Methodology for
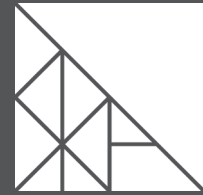# Boston's Population Projections

2016

THE BOSTON REDEVELOPMENT AUTHORITY RESEARCH DIVISION (BRA)
We strive to understand the current environment of the city to produce quality research and targeted information that will inform and benefit the residents and businesses of Boston. Our Division conducts research on Boston's economy, population, and commercial markets for all departments of the BRA, the City of Boston, and related organizations.

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CITATION
Please cite this publication as:
Boston Redevelopment Authority Research Division, September 2016

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Appreciation

Introduction

To inform the Imagine Boston 2030 planning process and to create an internal capacity to provide ongoing assistance regarding demographic analysis and projections, the Boston Redevelopment Authority (BRA) Research Division examined historical population trends, created projections for Boston's population through 2030 and a projection model to provide and test hypothetical scenarios or explore the impact of policy proposals.

Historical Population Trends

Figure 1 illustrates Boston's population changes from 1900 through 2015. Boston's population grew through the first half of the 20th century to a peak of 801,444 in 1950. The annexation of Hyde Park in 1912 brought an end to Boston's growth through land annexation. International immigration was an important factor in the early part of the 20th century, with the foreign-born population at about one third of Boston's population through 1920. The 1924 Immigration Act restricted international immigration, and the foreign born population fell to 13 percent of Boston's population in 1970, when immigration restrictions were eased. From 1950 to 1980, Boston's population declined by almost 30 percent to 562,994 due to the combination of lower international immigration and the rise of suburbanization. From 1980 to the present, Boston has experienced steady population growth driven by increasing international migration. Throughout, college students and other young adults have formed a significant portion of Boston's population.

FIGURE 1

BOSTON'S POPULATION
1900 – 2015
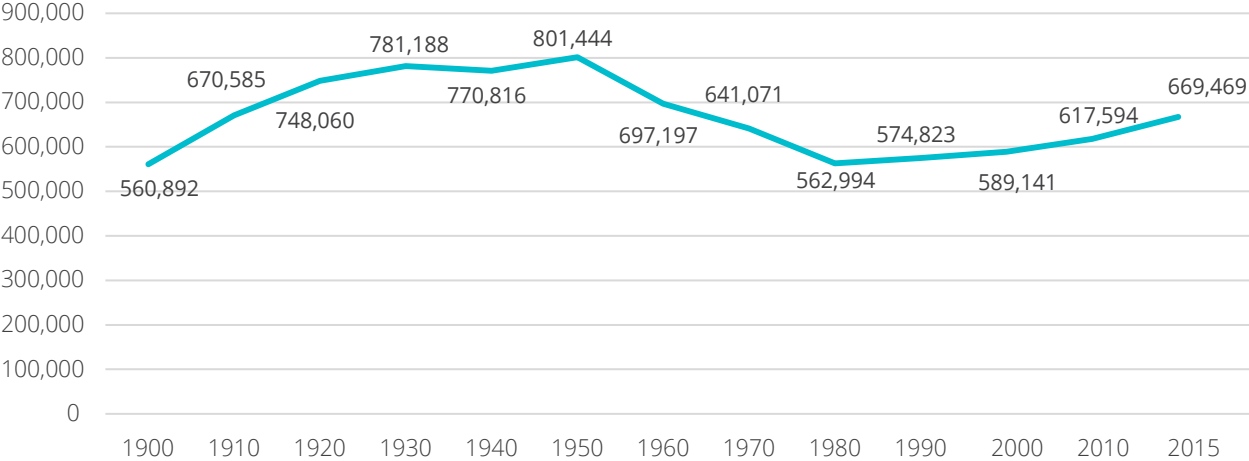
Source: U.S. Census Bureau, 1900-2010 Decennial Census, 2015 1-year American Community Survey, BRA Research Division Analysis

Population Projection Methodology

The BRA Research Division used a cohort-component population projection method to project Boston's population. This method uses the components of population change (fertility, mortality, and migration) to project each age cohort from a base of the 2010 Decennial Census. The equation for the projected population is as follows:

Projected Population = Population Base + Natural Change + Migration

Where:

Population Base: the population stock at the beginning of the projection period

Natural Change: the difference between births and deaths

Migration: the difference between in- and out- domestic migration plus the net gain/loss of international migrants

So that:

Projected Population = Population Base + [Births – Deaths] + [Domestic In-migration – Domestic Out-migration + Net International Migration]

We use historical data on births, deaths, and migration to calculate fertility, mortality and migration rates. We apply these rates to the population base (2010 Decennial Census population) to project Boston's population in five year increments. The following sections examine the components of population change in greater detail.

CHART

PROJECTED POPULATION CALCULATION

Population Base +

Natural Change

Births — Deaths +

Migration

Domestic In-Migration — Domestic Out-Migration + Net International Migration = Projected Population
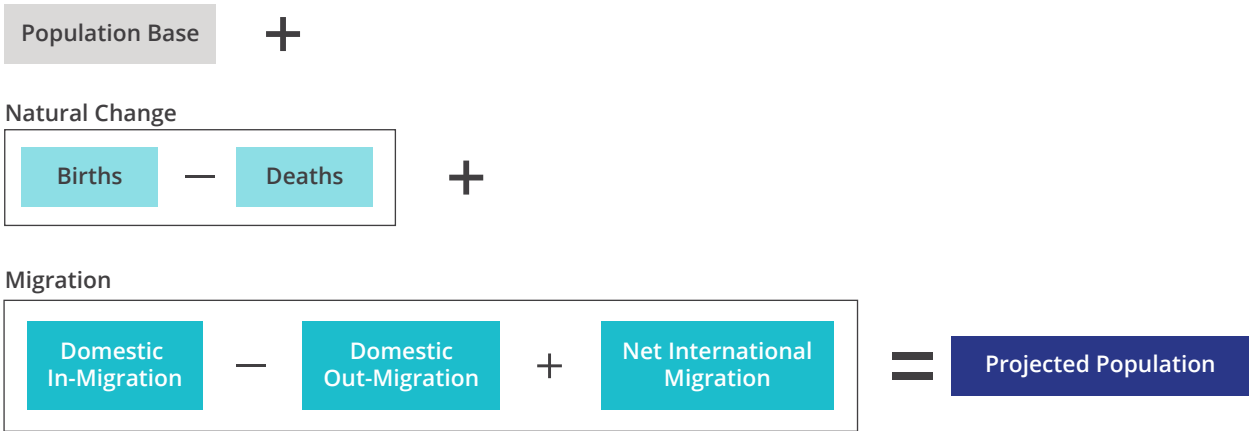
Natural Change in Population: Births-Deaths

Births

We examined births in Boston from 2000-2014 using Massachusetts Department of Public Health (MDPH) records. Boston has averaged 7,900 births a year since 2000. The fertility rate is the percentage of women of childbearing age who give birth in a year.

There is a noticeable recent trend toward slightly lower fertility rates overall and a significant trend towards births at older ages. This trend towards more births to mothers aged 30-plus and fewer to mothers under 30 is evident in birth data going back to 2000. It is also consistent with national data about the increase in mean age of mothers and U.S. Census projections

of a slight decline in fertility in the U.S. over the next 40 years.[1,2] Figure 2 illustrates Boston's annual birth rates by age of mother for 2006 to 2009 and 2010 to 2014. We use the more recent data (2010-2014) on births when generating age specific fertility rates in order to capture this shift towards births to older mothers. The projection methodology uses these fertility rates to project the number of births in each five year time period.

BOSTON'S ANNUAL BIRTH RATES BY AGE OF MOTHER
2006 - 2014
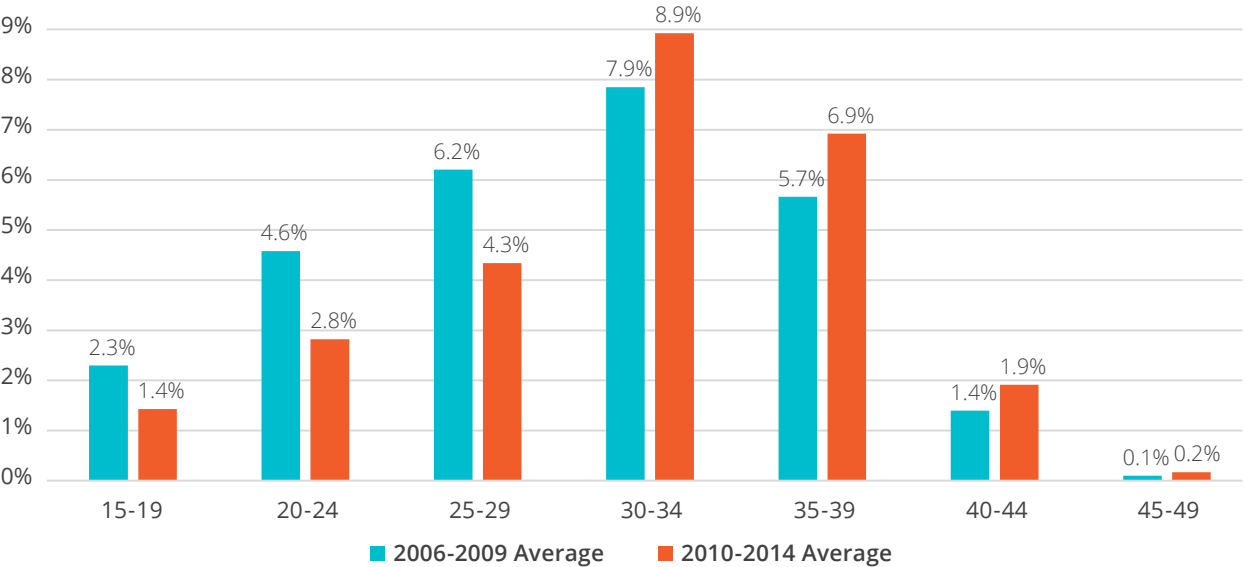
Source: Massachusetts Department of Public Health, Births to Boston Residents, 2006-2014 & U.S. Census Bureau, 2006-2014 1-year American Community Survey, 2010 Decennial Census, BRA Research Division Analysis

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[1] *Colby, Sandra L. and Jennifer M. Ortman, Projections of the Size and Composition of the U.S. Population: 2014 to 2060, Current Population Reports, P25-1143, U.S. Census Bureau, Washington, DC, 2014. http://www.census.gov/content/dam/Census/library/publications/2015/demo/p25-1143.pdf*

[2] *National Center for Health Statistics, "Mean Age of Mothers in on the Rise: 2000-2014", January 2016 http://www.cdc.gov/nchs/data/databriefs/db232. htm*
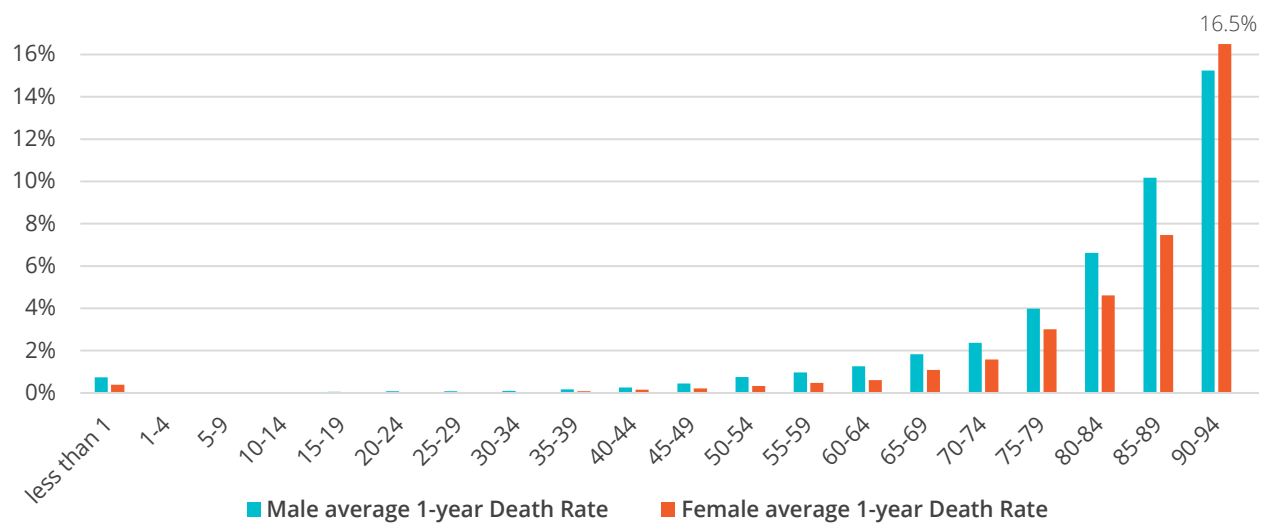
Deaths

We examined deaths in Boston from 2000-2013 using Massachusetts Department of Public Health records. The annual number of deaths in Boston declined over this time period despite the city's growing population. Boston deaths declined from an average of 4,367 a year from 2000 to 2004 to an average of 3,692 a year from 2010 to 2013. This decline can be explained by increasing one-year survival rates in the older age groups. To capture this trend, we used the more recent death data (2010 - 2013) to calculate age- and gender-specific survival rates to use in our projections. We calculated survival rates by dividing the average number of deaths 2010 to 2013 in each age cohort by a U.S. Census estimate of the number of people in Boston in each cohort and taking the complement of the death rate to produce a survival rate. Because of increased number of deaths in the first year of life, we calculated a separate survival rate for infants.

Figure 3 shows the one-year death rates by age cohort based on 2010 to 2013 data. Our projection methodology applies the age- and gender-specific survival rates to each age cohort to project the size of the cohort that survives into the next time period.

BOSTON GENDER-SPECIFIC ONE-YEAR DEATH RATES BY AGE
2010 – 2013

■ Male average 1-year Death Rate   ■ Female average 1-year Death Rate

Source: Massachusetts Department of Public Health, Boston Resident Deaths 2010-2013 & U.S. Census Bureau, 2010 Decennial Census, 2011-2013 1-year American Community Survey, BRA Research Division Analysis

Historical and Projected Natural Change in Boston's Population

Figure 4 shows the historical average annual births and deaths for 2000-2004, 2005-2009, and 2010-2013.[3] This historical average annual natural change (births minus deaths) rises from 3,596 for 2000 - 2004 to 4,228 for 2010 - 2013. The figure also shows the projected average annual births and deaths for 2016-2020, 2021-2025, and 2026-2030. The projections predict increasing numbers of births but also an increase in deaths such that projected average annual natural change falls back to 3,523 for 2026 - 2030. The average annual natural change in Boston's population (births minus deaths) ranges from approximately 3,500 to 4,200 per year. In the absence of migration, Boston's population would be expected to grow by this amount each year due to natural change (births and deaths).

FIGURE 4

HISTORICAL AND PROJECTED ANNUAL BIRTHS AND DEATHS IN BOSTON
2000 – 2030
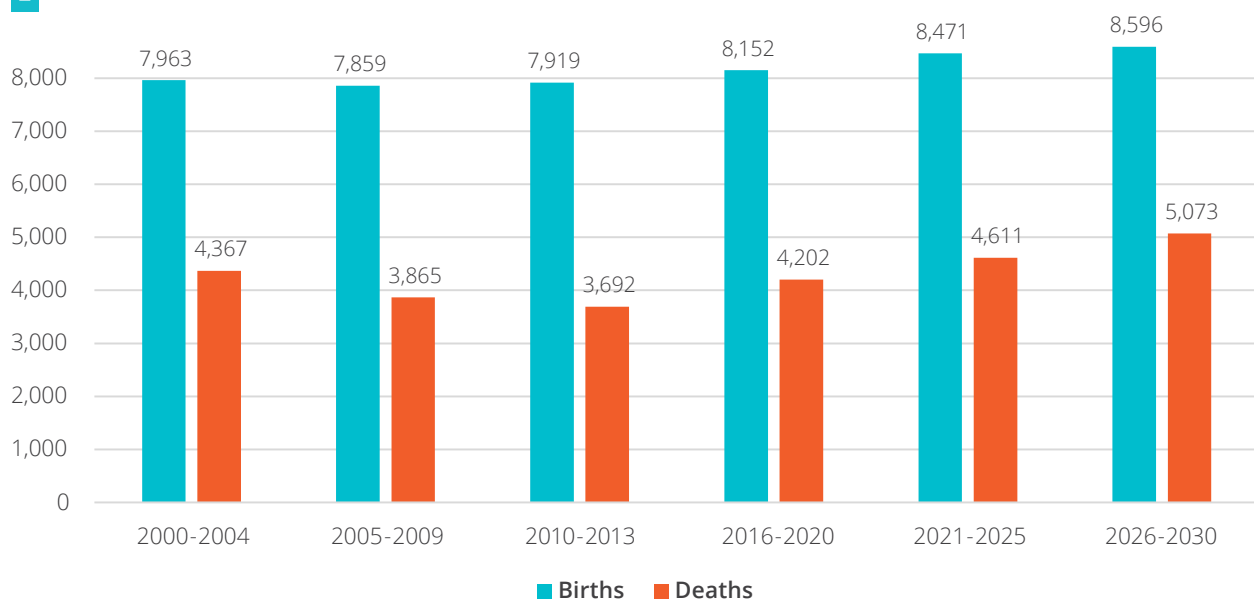
Source: Massachusetts Department of Public Health, Boston Resident Births and Deaths 2000-2013, BRA Research Population Projections 2016-2030, BRA Research Division Analysis

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[3] *At the time of publication, birth and death data were not available for 2014 and 2015. These data will be added to the projection model as they become available.*

Migration

In addition to natural change, migration is an important factor in shaping Boston's population growth and age distribution. The BRA Research population projection methodology makes use of American Community Survey (ACS) migration data to analyze migration patterns directly rather than simply attributing to migration any residual population change after births and deaths have been taken into account.

The ACS provides yearly estimates of people who moved to and from Boston in the previous year. We average eight years of migration data from 2007 to 2014 to smooth the effects of sampling error.

The BRA population projection model considers domestic and international migration. Domestic migration measures in- and out-migration separately. Domestic in-migration measures people who move to Boston from elsewhere in the United States including Massachusetts. The domestic in-migration rate for each cohort is the percentage of the U.S. population outside of Boston that moves to Boston. Domestic out-migration measures people who move from

Boston to elsewhere in the United States including Massachusetts. The domestic out-migration rate for each cohort is the percentage of Boston's population that moves elsewhere in the United States.

The model measures international migration as a net total representing in-migration from another country minus out-migration to another country. The ACS provides yearly estimates of people who moved to Boston from another country, but it does not provide a measure of people who moved from Boston to another country. However, the U.S. Census does provide yearly estimates of Suffolk County's net international migration. We apply the age and gender

FIGURE 5

AVERAGE ANNUAL NET TOTAL MIGRATION
2007 – 2014
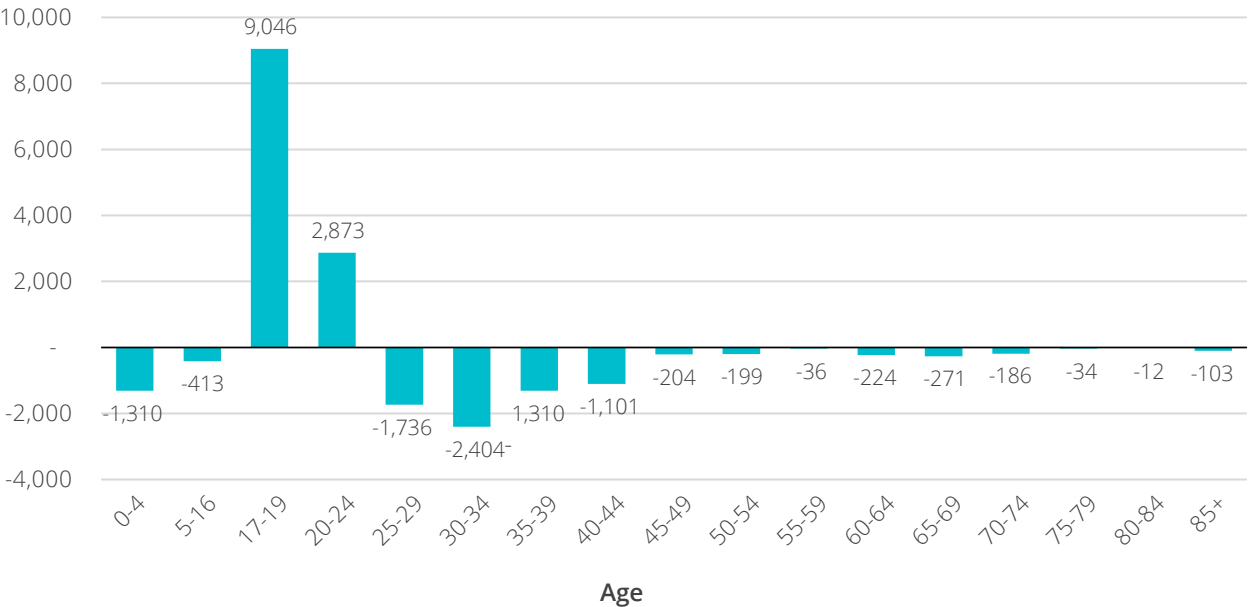
Source: U.S. Census Bureau, 2007-2014 American Community Surveys, PUMS, BRA Research Division Analysis

distribution of Boston's international in-migration to estimates of Boston's share of Suffolk County's net international immigration. The net international migration rate is the net percentage of Boston residents who moved internationally.

From 2007 to 2014, Boston had an average net gain of 2,376 people per year due to migration. Boston has distinct age patterns to its migration. As shown in FIGURE 5, the only ages that have a net positive migration are 17-24 year olds, as young adults come to Boston for educational and employment opportunities. Boston's population increases significantly as college students arrive in Boston to attend one of the region colleges or universities. In addition to college students, international migrants begin arriving in larger numbers at this age.

Children ages 0-16 and adults age 25 and over havenet negative migration to Boston. Boston has consistently experienced net out-migration of children. This out-migration occurs before children enter school and continues through high school age. For example, 33,053 children ages 0-4 in 2000 became 27,343 children ages 10-14 in 2010 for a net out-migration of over 17 percent.

From 2007 to 2014, approximately 66,671 people arrived in Boston each year while approximately 64,295 people left Boston. Figure 6 shows the rough estimates of the origins and destinations of these migrants.

Approximately 42 percent of arrivals in Boston come from Massachusetts, and 24 percent come from another city or town in Greater Boston.[4]

ORIGINS AND DESTINATIONS OF MIGRANTS TO AND FROM BOSTON
2007-2014
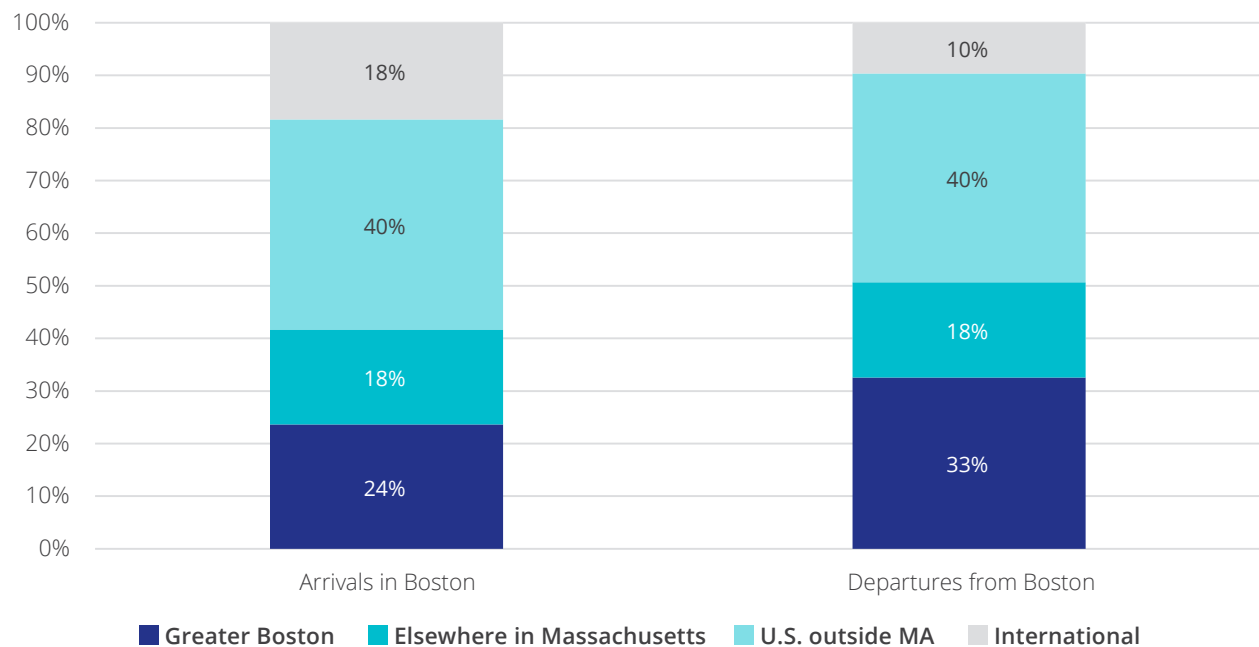
Source: U.S. Census Bureau, 2007-2014 American Community Surveys, PUMS, and Census Population Estimates, BRA Research Division Analysis. Note: Domestic migration shares are taken from 2007-2011 data due to a change in definition in 2012. International departures are estimated from Suffolk County population estimates as described earlier.

[4] Greater Boston is defined here as Salem, Lynn, Dedham, Waltham, Medford, Braintree, Chelsea, Revere, Cambridge, Everett, Somerville, Brookline, Newton, Quincy, and Milton.

Approximately 51 percent of departures from Boston go elsewhere in Massachusetts and 33 percent go to another city or town in Greater Boston. Boston has an average annual net loss of population to the rest of Greater Boston of approximately 5,138 people. Boston has an average annual net gain of population from the rest of Massachusetts outside of Greater Boston of approximately 350 people. Boston also gains on average 1,095 people from the rest of the United States outside of Massachusetts each year.

From 2007 to 2014, Boston had an average annual net gain of 6,070 people due to international migration. On average, each year, 6,070 more people arrive in Boston from another country than leave Boston to live in another country. These data measure migration by asking where the person lived one year prior to the survey. Migration questions do not consider the nativity or citizenship of the migrants, so these international migrants are not exclusively foreign born. A native born U.S. citizen who lives abroad and then moves to Boston would be considered an international migrant in the year of their arrival. The Census estimates that approximately 80 percent of international migrants to the U.S. are foreign born. Conversely, some foreign-born individuals may come to Boston from first living somewhere else in the United States. These individuals would be considered domestic migrants in the year they move to Boston, but once in Boston, they would be counted in the foreign-born immigrant population of Boston. Figure 7 shows these net migration flows between Boston and other regions.

FIGURE 7

AVERAGE ANNUAL NET MIGRATION FLOWS TO AND FROM BOSTON
2007-2014
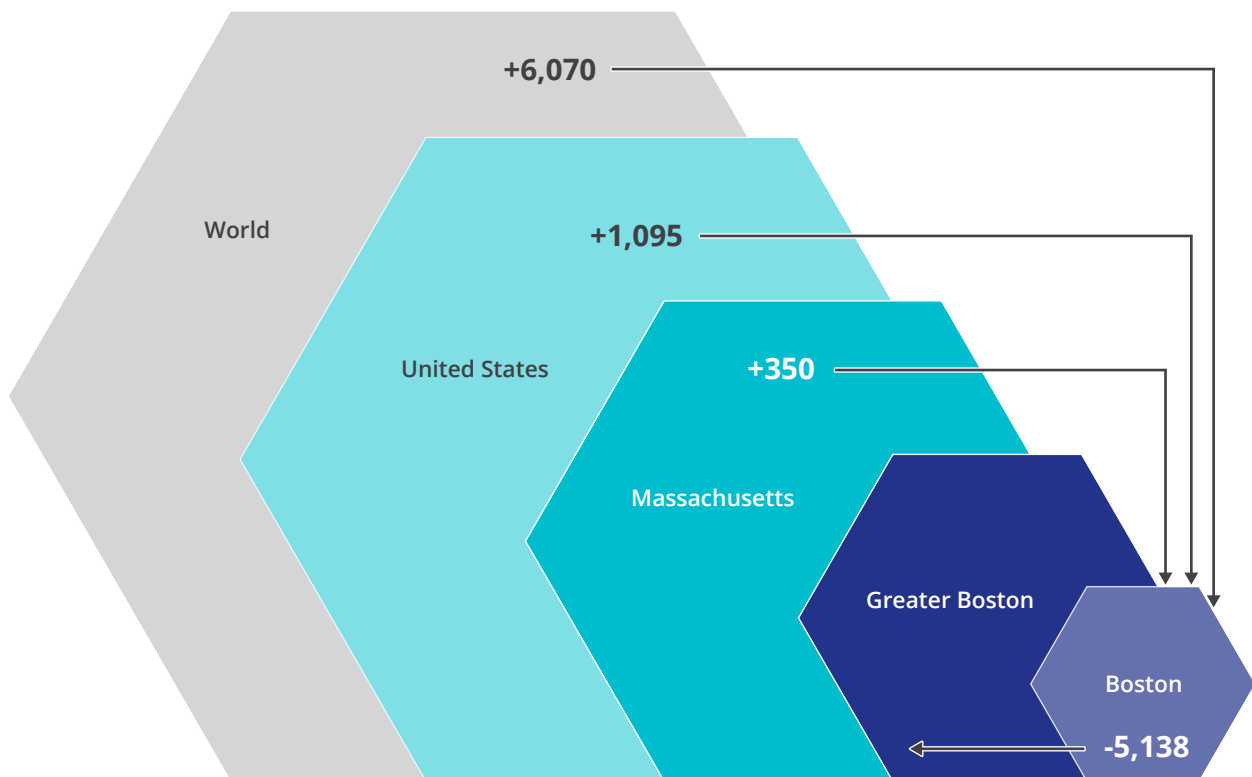
Source: U.S. Census Bureau, 2007-2014 1-year American Community Survey, PUMS, BRA Research Division Analysis

Projection Results

As previously documented, we created (1) age-specific fertility rates from Massachusetts Public Health Commission birth data from 2010-2014 and U.S. Census population data; (2) age- and gender-specific survival rates from Massachusetts Public Health Commission death data 2010-2013 and U.S. Census population data; and (3) age- and gender-specific domestic in- and out-migration and net international rates from U.S. Census migration and population data from 2007-2014.

We applied these constant rates to Boston's 2010 Decennial Census population divided into age and sex cohorts to project the population in five-year periods. We projected the 2015 population and then used that projection to launch the 2020 population. We continued this process until we projected Boston's 2030 population.

Boston's population is projected to grow to 723,500 by 2030, as shown in Figure 8. This represents an

average annual population increase for the city of 0.85 percent from 2010.

Figure 9 shows the age and gender distributions of the 2010 and 2030 Boston populations. The age structure of the 2030 projected population continues to be marked by large 20-24 and 25-29 cohorts. However, the population noticeably smooths out as other age cohorts increase in size.

FIGURE 8

BOSTON'S PROJECTED POPULATION THROUGH 2030
1900 - 2030
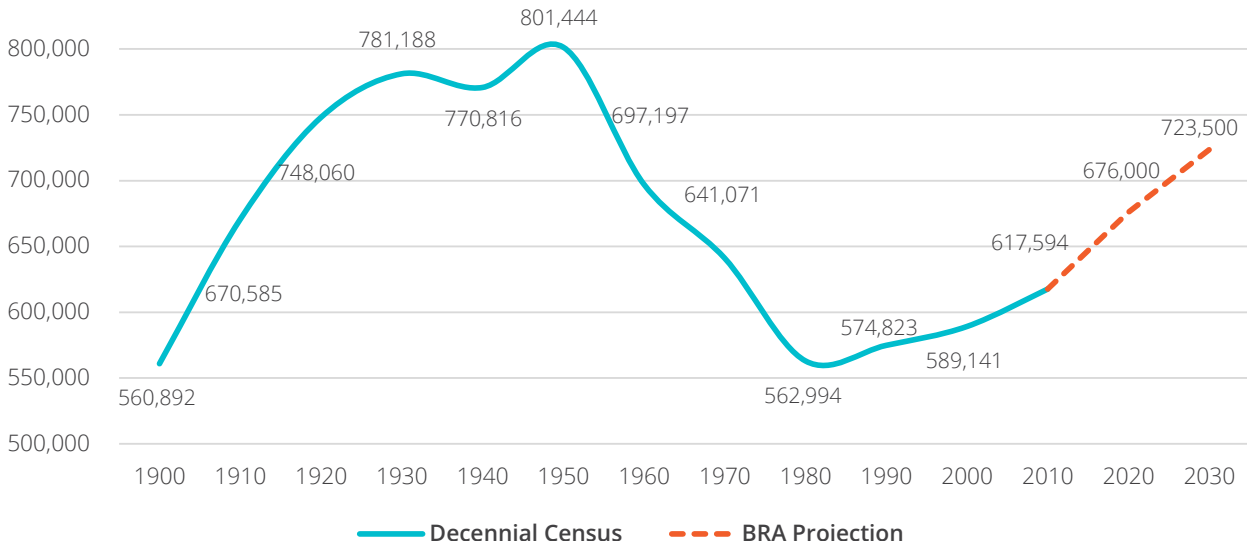
Source: U.S. Census Bureau, 1900-2010 Decennial Census, 2010-2030 Population Projections, BRA Research Division Analysis

FIGURE 9

2010 AND PROJECTED 2030 POPULATION PYRAMIDS
2010 - 2030
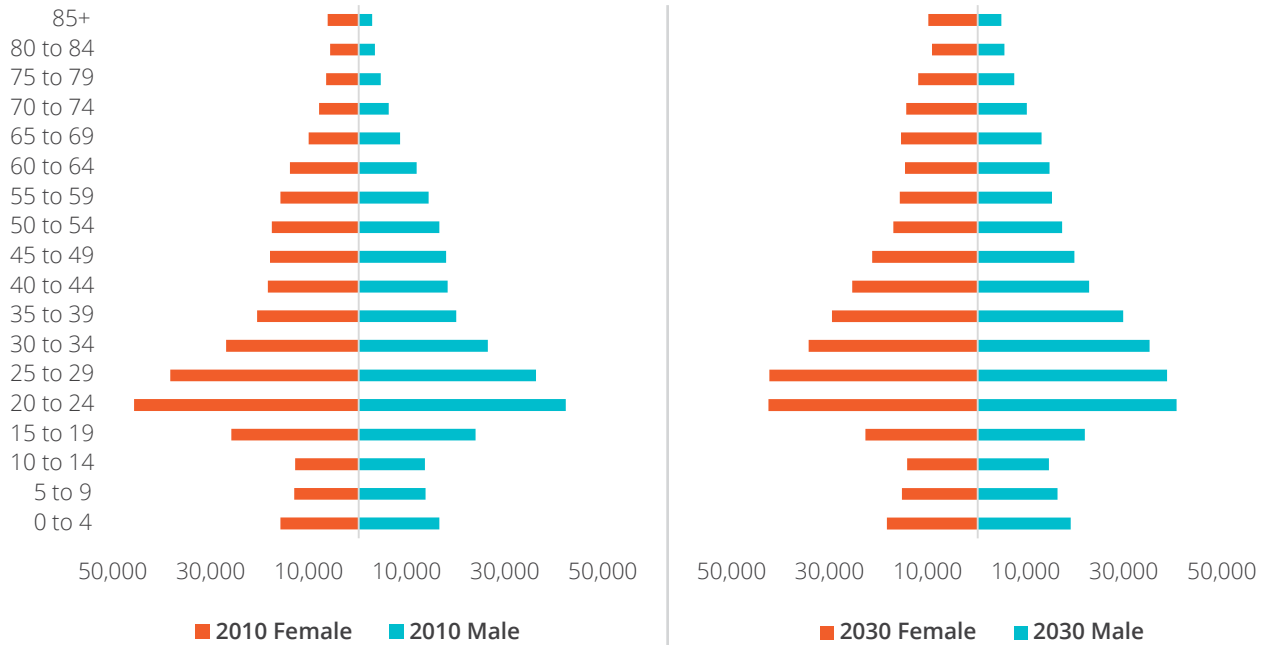
Source: U.S. Census Bureau, 2010 Decennial Census, 2030 Population Projections, BRA Research Division Analysis

The 2030 projected populations are larger than the 2010 populations in all age and gender cohorts except 15 to 19 and 20 to 24. Figure 10 illustrates the projected changes in the size of the age cohorts. As the Millennial generation ages, there are decreases in the young adult cohorts and increases in the middle aged cohorts. The population aged 30 to 44 is projected to grow by 46,520 people, an increase of 35 percent. The aging Baby Boomers lead to a 65 percent increase in the size of the population over age 65. The over 65 population is projected to increase by 40,408 people from 2010 to 2030. The 15-24 year old cohort loses approximately 10,000 people, a decline of 7 percent. This trend is consistent with national historical and projected trends.

Although the young adult cohorts remain the largest, their share of the city's population decreases as the 2030 projections project increases in the older age cohorts. Figure 11 illustrates the population share by age group throughout the projection period. The over 65 age cohort increases from 10 percent to 14 percent of the population, while the 15-29 age cohorts decrease from 34 percent to 29 percent of Boston's population by 2030.

FIGURE 10

PROJECTED BOSTON POPULATION BY AGE COHORT
2010 – 2030
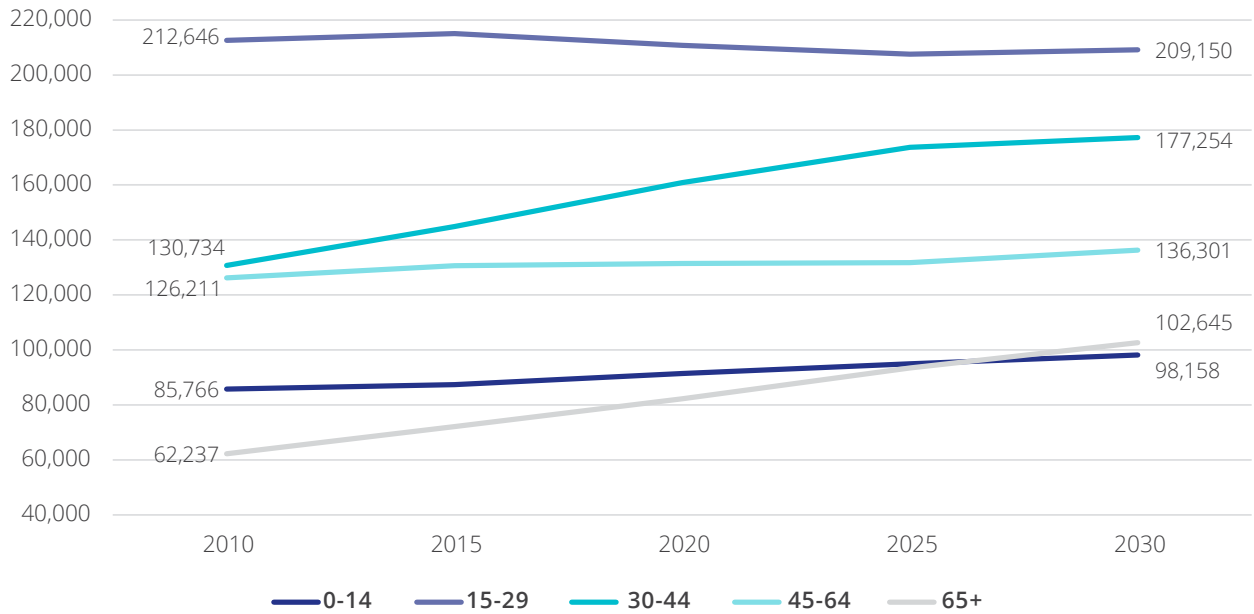
Source: U.S. Census Bureau, 2010 Decennial Census & BRA Population Projections, BRA Research Division Analysis

FIGURE 11

POPULATION SHARE BY AGE GROUP
2010 – 2030
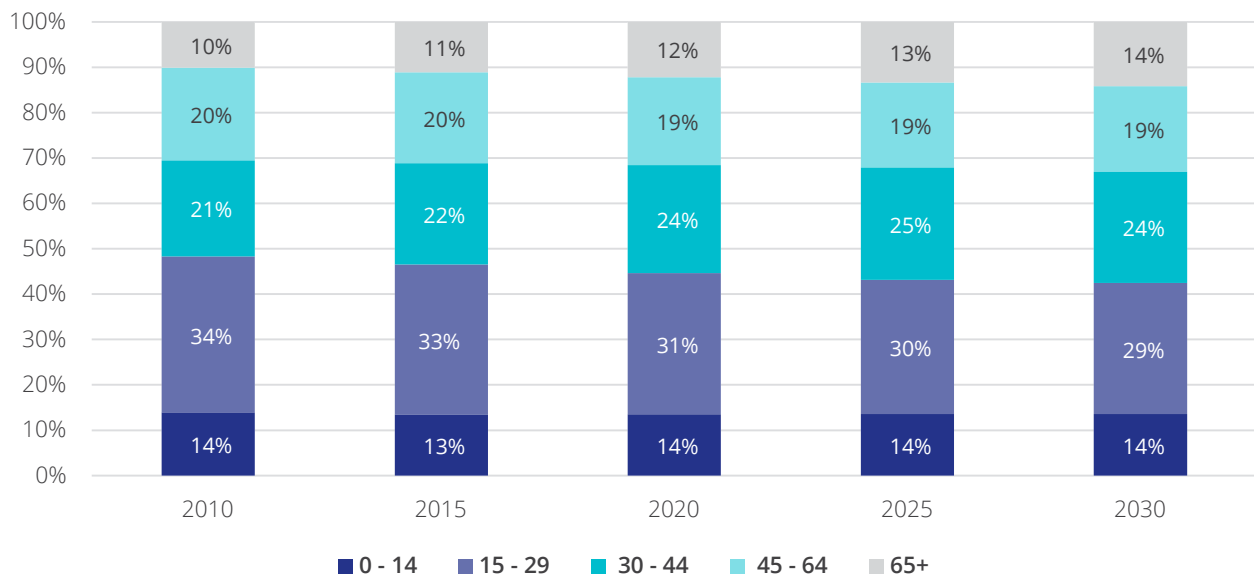

Source: U.S. Census Bureau, 2010 Decennial Census & BRA Population Projections, BRA Research Division Analysis

Comparison to Other Projections

In addition to the BRA's population projection for Boston in 2030, the Metropolitan Area Planning Council and UMass Donahue Institute have produced population projections. Each of these projections generated different fertility, survival, and migration rates resulting from choices made related to data sources and assumptions regarding measurement of migration. The BRA's projection of 723,500 represents a 0.85 percent average annual population increase while MAPC's "Stronger Region" projected population of 709,500 represents a 0.75 percent average annual population increase. UMass Donahue Institute's projected population of 752,000 represents a 1.09 percent average annual population increase.

Even though there is a range of 42,500 people among these three population projections for Boston, there are similar patterns among them. All three project faster population growth from 2010 to 2030 than from 1980 to 2010, with the most rapid population increase occurring 2010 to 2020, and slowing after 2020. All three show a decrease in the 15-29 population and an increase in the 30 to 44 population relative to Boston's total population. Finally, all three projections show an increase in the population 65 year or older.

FIGURE 12

COMPARISON OF POPULATION PROJECTIONS FOR 2030
1980 – 2030
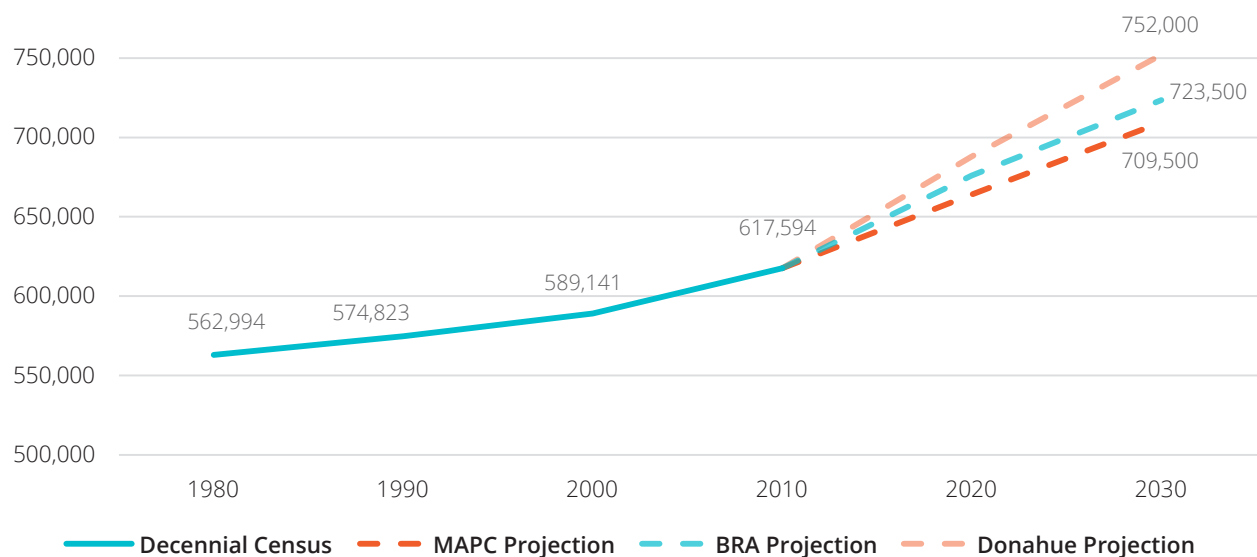
Source: 1980-2010 Decennial Census Reardon, Tim & Hari, Meghna, "Metro Boston 2030 Population and Housing Demand Projections," MAPC, 2014. Renski, Henry & Strate, Susan "Long-Term Population Projections for Massachusetts Regions and Municipalities," UMDI, 2014. BRA Research Staff Analysis

BRA Population Projection Model

The BRA Research Division created a population projection model that can be updated easily as new data become available. We plan to update our inputs of births, deaths and migration data annually. The model was designed with the flexibility necessary to test hypothetical scenarios or to explore the impact of policy proposals. Figure 13 illustrates the main components of the model and the relationships between the variables and the key components, data and rates.

FIGURE 13

BRA POPULATION PROJECTION MODEL

LEGEND | Projection | Key Component | "At-Risk" | Data | Rate

Fert_5Y
Boston operationalized 5-year fertility rate
=average **(BosBirth-year)*5**

BosBirth
Boston birth rate 5-year age cohort female age 10-45
Source: BPHC

BosDeath
Boston death rate 5-year age cohort
Death Rate = Death / **BosPop_5_Y**
Source: BPHC

BosPop_5Y
Boston population 5-year age cohort
Source: 2007-2014 ACS PUMS 1-year estimate, 2010 Decennial Census

Survived_to_End_Year
Boston residents survued at the end of projection periods.
=BosPop_5Y* Survive_5Y

Survive_5Y
Boston operationalized 5-year survival rate
$= [(1- \textbf{BosDeath}_{1\text{-year}})^{2.5}]*[(1-\textbf{BosDeath}_{1\text{-year}})^{2.5}]$

Projected Birth
=Boston Female Population Projections * Fert_5Y

Natural Change

Boston Population Projections

Migration

Domestic In-Migration
=USPop_Proj_2015-2040 * DomInMigR

Domestic Out-Migration
=Survived_to_End_Year * DomOutMigR

Net International Migration
= Survived_to_End_Year * NetIntMigR

USPop_Proj_2015-2040
=US population projections (Census) -
Boston Population Projections
(BRA Research)
Source: Census, BRA Research

DomOutMigR
Boston operationalized domestic out-migration rate
=BosDomOut_1Y_07-14 / US_Syn

NetIntMigR
Boston operationalized net international migration rate
=BosIntIn_1Y_07-14 / Bos_Syn

US_Syn
US synthetic population
=USPop_07-14 - US_IntIn_07-14 - (Bos_Syn - Bos_IntIn_1Y_07-14)

BosDomOut_1Y_07-14
Boston domestic out-migration 1-year age cohort, 2007-2014
Source:2007-2014 ACS PUMS 1-year estimate

DomInMigR
Boston operationalized domestic in-migration rate
= **BosDomIn_1Y_07-14 / US_Syn**

BosDomIn_1Y_07-14
Boston domestic in-migration 1-year age cohort, 2007-2014
Source: 2007-2014 ACS PUMS 1-year estimate

Bos_Syn
Boston synthetic population
=Bos_Dom-movers_1Y_07-11 + Bos_non-mover_07-14 + BostIntIn_07-14

BosIntIn_1Y_07-14
Boston international migration, 1-year eastimate, 2007-2014
Source: 2007-2014 ACS PUMS 1-year estimate

US_IntIn_07-14
US international in-migration, 2007-2014
Source: 2007-2014 ACS PUMS 1-year estimate

Bos_non-mover_07-14
Living in Boston at time of ACS survey and had not moved in previous 12 months
Source: 2007-2014 ACS PUMS 1-year estimate

Bos_Dom-mover_1Y_07-14
Living in Boston 12 months prior to ACS survey but had subsequently moved within the U.S.
Source: 2007-2014 ACS PUMS 1-year estimate

US_Pop_07-14
Us population, 2007-2014
Source: 2007-2014 ACS PUMS 1-year estimate