TECHNICAL APPENDIX

Methodologies for Chapter 3 Analysis

Previous research shows that the Boston metropolitan region suffers from a persistently high level of racial segregation. For example, a recent study of segregation trends across 52 U.S. metropolitan areas between 1970 and 2010 finds that Boston is consistently among the set of hypersegregated cities for black residents—meaning that blacks were highly segregated on at least four of the five dimensions of population distribution used by the U.S. Census Bureau to measure racial and ethnic segregation within a given area (Massey and Tannen, 2015)[1]. These dimensions are:

- Evenness, which refers to the spatial distribution of different racial and ethnic groups within a metropolitan area;
- Exposure, which measures the degree of potential contact, or the possibility of day-to-day interaction, between different racial and ethnic groups;
- Clustering, which describes the extent to which different populations live in segregated enclaves, spatially disparate from one another;
- Centralization, which indicates the degree to which a particular group is located near the center of an urban area; and
- Concentration, referring to the relative amount of physical space occupied by a group of people.

We make use of a subset of these measures to assess the degree of segregation in Greater Boston for three historically underrepresented populations: Asians, blacks, and Latinos. We bring together a variety of data available from the decennial census and the American Community Survey at the census tract level. We also make use of existing measures constructed by other researchers to be able to make comparisons with other metropolitan areas over time. In doing so, we aim to answer the following questions:

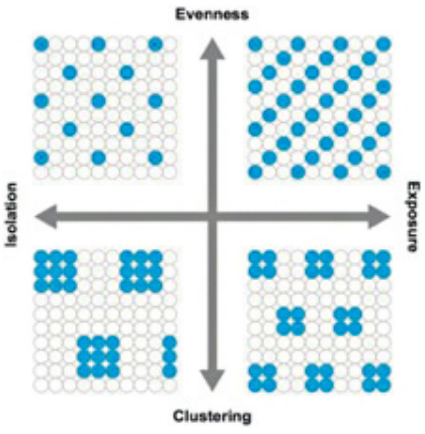
- Is the current level of racial segregation in Greater Boston high and if so, for which groups?
- Has racial segregation been increasing or decreasing over time in Greater Boston?
- How does racial segregation compare in Boston versus other metropolitan areas?
- Are there cities or towns within Greater Boston where racial segregation is declining?

Measures Used

We use several measures of segregation to be able to compare trends over time and across metropolitan areas focusing on both evenness as well as exposure, as conceptualized in Figure A.1. In capturing the spatial patterns of population groups, evenness is the opposite of clustering while isolation is the opposite of exposure. In their simplest forms, the upper right quadrant may be conceived as a possible scenario for integration or diversity, and the lower left quadrant for isolation.

FIGURE A.1

Dimensions of Segregation



Source: Reardon, Sean and David O'Sullivan. 2004. "Measures of Spatial Segregation." *Sociological Methodology*, 34(1): 121-162.

[1] Massey, Douglas S. and Jonathan Tannen. 2015. "A Research Note on Trends in Black Hypersegregation." *Demography*, Jun; 52(3): 1025–1034.

DISSIMILARITY INDEX

The first measure we examine is the dissimilarity index, the most common summary measure of "evenness"—the extent to which the distribution of two racial/ethnic groups differs across geographies. The index measures the degree to which the major non-white groups are distributed differently than whites across census tracts. Values range from 0 (complete integration) to 100 (complete segregation) with the value indicating the percentage of the minority group that would need to move to be distributed exactly like the white population. A value of 60 or greater is generally considered indicative of a very high level of segregation. It means that at least 60 percent of the members of one group would need to move to a different census tract in order for the two groups to be equally distributed. Values of 40 to 50 are usually considered indicative of a moderate level of segregation, and values of 30 or below are considered to be fairly low.

ISOLATION INDEX

Our second measure of racial segregation captures the degree of potential contact, or the possibility of day-to-day interaction, between different racial and ethnic groups. The isolation index measures the degree to which minority members are exposed only to one another. When measuring two groups, higher values of isolation indicate higher levels of segregation.

RACIALLY AND ETHNICALLY-CONCENTRATED AREAS OF POVERTY (R/ECAPS)

To assess the interaction of segregation and poverty, we use a census tract–based definition of racially and ethnically-concentrated areas of poverty (R/ECAPs).[2] To meet the racial/ethnic concentration threshold a census tract must have a non-white population of 50 percent or more (i.e., non-Latino whites must be in the minority). To meet the poverty threshold the tract must have 40 percent or more of the population living at or below the poverty line or a poverty rate that is three times the average tract rate, weighted by population, for the metro area/region—with the lower of these values applied.

ACTUAL VERSUS PREDICTED TO RESIDE RATIO

To account for income differences across racial groups, we use a measure developed by the U.S. Census Bureau that calculates the ratio of actual versus predicted racial/ethnic composition for each municipality. This "actual versus predicted to reside" measure has the advantage of not being size sensitive compared with other measures of segregation such as the dissimilarity or isolation indices—both of which have little meaning for very small geographic units, or geographies where there are very few residents in a specific racial/ethnic group as is the case for many cities and towns in the Greater Boston region.

In addition, the predicted, or expected, values are based on the region's income distribution by race as illustrated in Figure A.2, which shows the percentage of each racial/ethnic group that falls into each of the 16 different income bands specified by the Census. For example, among those households earning less than $10,000 annually, 15 percent are black and 19 percent are Latino. In contrast, among households earning over $200,000, only 2.5 percent are black and 3.0 percent are Latino. Thus, low income communities like Lowell or Lawrence, where more than 10 percent of households earn less than $10,000, would be expected to have more Latino and black residents than nearby Andover, where just 3 percent of households earn below $10,000.

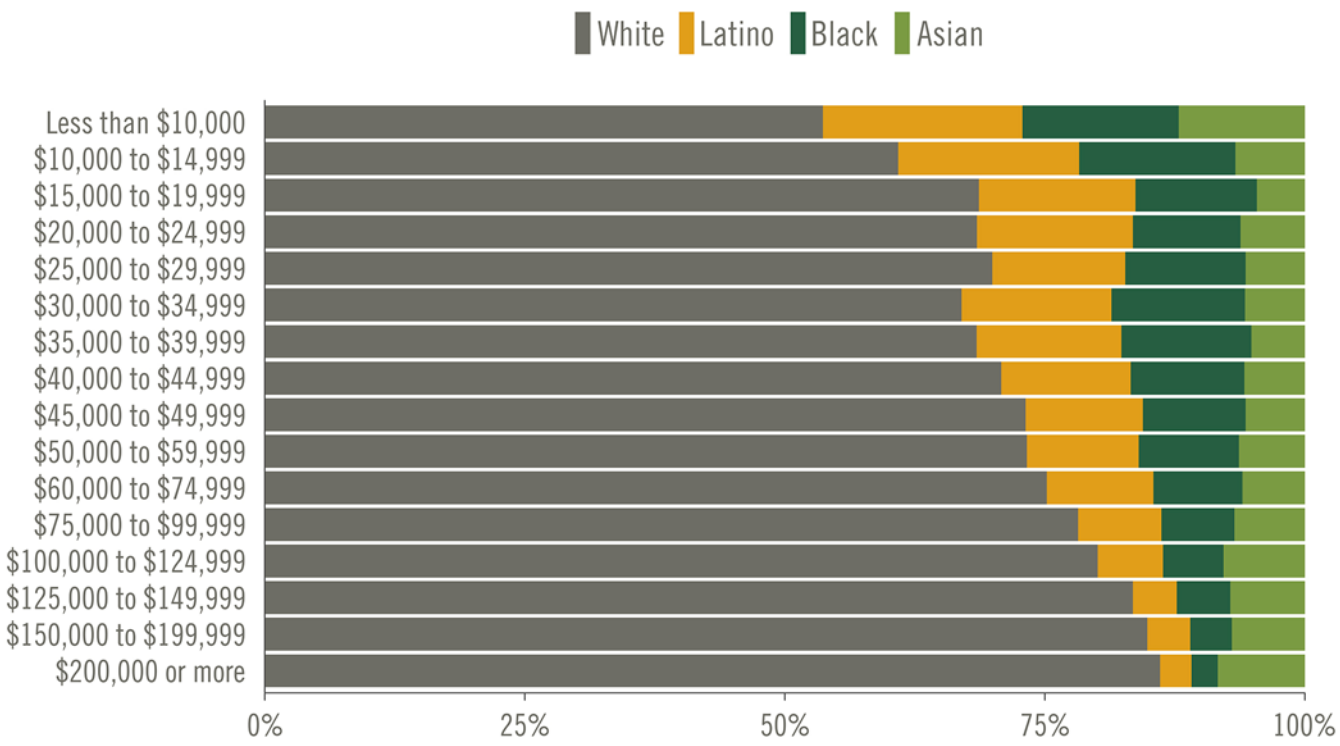
[2] To meet the racial/ethnic concentration threshold a census tract must have a non-white population of 50 percent or more (i.e., non-Latino Whites must be in the minority). To meet the poverty threshold the tract must have the lower of 40 percent or more of the population living at or below the poverty line or a poverty rate that is three times the average tract rate, weighted by population, for the metro area/region.

Thus, the predicted value for a racial or ethnic group in a municipality is calculated as the number of households the municipality has in a given income band multiplied by the racial/ethnic group's share of that income band for the Greater Boston region. The totals are then summed over all the income bands for each racial/ethnic group to determine the predicted number of each racial/ethnic group in the municipality. The actual number of residents in each racial/ethnic group is then compared with the predicted total for each racial/ethnic group to determine the actual to predicted ratio. Ratios near or equal to 1 indicate that the municipality is close to its predicted level of racial/ethnic composition based on both the racial/ethnic and income distribution of the Greater Boston region. Ratios less than 1 indicate that the municipality has fewer residents in a given racial/ethnic minority group than one might expect given the city or town income distribution.

FIGURE A.2

Household Distribution by Income and Race/Ethnicity

Greater Boston, 2017



Source: American Community Survey, 2013–2017, 5-year estimates.

HUD OPPORTUNITY INDICES

The qualities that define a community as offering opportunities for residents are multidimensional. As such, a variety of metrics can be used to measure progress. As part of its Affirmatively Furthering Fair Housing requirements, HUD developed its own process for measuring opportunities. First, the degree to which a neighborhood offers particular kinds of opportunities is quantified using metrics that rank each neighborhood relative to others in the state. Then, these neighborhood rankings are correlated with where people in particular subgroups live to develop a summary measure or index of that group's general access to that specific opportunity. This index can then be compared across subgroups to establish disparities in access to opportunity.

HUD focuses on six opportunity dimensions: poverty; school proficiency, labor market engagement, transportation cost, transit trips, and environmental health. These dimensions and the indicators used to assess how one neighborhood might compare to another are shown in Table A.1. HUD assigned each dimension a score, ranging from 0 to 100, with 100 representing the census tracts with

TABLE A.1

Understanding the HUD Opportunity Indices

HUD Opportunity Index	What is Measured	Interpretation (Index Values Range 0-100)
Low Poverty Index	Measures the contact that people in a given neighborhood have to others in poverty	**HIGH:** less exposure to others in poverty in a neighborhood **LOW:** more exposure to others in poverty in a neighborhood
School Proficiency Index	Performance of schools in a given neighborhood, as measured by the performance of elementary school scores on standardized reading and math tests	**HIGH:** higher performance of the school system in a neighborhood **LOW:** lower performance of the school system in a neighborhood
Labor Market Engagement Index*	Combines educational attainment, unemployment and labor force participation to estimate the local job market's engagement with households	**HIGH:** higher employment and human capital (education) in a neighborhood **LOW:** lower employment and human capital (education) in a neighborhood
Low Transportation Cost Index**	Evaluates spending on all public and private transportation including cars, taxis, public buses, and trains	**HIGH:** lower spending on transportation in a neighborhood **LOW:** higher spending on transportation in a neighborhood
Transit Trips Index	Reveals households' usage of mass transit in a neighborhood	**HIGH:** more likely that residents of a neighborhood utilize public transit **LOW:** less likely that residents of a neighborhood utilize public transit
Environmental Health Index	Neighborhood-level risk factors associated with carcinogenic, respiratory and neurological threats to air quality to measure the presence of air toxins	**HIGH:** less exposure to air toxins in a neighborhood **LOW:** more exposure to air toxins harmful to human health in a neighborhood

Source: U.S. Department of Housing and Urban Development, Affirmatively Furthering Fair Housing Data and Mapping Tool (AFFH-T) Affirmatively Further Fair Housing Data and Mapping Tool version 4.1 September 2017. UMDI summary from Massachusetts DHCD 2019 Analysis of Impediments to Fair Housing Choice.

Note: Null index values reported by HUD indicate that the index value was not reported for that particular geography.

* Labor Market Engagement reflects the number of jobs locally available, the resources of the local population to complete higher education, and discrimination and participation in the job market.

** Transportation costs may be low due to efficient transportation infrastructure or the heavy concentration of residences and employment opportunities in the neighborhood.

the most of that particular kind of opportunity and 0 the tracts with the least of that specific opportunity. This score is an index representing the weighted average of the data evaluated for each specific type of opportunity. For example, labor market engagement is a weighted average of the unemployment rate, labor force participation rate, and educational attainment. HUD Opportunity Indices with a higher score signify more of that type of opportunity for the people living in that location. Low index values represent challenging conditions, such as high exposure to others in poverty, high unemployment, lower educational attainment, lower-performing schools, elevated levels of air toxins, and remoteness from jobs and modes of transportation. HUD has discouraged combining the indices into composites for such purposes and has focused on the individual components of opportunity. For the purposes of this analysis we focus on poverty, school proficiency, labor market engagement, and environmental quality, which affects neighborhood health.

SUPPLEMENTARY INFORMATION ON PATTERNS OF SEGREGATION IN BOSTON

Table A.2 shows that just over 70 percent of the entire region's Latino households and 66 percent of black households resided in just 10 municipalities in 2017. The region's Asian households are somewhat more dispersed, with the top 10 communities containing 44 percent of all Asian households. White households are considerably more dispersed throughout Greater Boston. Among the top 10 communities for each of the major non-white racial/ethnic groups, only three communities—Boston, Cambridge, Lowell—were among the top 10 for all three minority groups.

TABLE A.2

Top Ten Massachusetts Communities for Major Racial and Ethnic Groups

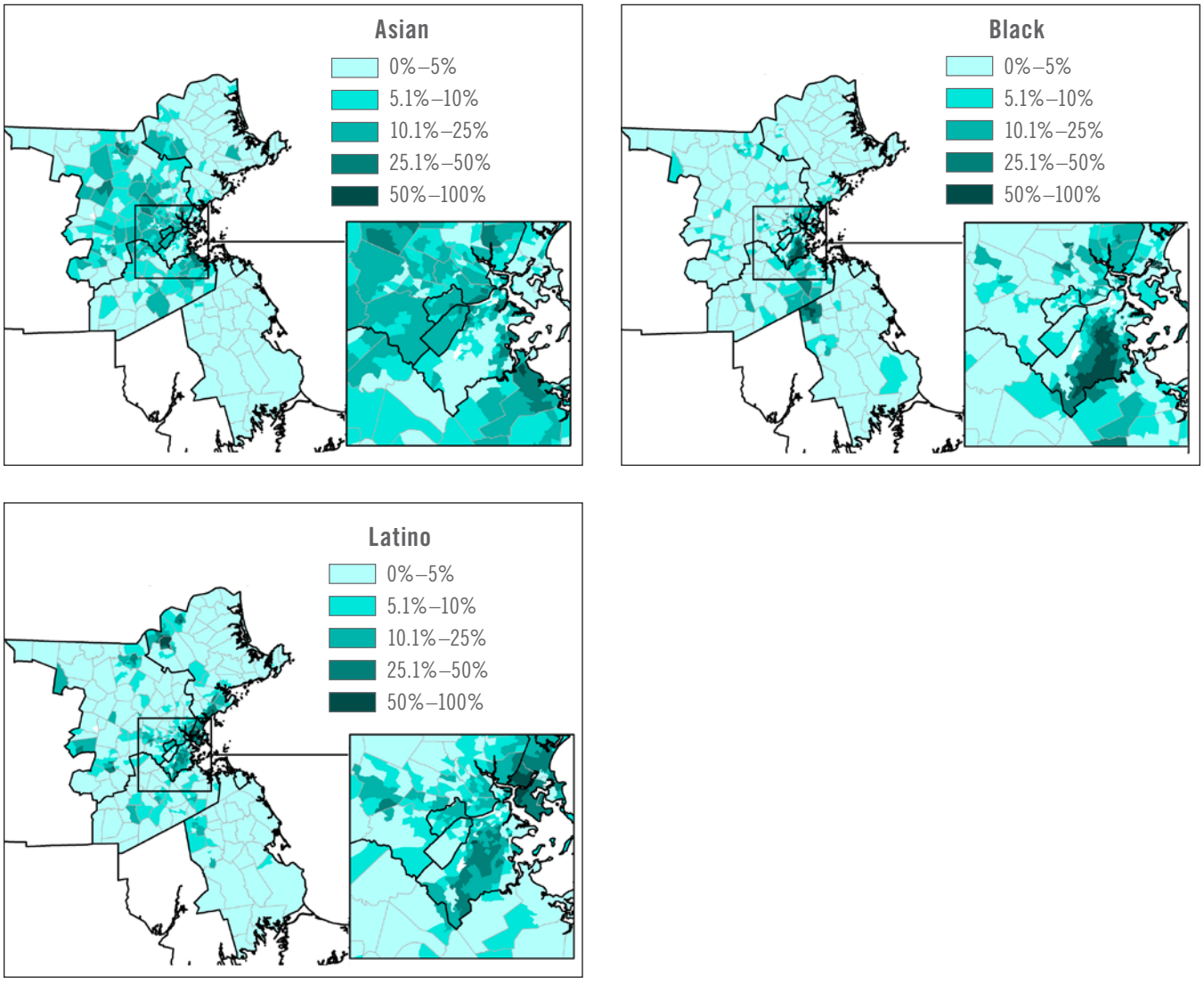
City/Town	Number Asian	Cumulative Percent	City/Town	Number Black	Cumulative Percent	City/Town	Number Latino	Cumulative Percent
Greater Boston	114,619		Greater Boston	127,309		Greater Boston	146,876	
Boston	23,225	15.8%	Boston	58,944	40.1%	Boston	42,705	29.1%
Quincy	8,615	21.7%	Brockton	11,927	48.3%	Lawrence	18,663	41.8%
Lowell	6,066	25.8%	Cambridge	4,800	51.5%	Lynn	9,813	48.5%
Cambridge	6,052	29.9%	Lynn	4,634	54.7%	Lowell	7,251	53.4%
Malden	4,965	33.3%	Randolph	4,191	57.5%	Chelsea	6,936	58.1%
Brookline	3,895	36.0%	Malden	3,026	59.6%	Revere	4,267	61.0%
Newton	3,704	38.5%	Lowell	2,885	61.6%	Methuen	3,919	63.7%
Lexington	2,832	40.4%	Everett	2,471	63.2%	Haverhill	3,817	66.3%
Waltham	2,707	42.3%	Quincy	2,148	64.7%	Framingham	3,585	68.7%
Somerville	2,475	43.9%	Somerville	2,027	66.1%	Cambridge	3,350	71.0%

Source: 2013–2017 5-Year Estimates of the American Community Survey.

While the region has become more racially diverse over the last several decades, the concentration of minority populations in a handful of municipalities means that some whites still have limited interactions with racial and ethnic minorities. For example, over half of all non-Latino whites in Greater Boston (53.5 percent) live in communities (109 of them) where less than 3 percent of the population is black. Nearly 45 percent live in communities (96 of them) where less than 3 percent of the population is Latino and just over one-third live in communities (72 of them) where less than 3 percent of the population is Asian.

MAP A.1

Share of the Population by Race, 2016



Source: 2016 1-year ACS, Tqble DPO5.

Analyzing the Metrics

BOSTON-QUINCY METROPOLITAN AREA VERSUS 50 LARGEST METROPOLITAN AREAS, 1980–2010

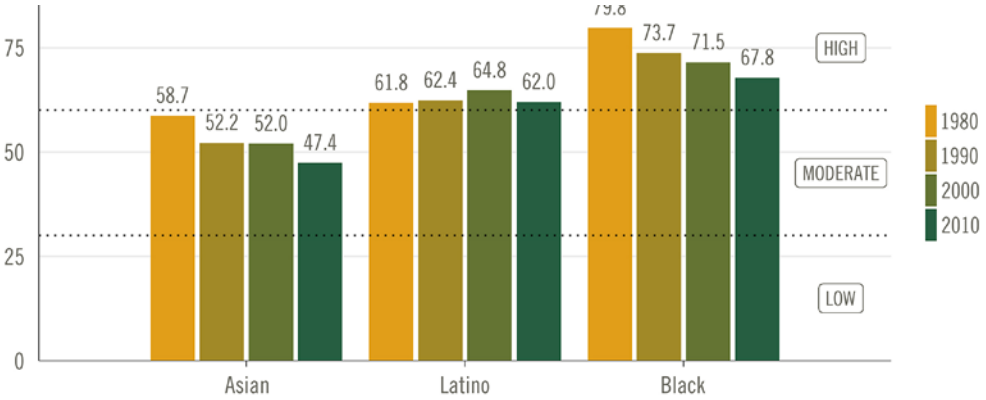
The first measure we examine is the dissimilarity index, the most common summary measure of "evenness"—the extent to which the distribution of two racial/ethnic groups differs across geographies. To be able to make apples-to-apples comparisons of the dissimilarity index across metropolitan areas over the past several decades, we draw on prior research that uses census data for a set of the 50 largest metropolitan areas, including the Boston-Quincy metro area comprising Norfolk, Plymouth, and Suffolk counties (Logan and Stults, 2011)[3].

Figure A.3 indicates some improvement in the dissimilarity index between 1980 and 2010 in the Boston-Quincy metro area, yet high levels of residential segregation remain between blacks and whites and Latinos and whites. Asians are considerably less segregated than blacks or Latinos, falling below the high segregation threshold of 60 in any given year. Both Asians and blacks have experienced considerable decreases in the dissimilarity index—on the order of 19 percent and 15 percent, respectively. Recent decreases in segregation for the Latino population between 2000 and 2010 were not quite large enough to offset the rise during the previous two decades. These improvements notwithstanding, Figure A.4 shows that the Boston-Quincy metro area remains markedly more segregated than the nation's 50 largest metropolitan areas. As of 2010, the Boston-Quincy metro area ranked 11th, 5th, and 4th in terms of the level of segregation among black, Asian, and Latino residents.

FIGURE A.3

Dissimilarity Index

Boston-Quincy Metro (Norfolk, Plymouth, Suffolk counties), 1980–2010

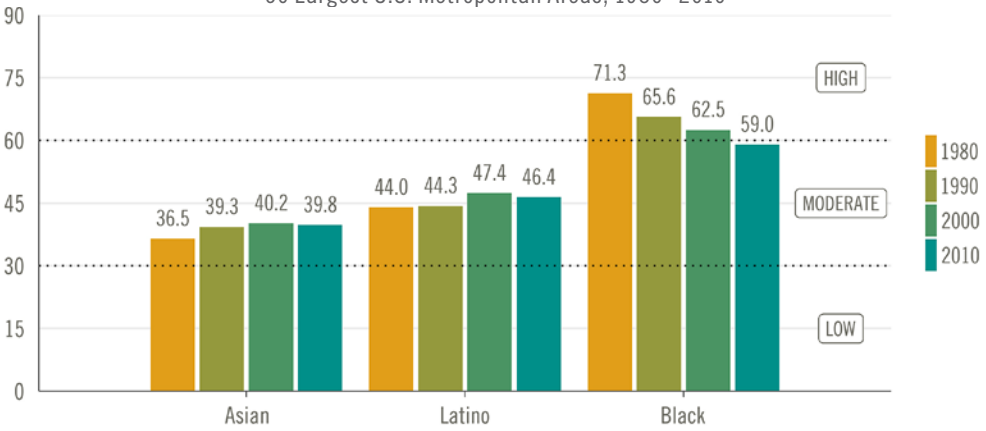


Source: Authors adaptation from Logan and Stults. (2011). *The Persistence of Segregation in the Metropolis: New Findings from the 2010 Census.*

FIGURE A.4

Dissimilarity Index

50 Largest U.S. Metropolitan Areas, 1980–2010



Source: Authors adaptation from Logan and Stults. (2011). *The Persistence of Segregation in the Metropolis: New Findings from the 2010 Census.*

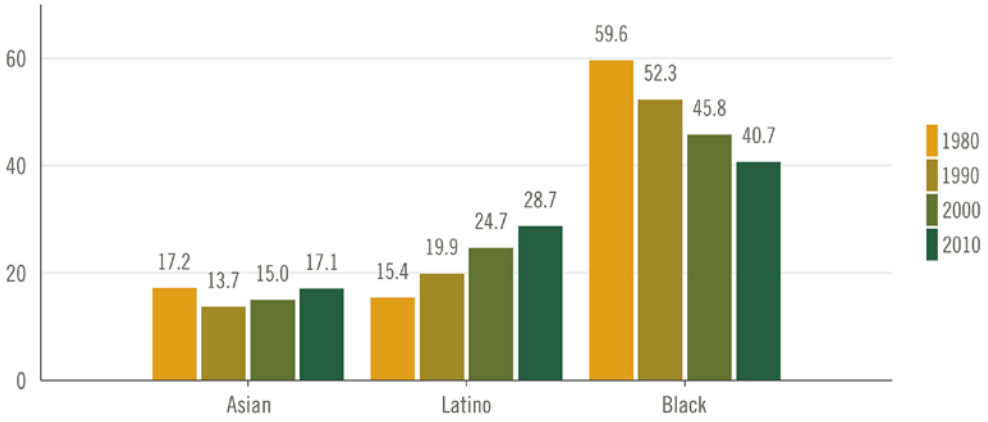
[3] Logan, John, and Brian Stults. (2011). The Persistence of Segregation in the Metropolis: New Findings from the 2010 Census. https://s4.ad.brown.edu/Projects/Diversity/data/report/report2.pdf

Another measure of racial segregation, the isolation index, captures the degree of potential contact, or the possibility of day-to-day interaction, between different racial and ethnic groups. Figures A.5 and A.6 show the trend over time in the isolation index across the same set of metropolitan areas for the period 1980 through 2010, including the Boston-Quincy metro area. Despite strong improvements in the isolation index for black residents over time, the 2010 level of isolation among blacks is five times higher in the Boston-Quincy metro area (Figure A.5) compared with the average index among the 50 largest metropolitan areas (Figure A.6). In comparison, 2010 isolation levels among Asian residents in Boston-Quincy are similar to those of other metro areas but have seen virtually no improvement over the 30-year period. In contrast, isolation among Latino residents in Boston-Quincy was about one-third lower than other metro areas as of 2010.

FIGURE A.5

Isolation Index

Boston-Quincy Metro (Norfolk, Plymouth, Suffolk counties), 1980–2010

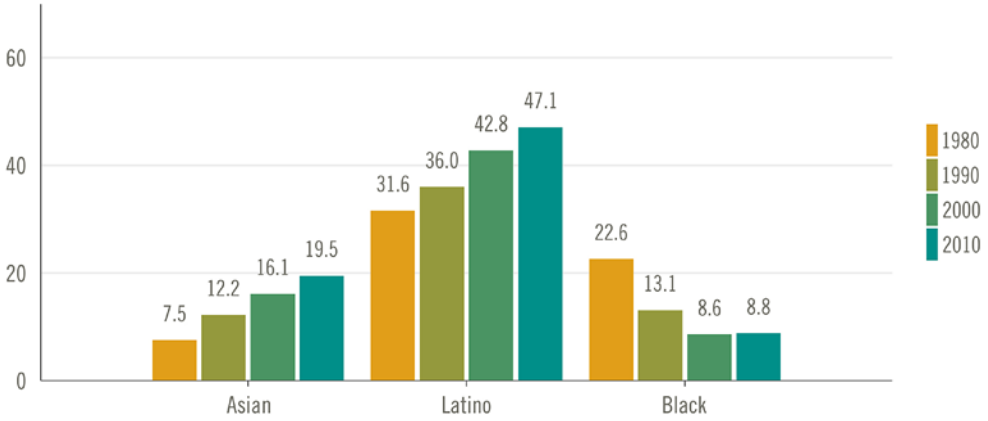


Source: Authors adaptation from Logan and Stults. (2011). *The Persistence of Segregation in the Metropolis: New Findings from the 2010 Census.*

FIGURE A.6

Isolation Index

50 Largest U.S. Metropolitan Areas, 1980–2010



Source: Authors adaptation from Logan and Stults. (2011). *The Persistence of Segregation in the Metropolis: New Findings from the 2010 Census.*

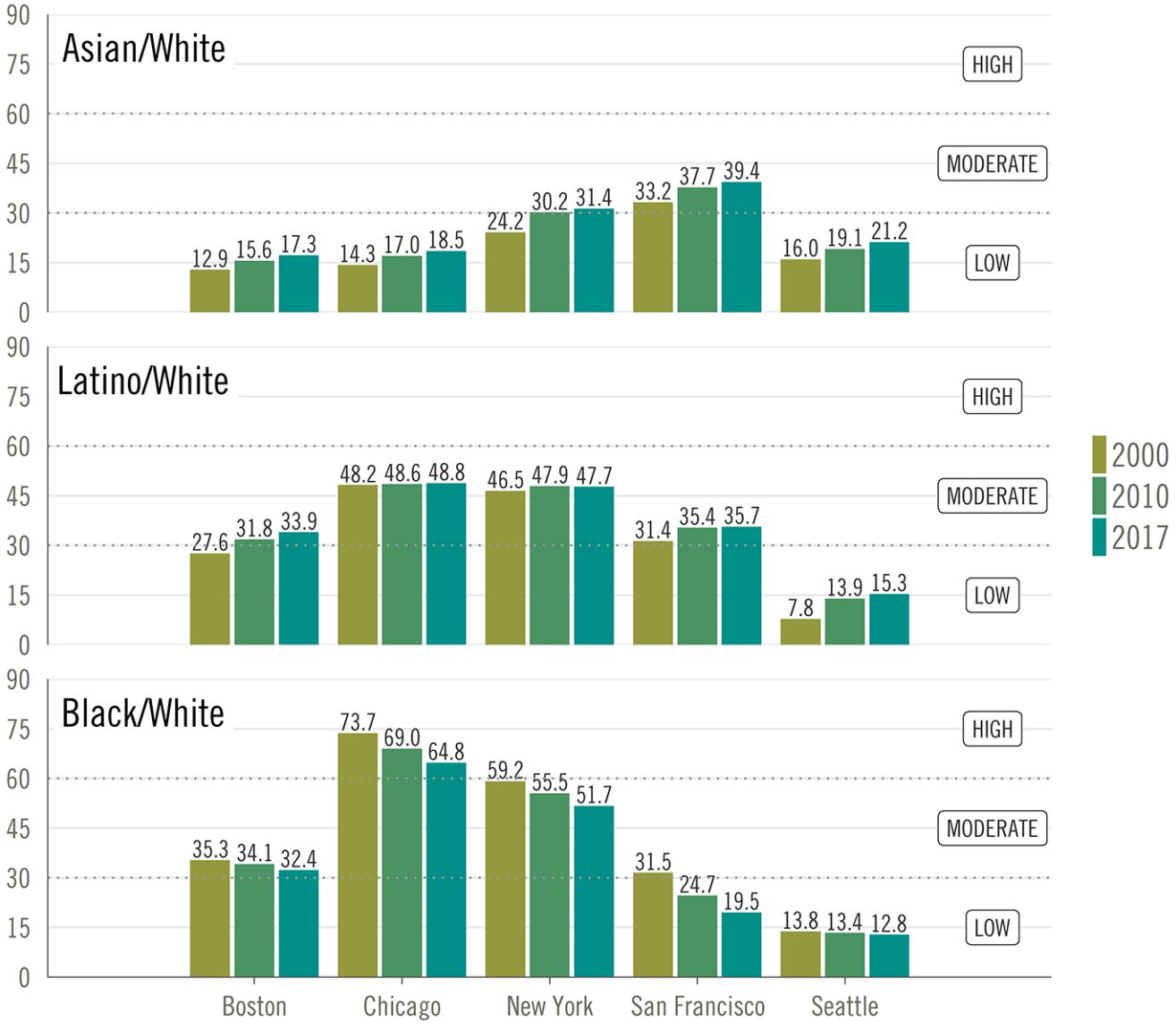
GREATER BOSTON VERSUS SELECTED METROPOLITAN DIVISIONS 2000–2017

Although isolation has been decreasing over time for blacks in Greater Boston, the index has steadily risen for Asian and Latino populations, as seen in Figure A.7. Still, isolation levels for Asians and Latinos are lower in Greater Boston than in most or all of the comparison metropolitan divisions. In contrast, despite recent improvements, isolation among blacks remains higher in Greater Boston than in Seattle or San Francisco, although half the level found in Chicago.

FIGURE A.7

Isolation Index for Boston versus Other Metropolitan Divisions

2000–2010–2017



Source: 2000 and 2010 Decennial Census and 2012–2017 American Community Survey

Regression Analysis of Relationship between Segregation and Housing Production

To assess the relationship between racial segregation and housing production, we use a novel longitudinal database of detailed municipal-level housing production and zoning regulations collected by Amy Dain of MassINC and supplemented by our own survey of zoning best practices. Unlike other studies, the database provides two snapshots of the municipalities—in 2005 and 2017—that allow us to examine changes over time in housing production (total and affordable) and zoning regulations (e.g., best practices) to be able to establish more robust relationships between land use and segregation. With this analysis, we specifically aim to answer the following research questions:

- What is the correlation between the growth in housing production and changes in racial segregation for Greater Boston between 2000 and 2017?
- Do cities and towns that build more housing experience a decrease in segregation over time?
- Does the type of housing that is produced (e.g., specifically affordable units) also matter for achieving a reduction in segregation?

To explore these questions we draw simple scatter plots of changes over time and determine statistical significance using a regression equation. The dependent variable is the change in the actual versus predicted to reside ratio. The independent variable is the change in one of our three measures of housing production: the change in the total per capita number of units permitted in the municipality, the change in the per capita number of units permitted for multifamily housing, and the change in the municipality's subsidized housing inventory (SHI) gap (difference between current status and 10 percent threshold required by Chapter 40B). In this way, we intend to test the relationship between racial segregation and overall production as well as the type of units produced. Table A.3 shows that the relationship between declining segregation and increasing multifamily permitting is indeed statistically significant.

TABLE A.3

Regression Estimates of the Relationship between Racial Segregation and Housing Production

	Change in Housing Production		
	Change in Total Permits Per Capita 2000-2017	Change in Multifamily Permits Per Capita 2000-2017	Change in Gap Percent SHI 2010-2017
Change in Gap of Actual versus Predicted to Reside for Whites 2000-2017	0.004 (0.074)	-0.182 ** (0.091)	0.218 (0.285)
Change in Actual Share of White Population 2000-2017	0.162 *** (0.055)	-0.174 ** (0.084)	-0.486 * (0.268)
	Change in Share of Population Asian 2000-2017	Change in Share of Population Black 2000-2017	Change in Share of Population Latino 2000-2017
Change in Share of Housing that is Multifamily, 2000-2017	0.023 ** (0.008)	0.021 ** (0.008)	0.039 *** (0.009)

Note: *Indicates statistically significant at the 10% level, **at the 5% level, and *** at the 1% level.

Overall, there appears to be some evidence that communities experiencing greater reductions in segregation between 2000 and 2017 were those that permitted more housing units, although the relationship does not hold uniformly across all types of housing. Figure A.8 below indicates that municipalities experiencing a reduction in the actual versus predicted to reside ratio for whites were those that also had larger increases in the supply of multifamily housing. However, Figures A.9 and A.10 show that no such pattern exists for either total per capita permitting or the gap between the municipality's SHI and that required under 40B. Thus, it appears that simply building more housing does not reduce segregation—it is necessary to build the right mix of different types of housing.

FIGURE A.8

Change in Actual versus Predicted Ratio for Whites versus Change in Per Capita Multifamily Permits

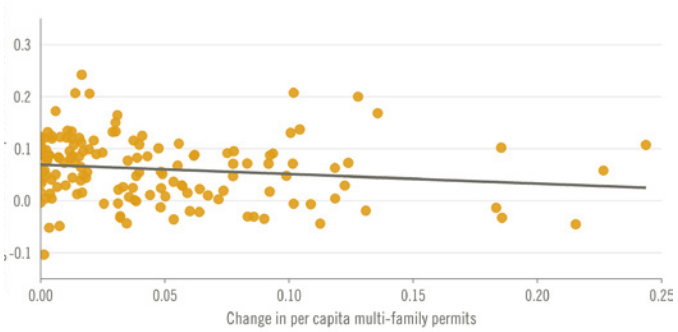


FIGURE A.9

Change in Actual versus Predicted Ratio for Whites versus Change in Per Capita Total Permits

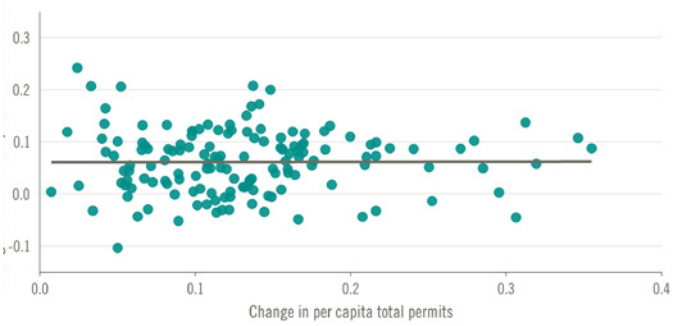
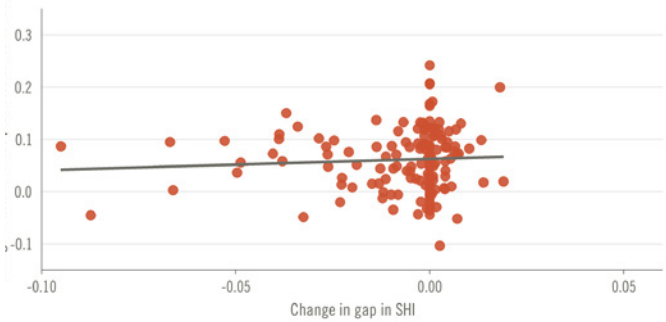


FIGURE A.10

Change in Actual versus Predicted Ratio for Whites versus Change in Gap in SHI



The changes in the actual versus predicted to reside ratio are small and may also reflect changes in the region's overall population as well as the share of each group that resides in each municipality. To further test the relationship between segregation and housing production, we also look at the correlation between the share of the municipality's population that is white and housing production. The results are qualitatively similar to those above and even stronger in magnitude. Figure A.11 shows that there is a strong and negative relationship between the change in the share of the white population and the change in multifamily per capita units. Again, Figure A.12 shows that the reverse is true for total per capita units. Lastly, Figure A.13 shows that those communities that

FIGURE A.11

Change in Share of Municipality Population White versus Change in Per Capita Multifamily Permits

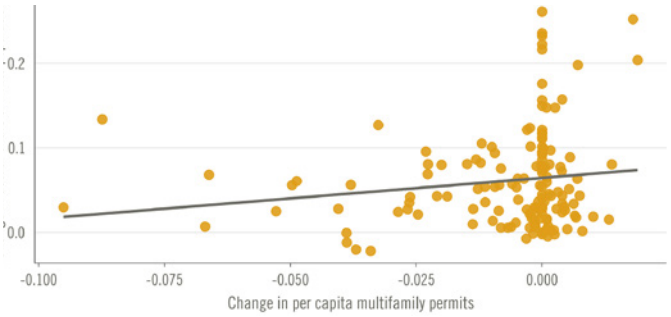


FIGURE A.12

Change in Share of Municipality Population White versus Change in Per Capita Total Permits

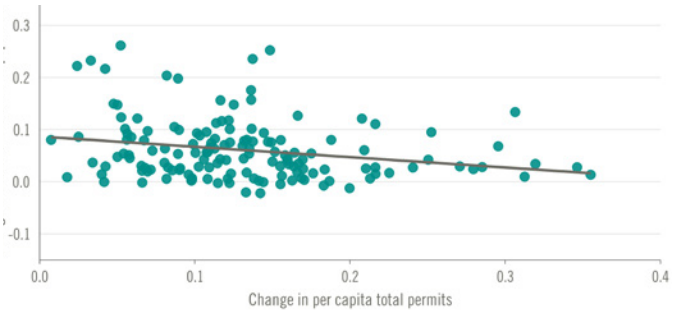
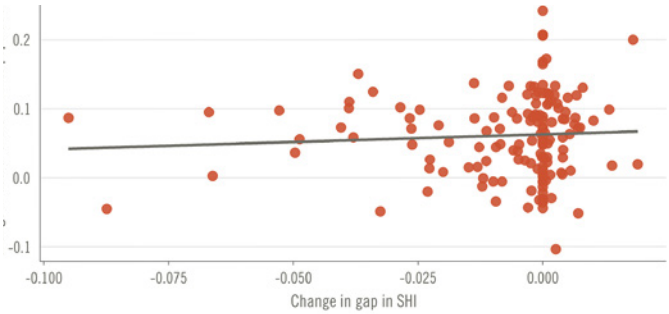


FIGURE A.13

Change in Share of Municipality Population White versus Change in Gap in SHI



reduced their SHI gap also saw a reduction in the share of the population that was white. Again, Table A.3 confirms that these relationships are statistically significant. Thus, not only is it necessary to build a mix of the types of housing but also to ensure that housing is affordable to a more diverse set of individuals and families.

Are some racial or ethnic groups helped more than others by an increase in housing production? Clearly, places that are building more multifamily housing are becoming more diverse across multiple dimensions.

While these results serve to highlight the potential link between housing production and racial segregation, we emphasize that we cannot say for certain that this is a causal relationship. Many other factors affect racial segregation as individuals choose where to live for a variety of reasons. It stands to reason that limiting the number and type of housing units serves to constrain the ability of individuals to reside in certain places; nevertheless, it's likely that housing production is correlated with other community characteristics that serve to make a place less segregated. That said, Table A.4 shows that among the top 10 communities producing multifamily housing between 2000 and 2017, the share of the white population ranged from 50.5 percent in Chelsea to 74.2 percent in Cambridge to 95.8 percent in Winthrop at the start of that time span. All of these communities experienced a reduction in the white population share between 2000 and 2017.

TABLE A.4

Change in Share of the Population that is White for Communities with the Largest Number of Multifamily Units Permitted, 2000-2017

	Share Multi-Family Permits		Share White Population	
City/Town	2000	2017	2000	2017
Chelsea	83.3%	100.0%	50.5%	32.9%
Boston	83.1%	99.0%	59.6%	52.1%
Watertown	66.7%	88.4%	93.8%	83.7%
Winthrop	100.0%	100.0%	95.8%	91.0%
Somerville	85.4%	92.5%	81.9%	78.2%
Cambridge	97.2%	89.3%	74.2%	67.2%
Revere	83.1%	74.2%	87.9%	67.5%
Quincy	86.8%	89.3%	86.0%	70.3%
Arlington	42.9%	89.1%	93.0%	87.0%
Everett	85.7%	89.7%	85.4%	60.1%