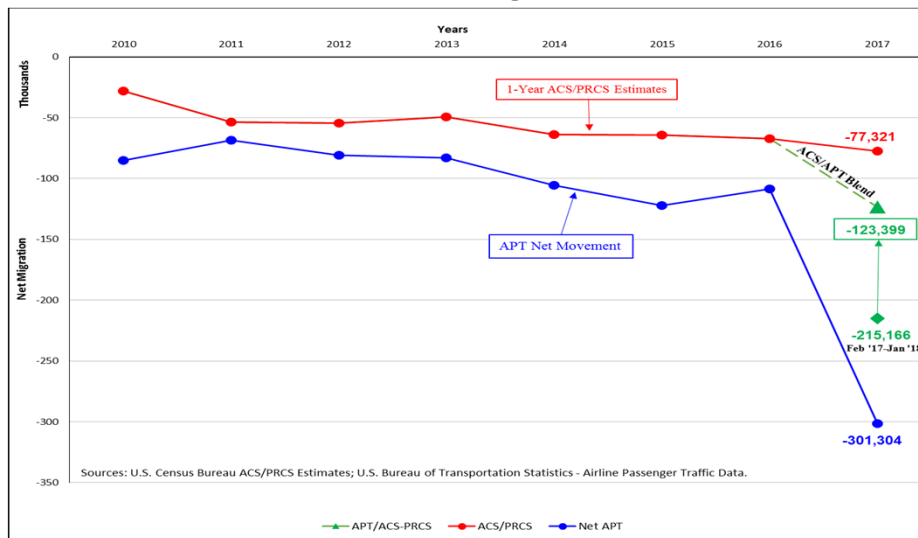
- Starting in 2018, APT data show large numbers of return migrants, particularly in January, slowing down in February, and returning to negative in April.
- The Puerto Rico population estimate is supposed to represent July 1, 2018 (while ACS/PRCS migration flow data represent calendar year 2017).
- We further adjusted the methodology as follows:
 - In order to account for January return migration, we used the APT time period from February 2017 to January 2018, prior to applying our two-year ratio.
 - Shifting our time period one month helped account for return migrants, yet keep most months (11 of 12) within the ACS/PRCS-equivalent calendar year.



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Net Puerto Rico-to-US Migration: 2010 to 2017



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Final Ratio Method Result

- This “shift” yields -215,166 in net APT migration, which when adjusted by the ACS ratio, results in a final figure of -123,399 net migration from Puerto Rico to the United States
- Method takes APT data for approximately the same time period as the ACS (shifted one month), adjusts this figure as if it were the ACS based on trends over the past two years (as if the ACS were able to measure this sudden migration), and also accounts for return migration early in 2018

ARMA Model

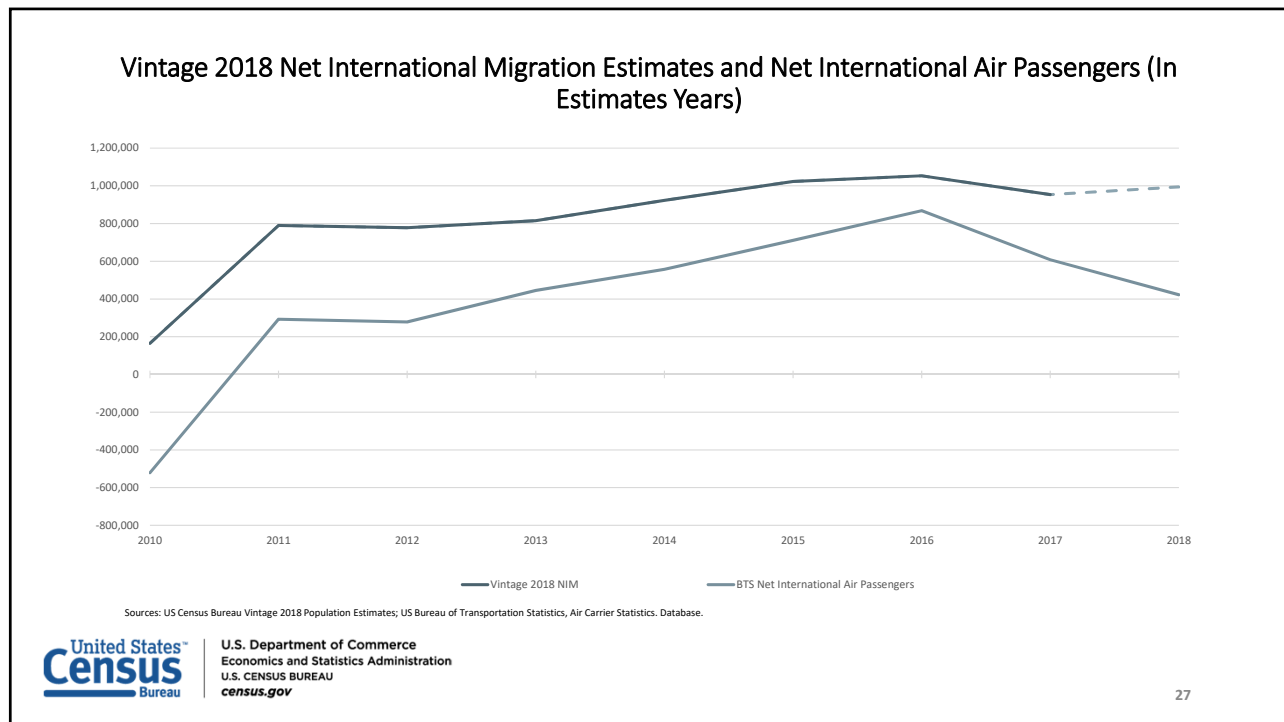
- Considered more sophisticated modeling techniques to see if we could improve our “blended” estimates
- Tried an autoregressive-moving-average (ARMA) model to predict a future value in the time series, using a Box-Jenkins method
- The most complex model we could use to fit the data was the simplest ARMA (0,0) model
- Model predicted Puerto Rico net migration of -262,350 for 2017 from the ACS-adjusted-to-APT data time series
- Result was relatively close to our initial unadjusted estimate of -215,166, using the simpler ratio method, supporting our confidence in the ratio method

Vintage 2019: Data Results for 2018

- APT: 88,000 net migration from United States to Puerto Rico
- ACS: -112,000 net migration from Puerto Rico to United States
 - 2018 ACS ROYA reflects a “lag” in the measurement of out-migration due to Hurricane Maria (picks up what happened in late 2017), and is very close to our final adjusted V2017 estimate (-123,000)
- For V2019 Estimates, need to “blend” both data sources again, taking into account return migration to Puerto Rico in 2018 as shown by APT data

Future Work

- Continue to monitor potential return migration to Puerto Rico
- Determine the viability of replacing ACS net migration estimates with APT-based estimates
 - Better understanding of APT data and why it differs from ACS estimates
 - Possible implementation next decade
- Modeling and/or integration of APT and ACS/PRCS data to calculate more robust estimates
- Other applications



Conclusions

- While the use of “big data” is still limited from the perspective of the United States for producing net international migration estimates, we continue to look at alternative sources to help improve, or at least benchmark, NIM estimates produced via our current methodology.
- For an island like Puerto Rico, with limited border crossings, we will continue to investigate the viability of using flight data, alone or in combination with other sources, to estimate migration.
- Our current survey-based methodology is effective when migration patterns are relatively stable, but will lag actual migration events when there are sudden changes in migration patterns, either due to natural disasters or significant national policy changes.
- Integration of multiple data sources will likely play a prominent role in the future production of international migration estimates and will continue to be pursued and incorporated into our estimates program.

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