Racial Segregation in the United States since the Great Depression: A Dynamic Segregation Approach

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Forthcoming in the Journal of Housing Economics

Abstract

Racial segregation is a salient feature of cities in the United States. Models like Schelling (1971) show that segregation can arise through white preferences for residing near minorities. Once the threshold or "tipping point" is passed, the models predict that all whites will leave. Our paper uses census-tract data for six cities in the United States from the 1930s and 1970-2010 to measure decadal, city-specific tipping points. We use a structural break procedure to estimate the tipping points and incorporate these in a regression-discontinuity design to estimate the impact on population trends for neighborhoods that exceed that threshold while controlling for city-specific trends in migration. We find that the magnitude of white flight for neighborhoods that have tipped in 2000 has fallen to between 23 and 36 percent of the level seen in 1970. There was no discontinuity in white flight after accounting for migration trends during the Great Depression. Finally, we show that in-migration of minorities in tipped neighborhoods do not fill in the gap left by white flight.

Keywords: Racial Segregation, Tipping, Structural Break, Regression Discontinuity

JEL Reference Codes: C23, D19, N92, R23

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The authors thank the special issue editor Stephen Ross, the associate editor and two referees. Their comments have greatly improved the quality of this paper. The authors also acknowledge helpful feedback provided by Justin Bucciferro and participants of the 2015 Annual Meeting of the Economic History Association as well as feedback from participants of the 2015 Annual Meeting of the Population Association of America, 2017 Asia Pacific Economic and Business History Conference and a brownbag seminar at the University of Melbourne. Emilia Perez-Orselli provided excellent research assistance. The usual disclaimer applies; any remaining errors are our own.

1. INTRODUCTION

Racial segregation is a salient feature of cities in the United States. Despite the Constitution of the United States declaring everyone is equal and federal laws such as the Fair Housing Act prohibiting discrimination on the basis of race, segregation has worsened across the country since the Civil Rights era (Massey, 2001). With the advent of World War 1, an estimated 3.5 million rural black migrants relocated to northern cities between 1910 and 1950 (Collins, 1997). While industrial jobs created during the two World Wars provided a catalyst for migration, blacks found themselves subject to direct actions against their presence or legally restricted from neighborhoods due to racially restrictive covenants (Wright, 1986; Brooks, 2011).

Despite the efforts to prevent blacks from migrating north, blacks were able to establish footholds within cities, often in declining neighborhoods. Once the foothold in a neighborhood reached a threshold or "tipping point", it is assumed that the white population would flee, a term colloquially known as "white flight". While research has generally stated that white flight began in the 1950s, Massey and Denton (1993) provide evidence of hostile reactions to blacks after the Great Migration. Harlem was an early example. Around 1910, Harlem experienced a real estate bubble and racial restrictions were eased due to the need for buyers. Over the next twenty years, 87,000 blacks moved into Harlem while 118,000 whites left (Osofsky, 1996). Figure 1 demonstrates this visually by plotting the share of black residents in a census tract between 1910 and 1940. It clearly shows Harlem, which was predominately white in 1910 transitioning to a black enclave by 1940.

There are two schools of thought that rationalize racial segregation. The first is the classic model of Tiebout (1956) and Rosen (1974) which attribute urban segregation to households' differences in incomes and preferences, which determine their willingness to pay for location characteristics. Given that blacks had restricted access to education, this led black households towards neighborhoods with lower levels of amenities commensurate with their income. Relatedly, Waldfogel (2008) finds evidence that the geographic location of restaurant chains is closely correlated to the local demographic composition. This suggests that any changes in racial composition may make the local amenities more attractive to new occupants and less attractive to the previous occupants.

–Figure 1 about here –

On the other hand, the theoretical frameworks of Schelling (1971) and Becker and Murphy (2000) attribute racial segregation to households' concerns about the demography of their neighbors. The seminal work of Card, Mas and Rosthstein (2008) examines the process by which a neighborhood can polarize towards complete segregation, or tipping. They attribute segregation in urban neighborhoods to white's preferences for not residing near non-white minorities.

Other models attempt to merge both schools of thoughts by explaining that segregation is an interaction between racial preferences and exogenous location characteristics (see Banzhaf and Walsh, 2010).[1] Recently, Caetano and Maheshri (2017) expand on the Schelling model to test for tipping behavior in schools in Los Angeles between 1995 and 2012. Adjusting for endogenous preferences for school quality, they find evidence that schools remain susceptible to tipping. Using census data aggregated at the census block level, Shertzer and Walsh (2016) find evidence that white flight can explain between 34 and 50 percent of the increase in segregation seen between 1910 and 1930. Using an instrumental variables approach, Boustan (2010) finds that a black migrant to a northern city between 1910 and 1940 led to 2.7 white departures.

We step back from looking for any causal claims on what is driving tipping or estimating the economic consequences of segregation (see Ananat 2011) and instead focus on how the long-term dynamics of tipping have changed for six cities in the 1930s and re-examine those cities from 1970 through 2010. Using census tract data, we closely follow the regression discontinuity approach of Card et al. (2008) to estimate the magnitude of white flight for neighborhoods that have tipped for six cities in the United States during the 1930s and compare those results for the same cities from 1970 through 2010.

We find that the magnitude of white flight as a percentage of whites leaving compared to the base year population peaked in the 1970s. While the point estimates found in the 1930s are close to the level found in the 1970s, they are not precisely estimated. The results suggest that there was no discontinuity in white flight in our sample during the Great Depression after accounting for migration trends. Lastly, we have found evidence that for neighborhoods that have tipped, the in-migration of minorities do not fully account for the population of whites leaving. This suggests that neighborhoods that have tipped become less dense over time and may help explain the declining fiscal capacity of central cities in our sample.

[1] Banzhaf and Walsh (2010) develop a general equilibrium model that captures the behavior of households when choosing the neighborhood they want to live in based on its endogenous demographics and its exogenous public good. Several interesting findings emerge from the model. When sorting arises from tastes for the exogenous public good rather than demographic tastes, some racial segregation can occur with richer households benefiting from higher levels of the public good. However, when tastes for endogenous demographic composition are incorporated in the model, further segregation occurs consistently with the prediction of Schelling's "tipping model". More importantly, policy that improves the public good in a low-quality but high minority neighborhood may lead to an increase in group segregation, as richer minorities move into the neighborhood due to the improvement in the public good. In neighborhoods where differences in public goods are less important, sorting is dominated by tastes of demographic preferences over income-based sorting on the public good.

This paper makes important contributions to the literature on dynamic racial segregation in the U.S. by highlighting the declining impact of white flight over a long time series of data and across six cities. These cities historically had substantial variation in the share of minorities in residence along with variation in relative growth of minorities since 1930. More importantly, our results are robust and valid with the inclusion of weighting by the base year population that controls for possible biases arising from variation in the tracts population.

Our paper proceeds as follows. Section 2 describes the theoretical and empirical methodology developed in Card et al. (2008). Section 3 reports the data source and descriptive statistics. Section 4 presents our empirical results and compares the findings for the 1930-1940 with the decadal periods spanning 1970-2010. Section 5 concludes and lays out some direction for future research.

2. EMPIRICAL APPROACH

2.1 Theoretical Model

Like Card et al. (2008), our model is developed on the framework of Schelling (1971) which was fleshed out in Becker and Murphy (2000). This allows clean comparisons between our results and previous findings. In these models, households segregate as their utility functions are directly dependent on the racial or ethnic composition of their neighborhood. Yet as discussed in Tiebout (1956) and Rosen (1974), segregation may merely be a product of sorting on exogenous location amenities, preferences for which are highly dependent on racial or ethnic characteristics.

Both Banzhaf and Walsh (2010) and Kasy (2015) indicate strategies to econometrically identify these separate effects by controlling for endogenous location preferences or exogenous changes in neighborhood composition. While Shertzer and Walsh (2016) and Caetano and Maheshri (2017) are able to control for endogenous location choices, the data limitations do not allow us to make such a correction. Instead, we rely on narrative evidence of the period to guide the modeling.

An economist for the Federal Housing Administration, Homer Hoyt wrote in 1939:

> "It is a mere truism to enunciate that colored people tend to live in segregated districts of American cities. As we have said [earlier], the reflection of adverse housing characteristics should tend to operate in the same manner in areas populated entirely by colored races as in areas populated only by whites. It is in the twilight zone, where members of different races live together that racial mixtures tend to have a depressing effect upon land values -- and therefore, upon rents."

Moreover, the existence of racial covenants in housing deeds that prevented households of racial, ethnic, and religions minorities from purchasing housing during the period is again suggestive that the white majority preferred living near white households. The enforcement of these covenants would have thus been unnecessary in a model in which blacks self-segregated into neighborhoods with other blacks based on the existing amenities. Yet even in the presence of different preferences for amenities outside of racial composition, we expect that our results are understating the true effect of tipping on white flight.

Figure 1 shows the share of blacks residing in a census tract in New York City between 1910 and 1940. It provides further evidence of tipping by illustrating the diffusion of blacks into Harlem and Bedford-Stuyvesant. This figure shows a spatial diffusion process in which black households are moving into neighborhoods and/or white households are moving out of neighborhoods that bordered the preexisting black neighborhoods.

Harlem emerged as a black enclave in the early 20th century after a local housing bubble burst. This allowed several black churches and charities from lower Manhattan to purchase properties and sell or rent to black households (Kollmann 2012). While this suggests exogenous housing characteristics must be accounted for, the likelihood that the only neighborhoods experiencing intra-city falls in market prices also being the neighborhoods experiencing black in-migration are unlikely.

The premise of the theoretical model of Card et al. (2008) is that whites have an aversion to residing with minorities and thus their utility from residing in a certain neighborhood is affected by the relative share of minorities. Once minorities have achieved a certain threshold (i.e., it has exceeded a certain share in the neighborhood), the neighborhood "tips" and becomes predominantly non-white. As suggested in Figure 1, Harlem and Bedford-Stuyvesant illustrate this tipping behavior. This *prima facie* evidence suggests that tipping could well have existed in some cities, including that of New York in the 1930s and persisted throughout the 20th century.

Consider a neighborhood with homogenous housing and there are two potential buyers: whites (w) and minorities (m). The inverse demand function for homes in the neighborhood with minority shares is denoted by $b^g(n^g, m)$ where $g = w, m$. Here, there are n^g families from group g who are prepared to pay $b^g(n^g, m)$ to reside in that neighborhood. The partial derivatives of the inverse demand for whites and minority with respect to n^w and n^m, respectively, are by construction weakly negative, while $\partial b^w / \partial m < 0$ captures the social interaction effects on the bid-rent functions. Further, the assumption is that above a particular threshold of minority shares, $\partial b^w(n^w, m) / \partial m < 0$.

There exists an integrated equilibrium with minority share $m \in (0,1)$ in which the amount the m^th^ highest minority bidder is willing to pay is equal to that of the (1-m)^th^ highest white bidder, so that $b^m(m,m) = b^w(1-m,m)$. Under the assumption that $\partial b^w/\partial m$ is positively sloped at m=0 and becomes downward sloping for some range of m, $b^w(1-m,m)$ has a concave shape shown in the figure below. For ease of illustration, $b^m(m,m)$ is assumed to be linear and downward sloping.

–Figure 2 about here –

Suppose a neighborhood begins in which the bid rent functions of minorities is represented by Line A in Figure 2. In this scenario, there are three equilibria: the end points of the minority share are locally stable equilibria in which the neighborhood is fully segregated and an unstable mixed equilibrium. A positive shock in housing demand by minorities would be represented by an upward shift of $b^m(n^m,m)$ and would result in moving to line B. There still exist two stable equilibrium in this case, but now the lower equilibrium will be a mixed equilibrium and C remains a 100% minority segregated equilibrium. The unstable mixed equilibrium remains, but has a lower share than in Line A. Further positive shocks to minority demand could result in a push to Line C in which we have only two equilibria: A mixed stable equilibrium in which the minority bid-rent curve, b^m is tangent to the white bid-rent curve, b^w and a stable minority segregated equilibrium. The mixed stable equilibrium is known as the tipping point. Any further increases to minority demand at this point will result in the neighborhood tipping and becoming fully segregated and populated by minorities.

2.2 Empirical Methodology

To test for the magnitude of white flight, we begin by estimating tipping points using the structural break method used by Card et al. (2008) to identify city-specific tipping points. This method relies on structural break tests and chooses the break point associated with the best-fitting model for census tract-level population changes. However, we undertake further analysis by utilizing base year population weights to the census tracts and apply them to the data to correct for heterogeneity in the census tract population. Applying population based weights can reduce the magnitude that small population tracts can skew the results.[2]

We accommodate changes in the population of a neighborhood by expressing changes in the numbers of white and minority residents as a fraction of the base year total population. Following Card et al. (2008), we define $W_{i,c,t}$ as the number of whites, $M_{i,c,t}$ the number of minorities which is

[2] An alternative approach consisting of weighting the census tracts by the inverse z-score of the population was also employed to underweight both the smallest and largest census tracts. However, this approach produced very similar results to when the census tract are unweighted and are thus omitted from further discussion.

further defined in Section 3 and $P_{ic,t} = (W_{i,c,t} + M_{i,c,t})$ the number of total residents of neighborhood i in city c in the year t. The primary dependent variable is the change in the neighborhood's white population between the current year t and the base year t_0 , taken as a share of the initial population in the base year, $DW_{i,c,t} = (W_{i,c,t} - W_{i,c,t_0})/P_{i,c,t_0}$. We similarly examine the change in the minority and total population. To establish the dynamic of tipping, the dependent variable is specified as:

$$DW_{i,c,t} = p(\delta_{i,c,t_0}) + d\, I(\delta_{i,c,t_0} > 0) + \tau_c + \boldsymbol{X}_{i,c,t_0}\beta + \varepsilon_{i,c,t} \qquad (6)$$

where $\delta_{i,c,t_0} = m_{i,c,t_0} - m^*_{c,t_0}$, such that $m_{i,c,t_0} = \frac{M_{i,c,t_0}}{P_{i,c,t_0}}$. Here, m^*_{c,t_0} is the tipping point or threshold. Note that τ_c is a city fixed effect and $\boldsymbol{X}_{i,c,t_0}$ is a vector of neighborhood control variables. Depending on the availability of data for the neighborhood control variables in different periods and are discussed in Section 3. $p(\delta_{i,c,t_0})$ is a smooth control fourth-order polynomial function. This specification is estimated for the following decadal periods: 1930s-1940, 1970-1980, 1980-1990, 1990-2000 and 2000-2010.

Before estimating equation (6), it is necessary to estimate m^*_{c,t_0} from the data. This requires the assumption that there exists a tipping point for which $d \neq 0$. In establishing the location of the tipping point, we employ a structural break test which involves searching over the minority share in the base year for each city, m_{i,c,t_0} for a break point satisfying certain conditions. Using a simplified version of equation (6) which ignores the covariates and replacing the polynomial function $p(\cdot)$ with a constant, we estimate:

$$DW_{i,c,t} = \alpha_c + d_c\, I(m_{i,c,t_0} > m^*_{c,t_0}) + \varepsilon_{ic,t} \qquad (7)$$

for $0 \leq m_{ic,t_0} \leq M$ where M is set to 60% and the value of m^*_{c,t_0} is determined in the [0,50%] interval based on the condition that the R^2 of (7) is maximized for each city and each decadal period.[3]

A consistent estimate of the threshold can be obtained following this procedure as long as equation (7) is correctly specified (Hansen, 2000). These equations are estimated using a two-thirds subset of our sample for each city with the remaining one-third used in subsequent regression discontinuity analysis described below. Failure to maintain two independent samples could result in any hypothesis test estimating the magnitude of the tipping point to reject the null hypothesis of no effect of tipping too often (Card et al., 2008). However, as we do not conduct any tests for inference on the tipping points, we will not be directly comparing the tipping points across cities or over time.

[3] We ran several robustness checks by exploring values of M between 40% and 80% in which we searched for the value of m^*_{c,t_0} between 0% and $M - 10\%$. The estimated tipping points were largely unchanged in this case. Estimates available in the data appendix.

3. DATA AND DESCRIPTIVE STATISTICS

The data primarily comes from two main sources: the National Historical Geographic Information System (NHGIS) (Minnesota Population Center, 2011) and the United States Census Bureau (U.S. Census Bureau, 2000 and 2000a). We compiled demographic and housing data at the census tract level for six cities: Boston, Chicago, Louisville, New York, Philadelphia, and Washington, DC. The six cities were chosen on the basis of available data from the 1930s, but have unique characteristics that showcase their different histories.

Data from the 1930s and 1940 were compiled primarily from the NHGIS with one main exception. As the NHGIS does not have sufficient compiled tract-level data for Louisville and Philadelphia, we have used tract-level data from a 1934 real property inventory of the two cities for the base period. We define minority for this period as any non-white and "other" race enumerated in the census. The share minority in 1934 was based on the share of non-white families whereas the 1930 and 1940 definition is based on the share of non-white population. In our pooled regression, we use the population density of the tract in the base year in which the unit is thousands of people per square mile.

For tract-level census data from 1970 through 2010, data were primarily obtained from the NHGIS and supplemented with data from Summary Table 1 and 3 obtained via American FactFinder on the U.S. Census Bureau website. In the 1970-2010 data, our definition for the city is the Combined Statistical Area (CSA) defined by the U.S. Census Bureau. We have standardized the boundaries of the tracts from 1970 through 2010 to the 2010 boundary definitions using the Longitudinal Tract Database (Logan, Zengwang, and Stults, 2014).[4]

As noted in Card, Mas, and Rothstein (2008), the US Census did not separately identify white and nonwhite Hispanics in 1970. Therefore, we imputed the figures from 1980 census data by estimating a regression of the white, non-Hispanic share in a tract on the black share, white share and Hispanic share for each city. We then predicted the 1970 white non-Hispanic share in the tract by using the coefficient estimates. We dropped any tract in which the predicted share in 1970 was less than 0.1 and censored any other observations that were not between 0 and 1.

In the pooled regressions from 1970 through 2010, we used the covariates described in the Data Appendix in Card, Mas, and Rothstein (2008): the proportion of persons 16+ years old who are in the civilian labor force and unemployed; natural log of mean family income; the fraction of workers who

[4] While there may be concerns about endogenous boundaries, Card et al. (2008) did not find significant differences in their estimated tipping points or subsequent results using the 2000 boundaries from the Neighborhood Change Database or boundaries set by those in their base year.

use public transport to travel to work; fraction of homes that are non-seasonal vacant, fraction that are renter-occupied; and fraction that are single-unit (includes trailers and RVs).

To minimize the effect of outliers driving the results and to replicate the modern data as close as possible, we closely followed the methodology of Card et al. (2008). We dropped tracts which experienced more than 500 percent white population growth over a decade as well as tracts which had five times the growth exceeding the city mean. In addition, we dropped tracts which had a base year population under 100 people.

–Table 1 about here –

Table 1 describes the mean racial composition of black and white population in a census tract and reports the unconditional mean change in the white (minority) population over the ten-year period as a share of the total population in the base year. We report these statistics across the six cities for three ten-year periods: 1930s-1940, 1970-1980 and 2000-2010. To minimize the distortion of the small tracts on the outskirts of the city we have weighted the means by the tract-level population in the base year.

Panel A highlights the different demographic composition across the cities in the 1930s. While New York is often seen as a multicultural hub today, 95% of the population in a typical census tract were white in 1930. This contrasts with Washington DC in which more than 25% of the population in a typical tract were a minority in the 1930s. The panel also highlights that despite the large minority population, Washington also experienced the strongest growth for both the minority and the white population in 1940 as compared to the base year population in 1930. This is likely due to the substantial growth in federal government expenditures during the Great Depression. The panel also shows evidence that higher minority shares in tracts were associated with the white population leaving. For example, Boston saw a decline in the white population in a tract of 1.70 percent on average despite minorities representing only 2.87 percent of the population of a tract on average.

Panel B jumps ahead 40 years and showcases the changes in demographics for the six cities. Five of the six cities had increased average tract shares of minorities, the exception being Louisville in which the share minorities fell 1.36 percentage points. Interestingly between 1970 and 1980, the average tract saw increases in the minority population and declines in the white population. Louisville is the only city of the six that saw the minority population increases more than one percentage point higher than the white population. Chicago saw an increase of 0.59 percentage points, while the remaining four cities experienced declines in the average tract population growth of 1.23 to 5.61 percentage points.

Finally, Panel C showcases the change in demographics in the six cities during the last two censuses. By 2000, New York had overtaken Washington DC for the largest average share of minorities in a tract. On average, 46.55 percent of a tracts population are a minority in New York compared to 44.70 percent in Washington, DC. While Louisville had the second highest minority share in the 1930s, it had the lowest share of minorities in 2000 of the six cities and only 1.1 percentage points higher than the share in 1930. Louisville was one of two cities that experienced positive growth in the white population over the 2000s, but unlike Washington, DC which had very modest growth, the white population in a tract increased 3.86 percent between 2000 and 2010. Even though the white population was leaving between 2000 and 2010, the magnitude of the minority population growth now exceeded the magnitude of the white population fall in the four cities.

While Table 1 shows evidence of white families leaving the cities in our sample, it is unable to illustrate cursory evidence of white flight. Table 2 breaks down the growth in the white population over the decade as a share of the total population in the base year across the distribution of minority population shares in a tract in the base period. The summary statistics are again weighted by the 1930s base year population to account for the effects of small tracts distorting the means.

–Table 2 about here –

Panel A of Table 2 reports the changes in the white population for the 1930s. The table shows that tracts that had fewer than a five percent minority share experienced positive growth in the white population in the 1930s. Outside of tracts between 10 and 20 percent minority, the remaining tracts experienced a fall in the white population in the 1930s population relative to the base year. The magnitude of the white population falling also increases from -3.06 percent when the minority share is between 5 to 10 percent through to -11.31 percent when the minority share is between 40 to 50 percent. Moreover, we see that 83.3 percent of the census tracts in our 1930s sample had less than a five percent minority share of the population.

The second panel of Table 2 shows the percent change in the white population from 1970 to 1980. Regardless of the minority share in 1970, the white population on average was leaving all tracts in the 1970s. However, we can see a clear increase in the magnitude of the decline depending on the minority share. For tracts that had less than 1 percent minorities, the white population decline 0.40% relative to the 1970 population. However, the magnitude of the fall increases to 32.82 percent for tracts with a minority share between 30 to 40 percent.

The last panel shows the change in the white population over the 2000s. The results are closer to the 1930s than the 2000s in that tracts with small minority shares experienced white population growth over this period. Tracts with less than 10 percent minority shares experienced growth over the 2000s. In particular, we saw an average 8.39 percent growth if a tract had less than 1 percent share of minorities in 2000 and 1.76 percent growth if the tract had a share of between 5 to 10 percent minorities in 2000. Any higher, and on average a tract experienced a decline in the white population, yet this magnitude is smaller than the declines experienced in the 1970s with a peak decline of 8.71 percent of the white population over the 2000s for tracts that had a 40 to 50 percent minority share in 2000. These results provide evidence that white flight existed, yet we will further explore these using the structural break methods in Section 4.

In addition to the change in the white population, and not surprisingly from the earlier results, we can see how the cumulation of whites leaving and minorities entering the sample over the decades have changed the distribution of the tract's minority shares. Whereas 66.4 percent of tracts in the 1930s had less than 1 percent minority share, this fell to only 2.6 percent of tracts in the 1970s. This becomes more extreme by 2000 with only five tracts of the 7681 in our sample had a minority share under 2000. While segregation indexes have shown cities becoming more segregated over time, there was a small increase in integration across all tracts, although nearly a third of tracts by 2000 exceeded a 50 percent minority share.

4. EMPIRICAL RESULTS

4.1 Tipping Point Estimates

While Table 2 provides evidence that neighborhoods in our data have tipped, it is not precise enough to estimate the tipping points for any given city. Using Equation (7), we estimated the tipping points using the structural break method discussed in Card et al. (2008) for the six cities in our analysis. The results are presented in Table 3 that breakdown the tipping point by city, decade of analysis and weighting method. As described earlier, we estimated the tipping points for both unweighted census tracts as well as those that adjust for the base year population weights to account for any biases introduced by the inclusion of low population tracts. However, as we do not conduct any tests for inference on d_c, we must remain cautious on comparing the results across cities or over time.

–Table 3 about here –

The table shows that the estimated tipping points in the 1930s in particular varied across both cities and weighting schemes.[5] The estimates across weighting schemes in the later periods are more stable and that may be due to the later standardization of tract definitions. While not directly comparable, it is worthwhile to note that the two cities with the highest estimated unweighted tipping points in the 1930s, Louisville and Washington DC, had a unique historical layout that may have led to the higher estimates. Both cities possessed slum alleyways in the older neighborhood that blacks primarily resided in with whites residing in the main streets (see Wright, 1980; Vlach, 2010). While we need to be cautious to directly interpret the tipping points, we find that five cities had higher tipping points in 2000 compared to 1970. This trend is consistent with the findings of Card et al. (2008) which found tipping point estimates on average increased between 1970 and 1990.

–Figure 3 about here –

The theoretical model predicts that once a neighborhood tips, it quickly converges to the fully minority segregated equilibrium. While Figure 1 shows that Harlem and Bedford-Stuyvesant became black enclaves in the beginning of the 20th century, it was a process that took over 30 years to complete. Figures 3 and 4 present city-level figures which show the change in the white population over the 1930s and 1970s, respectively. Each dot represents all tracts within $\pm$0.5 percentage point spread of the share of minorities in the base year. The y-axis represents the mean change in the tract-level white population over the decade. We have also plotted the unweighted and weighted tipping points for each graph as solid and dashed vertical lines respectively. The solid curve is a local linear regression with a tricube weighting function and a bandwidth of 0.8. The local linear regression was estimated on both sides of the unweighted tipping points and are used to visualize any trend in the data. We used the one-third of the tracts that were not used to estimate the tipping points in Table 3.

As we have not conducted any tests for inference, we again need to be cautious on interpreting these figures which are used primarily as comparisons to Card et al. (2008). While the local linear regressions in Figure 3 shows evidence of white flight in neighborhoods past the tipping point for five cities, the few tracts prior to the estimated tipping points further create difficulties in

[5] As a robustness check, we ran 1000 simulations of the tipping point estimation using a randomly selected two-third subsample for the 1930-1940 and 1970-1980 periods. We found evidence that in the 1930s, the distribution of estimated tipping points were multimodal. Boston and New York had a small spread on the estimated tipping points while Philadelphia had a low spread when we did not weight observations by the base year population. Louisville and Washington, DC had a higher spread. Further while the spread of tipping points are higher in the 1930s than in the 1970s, our chosen sample was reflective of commonly estimated tipping points in the city. The results of the simulation are found in the data appendix.

establishing any trends in the white population. Taken together, there is little evidence to suggest that there was discontinuity in white flight in this period.

–Figure 4 about here –

Figure 4 presents the period between 1970 and 1980. Chicago, New York and Philadelphia provide some visual evidence of white flight and are visually similar to the results found in Figures I and IV of Card et al. (2008). The remaining three cities do not have clear pre-trends to establish evidence of a discontinuity which was also found in the case of Pittsburgh in the 1980s in Card et al. (2008). The remaining decades can be found in the Data Appendix. Within those figures, we can see that the magnitude of white flight in tipped neighborhoods has fallen in the decades after the 1970s.

4.2 Dynamics of racial segregation around the tipping point

A more useful way to explore whether a tract exceeding its tipping point resulted in white flight is to pool the data and detrend the results from the city-specific trends. Figures 5 and 6 plot the share of the minority population in a census tract minus the city-level estimated tipping point. These detrended results are grouped into 1 percentage point bins and plotted on the x-axis. On the y axis is the average change in the white, non-Hispanic population (after 1970) over a decade which is expressed as a percentage of total base year population differenced from the mean city-level population change.

Figure 5 reports the results using the unweighted tipping points and Figure 6 reports the results using the weighted tipping points. We have constrained the figures to only include tracts within 30 percentage points above and below the estimated tipping points. In addition we have plotted both a local linear regression and quartic polynomial on both sides of the estimated tipping point to illustrate the trends in the data and whether any discontinuities in the trend exists which would suggest further evidence of white flight. It is worthwhile to point out that due to higher variance in the data, the scale of y-axis for the 1930s time period is wider than the later periods.

–Figures 5 and 6 about here –

Figure 5, which is modelled after Figure V of Card et al. (2008), shows evidence of discontinuities in the 1970s, 1980s and 1990s. For these three decades, we see an upward trend in the tracts below the estimated tipping point with a clear break after which the white population is not only less than prior to the break, but the change in the white population is below the city-wide trends. However, the data for the 1930s as well as the 2000s are not as clear. The trend in the 1930s is already falling prior to the tipping point with little discontinuity after the break. A similar pattern emerges in the 2000 data, although the slope in the latter decade is not as steep. Overall, these figures suggest that if discontinuities are found in the 1930s and 2000s, the magnitude of white flight should be less pronounced than in the middle periods, particularly in the 1970s.

When adjusting for the populated weighted estimates of the tipping points, the results still hold generally. In both cases of the 1930s and 2000s, we again do not see any substantial deviation from trends. The gap in the 1990 period is still present although the magnitude appears slightly smaller although this is exaggerated as the scale of the y axis is larger in the population weighted results due to increased variance in the 1970 data. However, the discontinuity appears to have vanished in the 1980 data. Relying on the population weighted results suggests that while tipping behavior may have occurred, the resultant white flight may have been largely non-existent outside of the 1970s.

As we are unable to conduct any hypothesis tests from the figures themselves, we have run a series of pooled regressions, shown in Table 4, that incorporate the regression discontinuity design discussed previously and displayed in the figures. The dependent variables in the main results are the change in the white population as a percentage (multiplied by 100) of the census tract's base year population. Our main variable of interest is an indicator variable that equals one if the census tract exceeds the city-specific tipping point. If the coefficient estimate is statistically significant, this will signal evidence of tipping or white flight. We have included city fixed effects to detrend the data as well as a quartic polynomial of the deviation in the tract's minority share from the candidate tipping point.[6] A series of controls to account for tract-level differences in neighborhood-level amenities have been included and are discussed in Section 3. In addition to estimates for changes to the white population, we have included estimates of the minority and total population for both the unweighted and population weighted estimates. The standard errors are clustered by city (1930s) or CSA. Lastly, the regression results use the one-third of the census tracts that were not used to estimate the tipping points in Table 3.

–Table 4 about here –

Columns 1 and 2 from Table 4 report the coefficient estimate and standard error of the indicator variable for the unweighted and population weighted estimates respectively for the white population. In the 1930s, the magnitude of the point estimates of the coefficients are large suggesting that on average, the white population declined between 7.5 percent (weighted) and 9.4 percent (unweighted) for neighborhoods exceeding the estimated tipping point. Only the

[6] As a robustness check, we have estimated results without including city fixed effects. The estimated coefficient signs and statistical significance were generally robust to the exclusion of fixed effects. The results can be found in the data appendix.

unweighted results are statistically significant at the 10% level. These results are inconsistent with the lack of any discontinuity in Figures 5 and 6 for 1930. The main difference between Figures 5 and 6 While and Table 4 is as follow. Figures 5 and 6 are obtained from a non-parametric model which is used to capture the relationship between tract share minority and change in the white population. On the other hand, the results in Table 4 are obtained from a regression which controls for metropolitan area fixed effects. For robustness check, we run regression (6) without controlling for city fixed effects. The estimates which are reported in Table 7 of the appendix are of similar magnitude to those reported in Table 4, but not statistically significant. It can be inferred from these results that the differences are likely due to the use of a higher order polynomial in the regression specification (6). Combined with Figures 5 and 6, these results suggest that there is not strong evidence of a discontinuity at the tipping point.

In the 1930s, the point estimates of the coefficients {are sizable} suggest{ing} that on average, the white population declined between 7.5 percent (weighted) and 9.4 percent (unweighted) for neighborhoods exceeding the estimated tipping point. Only the unweighted results are statistically significant at the 10% level. {These results are inconsistent with the lack of any discontinuity in Figures 5 and 6 for 1930. The main differences between Figures 5 and 6 and Table 4 are that 1. Figures 5 and 6 use a non-parametric model to relationship over tract share minority, and 2. The models in Table 4 condition on metropolitan area fixed effects.} When we do not control for city fixed effects, the estimates are of similar magnitude {to Table 4}, but not statistically significant. {Therefore, the differences are likely due to the use of a higher order polynomial in the regression models…} Combined with Figures 5 and 6, these results suggest that there is not strong evidence of a discontinuity at the tipping point

Unlike the 1930s, the unweighted and weighted results from 1970 to 2000 are suggestive of a discontinuity in the white population after the tipping point. This is also consistent with both Figures 5 and 6. We see negative and statistically significant results on the tipping point coefficient with the exception of the weighted results in 1980. As also highlighted in the figures, the magnitude of the discontinuity has fallen from 1970 through 1990 with little evidence of tipping in 2000. Compared to Card et al., the estimated discontinuities are larger in 1970 and smaller in the subsequent two decades.

Overall, the white population regressions suggest that while the tipping points had not consistently improved between 1980 and 2000, the magnitude of white flight became less pronounced over time. While we cannot infer any causal interpretations, this would be consistent with the improvements of white attitudes in regards to blacks and other minorities since the 1970s.

The point estimates of the 1930s suggest that neighborhoods that tipped experienced white flight similar to neighborhoods that tipped in the 1970s and 1980s. This is consistent with the portrayal of Harlem and Bedford Stuyvesant during the period and found in Figure 1. Yet the lack of precision in the estimates combined with the lack of any visible change in trends found in Figures 5 and 6 lead us to conclude that there is little evidence of white flight that has been a feature of the latter decades of the 20th century. We speculate that this may be due to the adverse economic conditions of the period along with the lack of transportation alternatives to allow whites to migrate to suburbs.

Changes in the white population tell only part of the story. While the main results have focused on white flight, it is just as important to understand how the minority population responded in neighborhoods that have tipped. Columns 3 and 4 show the regression estimates and standard error of the tipped indicator variable for the minority population. As we can see from the unweighted estimates in Column 3, only the coefficient estimate for 1970 was statistically significant. Further, the point estimates for the remaining decades were under one percent and less than the magnitude of the white flight. This suggests that minorities were not filling in the difference for neighborhoods that exceeded the tipping points. When we control for population weights, we find that the magnitude of the point estimates of the change in the minority population increase and are statistically significant for 1970 through 2000.

To fully test for the change in population, we ran a series of regressions with the change in the total population as the dependent variable and the results are reported in Columns 5 and 6 of Table 4. These results confirm that for neighborhoods that have tipped, the total population has either fallen (unweighted estimates) or remain largely unchanged (weighted estimates). These results are consistent with the findings of Card et al., and moreover are consistent with the falling populations of urban centers in the latter half of the 20th century.

5. CONCLUSION

Our paper uses census-tract data for six cities in the United States from the 1930s and from 1970 to 2010 to measure decadal, city-specific tipping points. The purpose is to understand the long-term dynamic of tipping in those cities. To accomplish this, we use the structural break procedure described in Card et al. (2008) to estimate the tipping points and incorporate these in a regression-discontinuity design to estimate the impact on population trends for neighborhoods that exceed that threshold while controlling for city-specific trends in migration.

Since 1970, there is evidence of a discontinuity, or "white flight" in neighborhoods that have exceeded the estimated tipping points in every decade. Yet the magnitude of white flight has been weakening. The regression discontinuity models suggest that for neighborhoods that tipped in 2000, white flight was between 23 and 36 percent of the level seen in 1970. While the point estimates of the models suggest white flight in the 1930s was of similar magnitude to those estimated in the 1970 and 1980s, they were less precise. Combined with Figures 5 and 6 showing a downward trend in the white population prior to tipping, there is insufficient evidence to conclude there was a threshold in which whites would quickly abandon neighborhoods during the Great Depression.

The estimates of the change in the minority population changes for tipped neighborhoods showcase a different dynamic to the white population. The unweighted estimates were generally statistically insignificant, but even in the case of the population weighted estimates, the magnitude of the point estimates of incoming minorities did not offset the fall in the white population. This is consistent with Boustan (2010) who found that the white population fell in northern cities between 1910 and 1940 as a result of black migration.

Our results are premised on the Schelling model which attributes racial segregation to households' preferences about the demographic characteristics of their neighbors. White households make a choice to remain or leave a neighborhood only on the composition of minorities. While our theoretical model allows for changes to demand for minorities, it is not explicitly written on what factors may shift the demand for minorities in the neighborhood.

Tiebout (1956) and Rosen (1974) suggest that segregation can be attributed to racial differences in income and preferences for amenities. Waldfogel (2008) notes that due to the fixed costs of establishing retail or commercial establishments, they open once there is a minimum number of possible customers. If these establishments are differentially preferred by whites and minorities, this could change the demand curve for whites and minorities in the neighborhoods and bring about racial segregation. Hellerstein, McInerney and Neumark (2011) find evidence that labor market networks, particularly those for low skilled workers are dependent on the proximity of its workers. This appears due to the presence of social networks. Given the general low educational attainment of minorities, we may expect them to have relatively stronger preference for segregation under these conditions.

In all likelihood, racial segregation in cities arises from a confluence of factors. As noted above, Shertzer and Walsh (2016) attributed white flight to no more than half of the increased segregation seen between 1910 and 1930. Rather than search for further causal stories, we believe that this paper provides a good overview of segregation in the United States for these six cities. While the causes may vary, the effect of segregation is clear. Cutler and Glaeser (1997) and Ananat

(2011) find clear evidence that segregation worsens black poverty and widens the black-white income gap.

REFERENCES

Ananat, Elizabeth O. (2011). "The Wrong Side(s) of the Tracks: The Causal Effects of Racial Segregation on Urban Poverty and Inequality." *American Economic Journal: Applied Economics*. 3(2): 34-66.

Banzhaf, Spencer H. and Randall P. Walsh (2010). "Segregation and Tiebout Sorting: Investigating the Link between Investments in Public Goods and Neighborhood Tipping." NBER Working Paper 16057.

Becker, Gary S. and Kevin M. Murphy (2000). *Social Economics: Market Behavior in a Social Environment*. Harvard University Press.

Boustan, Leah P. (2010). "Was Postwar Suburbanization `White Flight'?", *Quarterly Journal of Economics.* 125(1): 417-443

Brooks, Richard R.W. (2011). "Covenants without Courts: Enforcing Residential Segregation with Legally Unenforceable Agreements." *American Economic Review*. 101(3): 360-365.

Caetano, Gregorio and Vikram Maheshri (2017). "School Segregation and the Identification of Tipping Behavior." *Journal of Public Economics*. 148: 115-135.

Card, David, Alexandre Mas, and Jesse Rothstein (2008). "Tipping and the Dynamics of Segregation." *Quarterly Journal of Economics*. 123(1): 177-218.

Collins, William J. (1997). "When the tide turned: Immigration and the Delay of the Great Black Migration." *Journal of Economic History*. 57(3): 607-632.

Cutler, David and Edward L. Glaeser (1997). "Are Ghettos Good or Bad?" *Quarterly Journal of Economics*. 112(3): 827-872.

Hansen, Bruce (2000). "Sample Splitting and Threshold Estimation." *Econometrica*. 68(2): 575-603.

Hoyt, Homer (1939). *The Structure and Growth of Residential Neighborhoods in American Cities*. Washington, DC: Federal Housing Administration.

Kasy, Maximilian (2015). "Identification in a model of sorting with social externalities and the causes of urban segregation." *Journal of Urban Economics*. 85(1): 16-33.

Kollmann, Trevor M. (2012). "The Impact of African American Migration on Housing in New York City Neighborhoods during the Great Depression." Working Paper.

Logan, John R., Zengwang Xu, and Brian Stults. 2014. "Interpolating US Decennial Census Tract Data from as Early as 1970 to 2010: A Longitudinal Tract Database" The Professional Geographer 66(3): 412–420.

Massey, Douglas (2001). "Residential Segregation and Neighborhood Conditions in US Metropolitan Areas." In *America Becoming: Racial Trends and their Consequences*, Volume 1. Editors Smelser, Neil J, William Wilson and Faith Mitchell. Washington, DC: National Academy Press.

Massey, Douglas and Nancy Denton (1993*). American Apartheid: Segregation and the Making of the Underclass*. Cambridge, MA: Harvard University Press.

Minnesota Population Center. *National Historical Geographic Information System: Version 2.0*. Minneapolis, MN: University of Minnesota 2011.

Osofsky, Gilbert (1996). *Harlem: The Making of a Ghetto*. Chicago, IL: Elephant Paperbacks

Rosen, Sherwin (1974). "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Political Economy*. 82:34-55.

Schelling, Thomas C. (1971). "Dynamic Models of Segregation." *Journal of Mathematical Sociology*. 1(2): 143-186.

Shertzer, Allison and Walsh, Randall P. (2016). "Racial Sorting and the Emergence of Segregation in American Cities." *NBER Working Paper 22077*.

Tiebout, Charles (1956). "A Pure Theory of Local Expenditures." *Journal of Political Economy*. 64: 416-424.

U.S. Census Bureau (2000). Census 2000 Summary File 1.

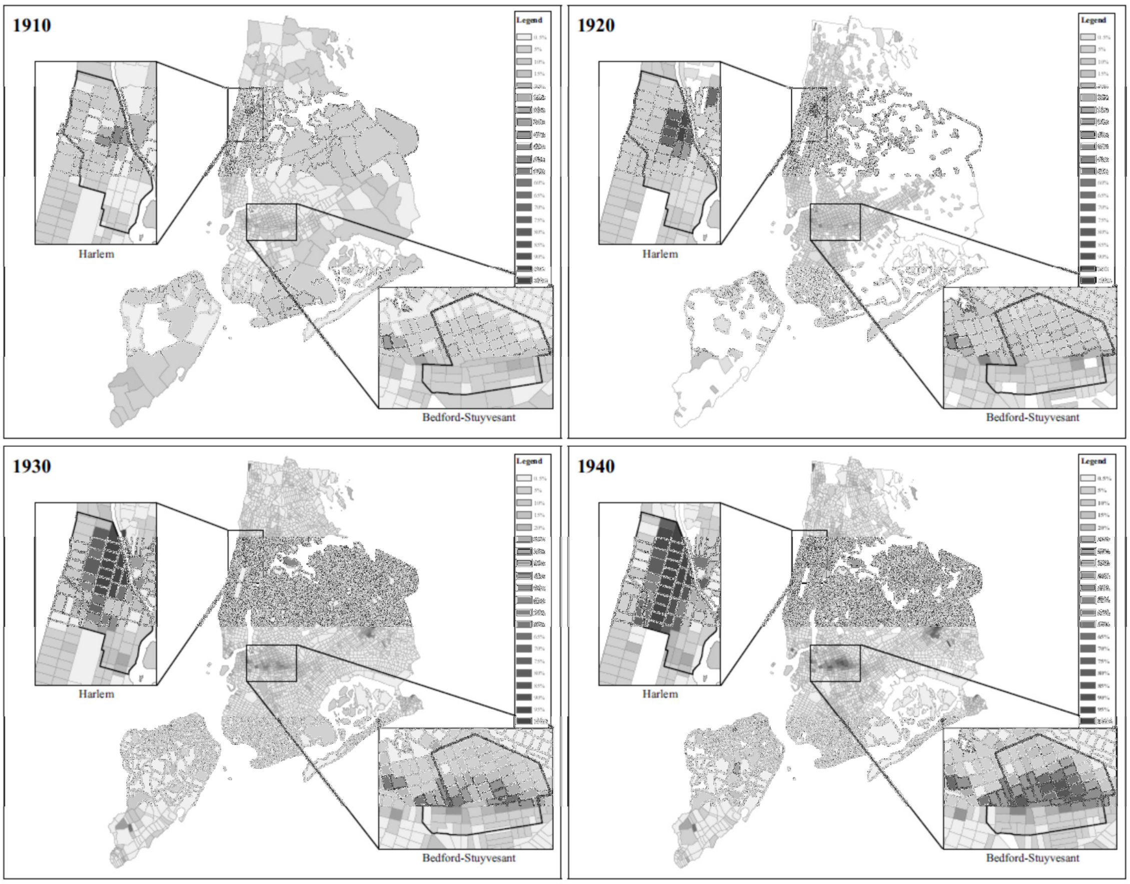
U.S. Census Bureau (2000a). Census 2000 Summary File 3.

Vlach, John M. (2010). "From Slavery to Tenancy" in *Housing Washington*. Editor Richard Longstreth. Chicago, IL: University of Chicago Press.

Waldfogel, Joel (2008). "The median voter and the median consumer: Local private goods and population composition." *Journal of Urban Economics*. 63(2): 567-582.

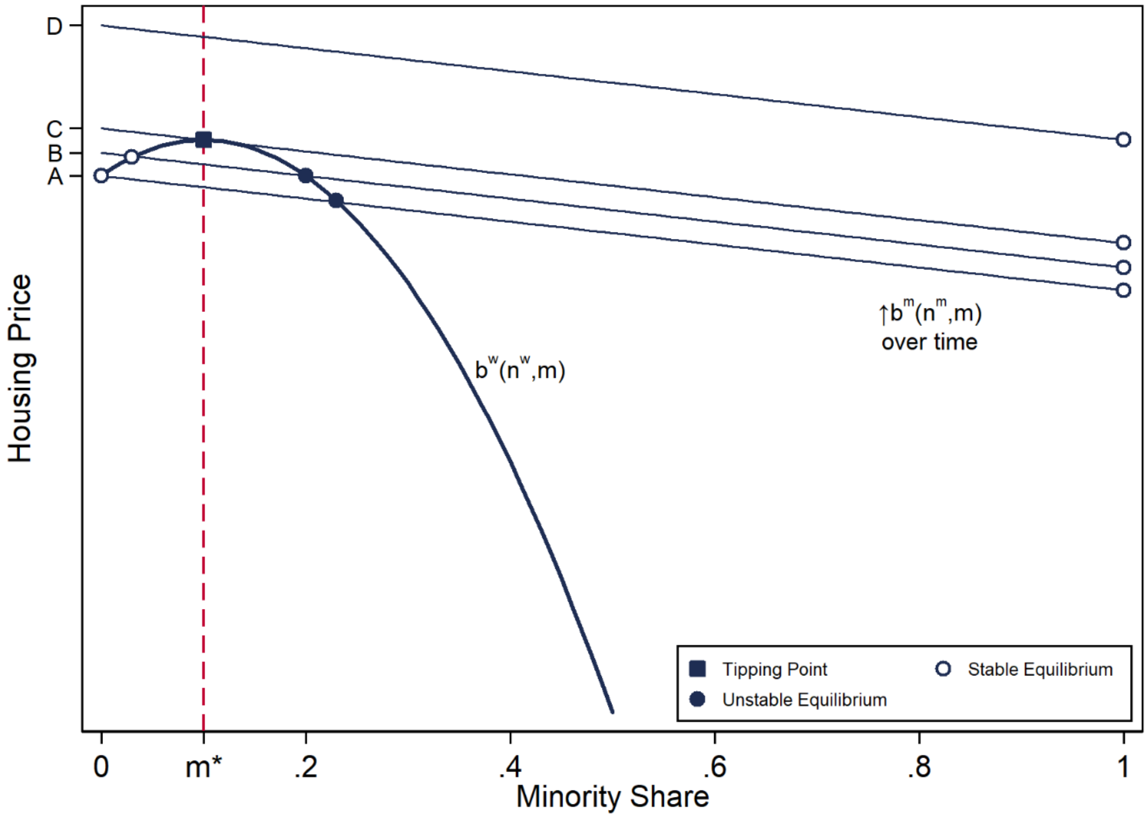
Wright, George C. (1980). "The NAACP and Residential Segregation in Louisville, Kentucky, 1914-1917." *The Register of the Kentucky Historical Society*. 78(1): 39-54.

Figure 1 Share of Non-White Population in New York by Census Tract



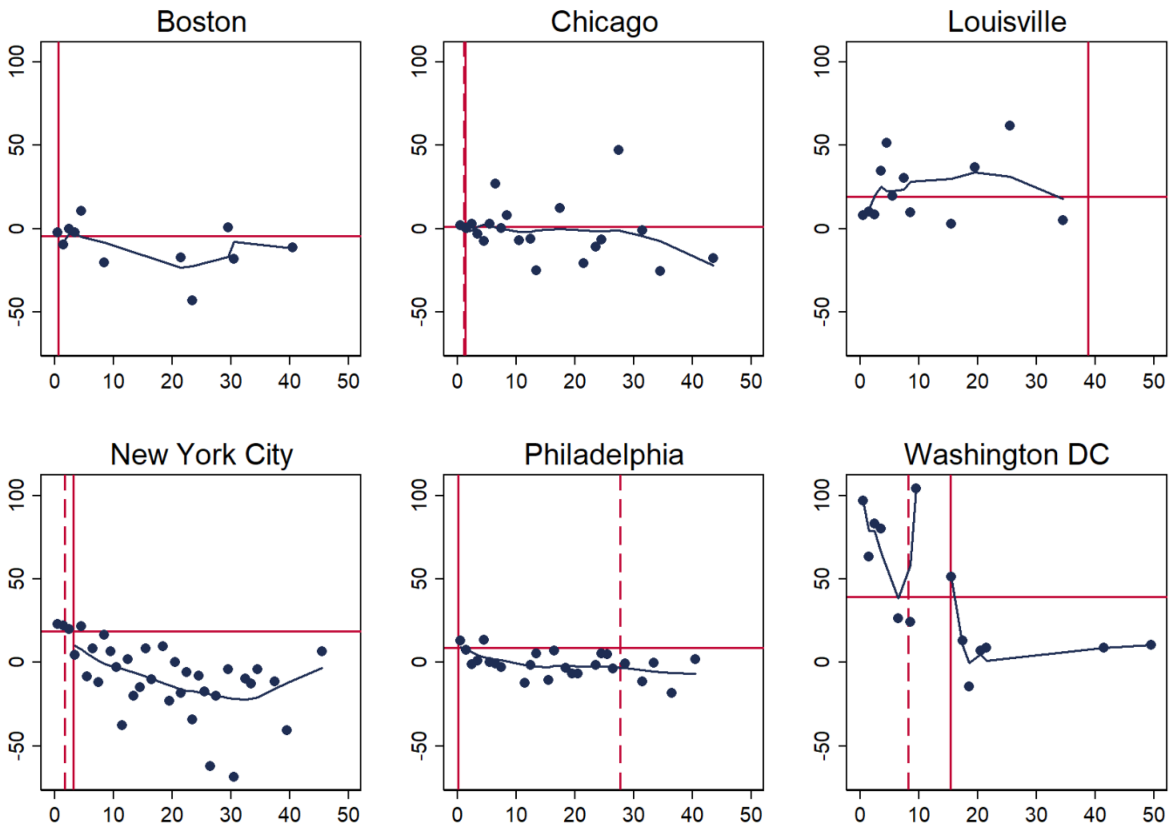
Note. The shaded areas reference the share of black population in a census tract. Darker areas indicate a higher share. Two black enclaves in the 20th century are separately highlighted, Harlem in Manhattan and Bedford-Stuyvesant in Brooklyn. Source: NHGIS

Figure 2 Increasing Minority Demand Leads to a Tipping Point



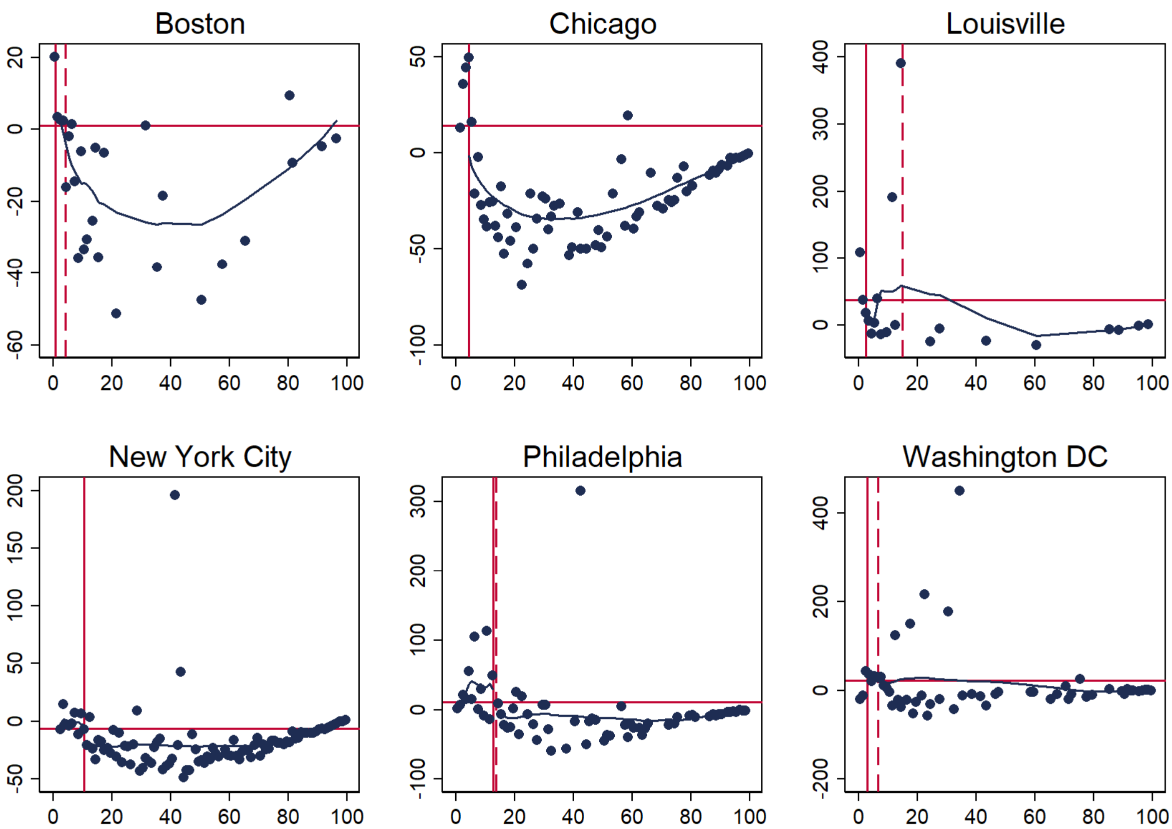
Note. Reproduction of Figure III in Card, Mas and Rothstein (2008)

Figure 3 **Changes to Neighborhoods in Six Cities for the period 1930 – 1940**



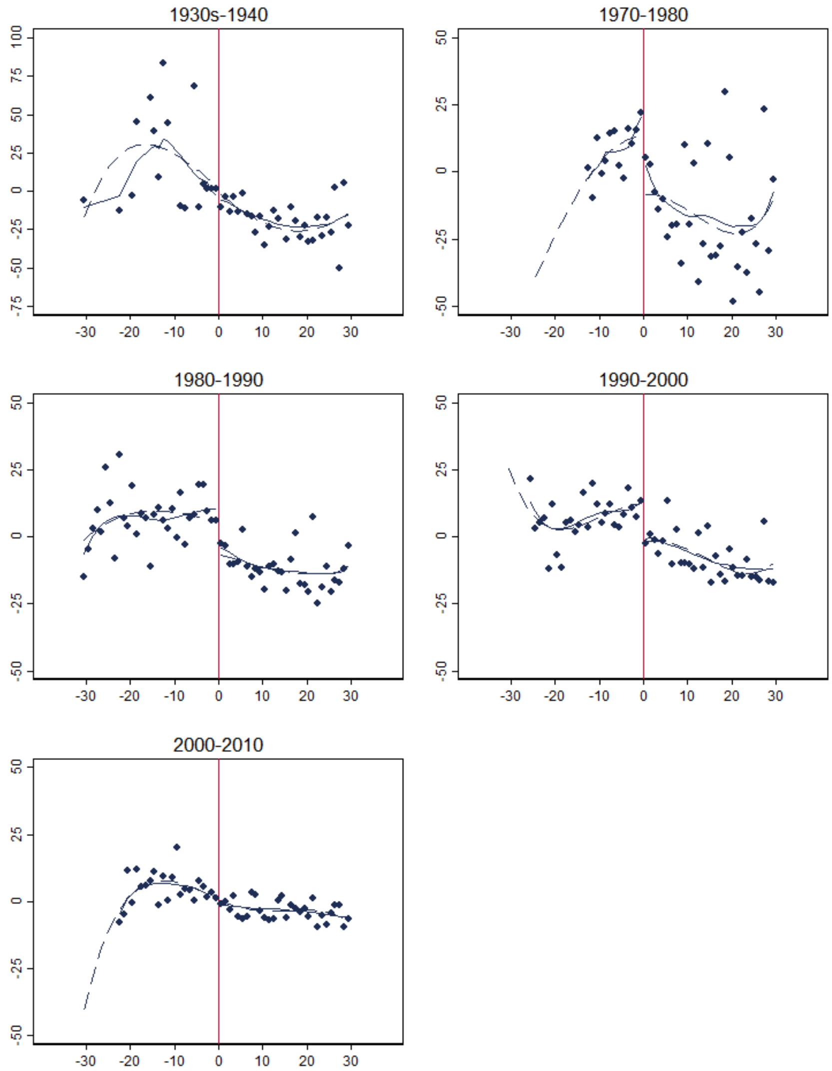
Note. The scatter plot displays on the y-axis, the mean change in the tract-level white population from the base year in the 1930s to 1940 as the percent of the total population in the base year population. The x-axis represents the share of the black and "other" race in the census tract in the base year. Each dot represents all tracts within a width of a ± 0.5 percentage points from the midpoint. The solid vertical line is the tipping point estimated using structural break method described in Card, Mas and Rothstein (2008) using no weights. The dashed vertical line, if visible, uses population in the base period as weights when estimating the tipping points. The curve is a locally weighted regression with a tricube weighting function and a bandwidth of 0.8. The curves were estimated separately before and after the estimated unweighted tipping point. All series use two-thirds of the sample. The horizontal line depicts the unconditional mean change in the white population over the decade.

Figure 4 **Changes to Neighborhoods in Six Cities for the period 1970 – 1980**



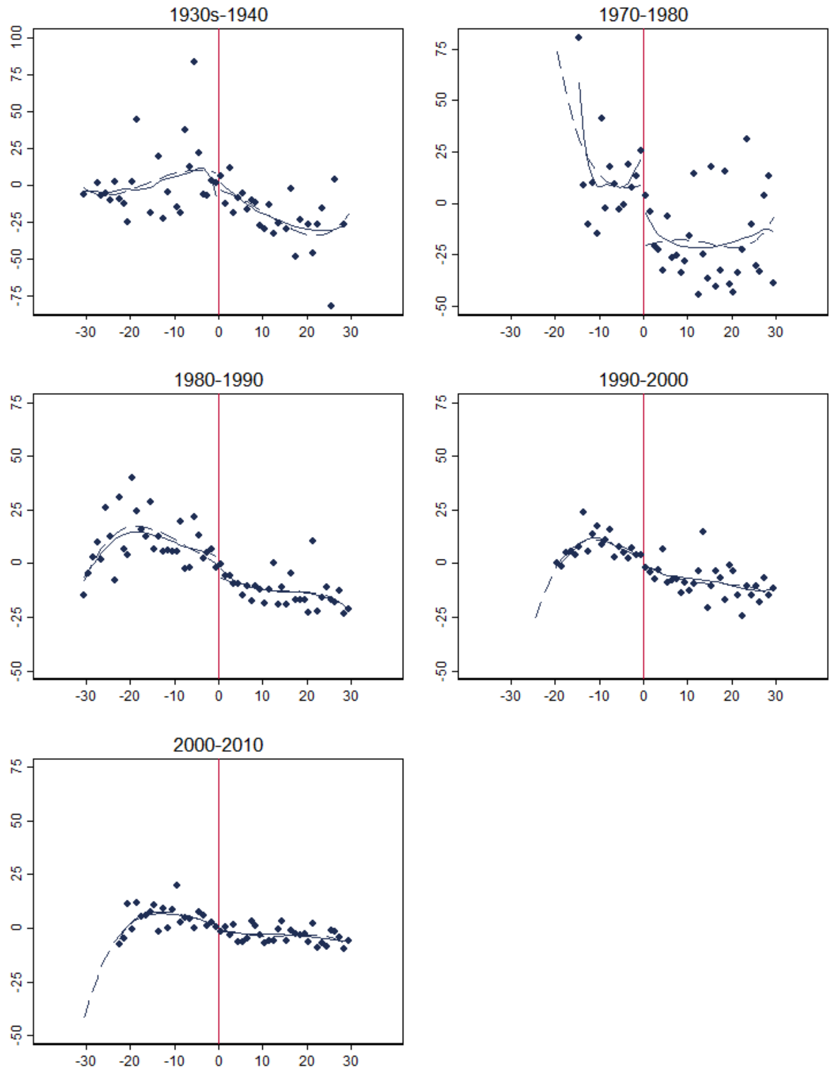
Note. The scatter plot displays on the y-axis, the mean change in the tract-level white, non-Hispanic population over the decade as the percent of the total population in the base year population. The x-axis represents the share of the black and "other" race in the census tract in the base year. Each dot represents all tracts within a width of a ± 0.5 percentage points from the midpoint. The solid vertical line is the tipping point estimated using structural break method described in Card, Mas and Rothstein (2008) using no weights. The dashed vertical line, if visible, uses population in the base period when estimated the tipping points. The curve is a locally weighted regression with a tricube weighting function and a bandwidth of 0.8. The curves were estimated separately before and after the estimated unweighted tipping point. All series use two-thirds of the sample. The horizontal line depicts the unconditional mean change in the white population over the decade.

Figure 5 Changes to Neighborhoods in an Unweighted Pooled Sample by relationship to candidate tipping point



Note. The horizontal (X) axis is the share of the minority population in a census tract minus the estimated tipping point (structural break method) for the city. The vertical (Y) axis is the change in the White, non-Hispanic population over a decade, expressed as a percentage of the total base year population differenced from the mean city-level change. The scatter plot depicts the average in 1-percentage-point bins. The solid line is a local linear regression with an Epanechnikov kernel and a bandwidth set to 5 that is fit on both sides of zero. The dashed line is a global fourth order polynomial with an intercept shift at zero. All series use the one-third of the sample not used to estimate the tipping points. Unweighted uses the tipping points estimated using no weights, Population Weighting uses estimates calculated adjusting for tract-level total population in the base period.

Figure 6 Changes to Neighborhoods in a Population Weighted Pooled Sample by relationship to candidate tipping point



Note. The horizontal (X) axis is the share of the minority population in a census tract minus the estimated tipping point (structural break method) for the city. The vertical (Y) axis is the change in the White, non-Hispanic population over a decade, expressed as a percentage of the total base year population differenced from the mean city-level change. The scatter plot depicts the average in 1-percentage-point bins. The solid line is a local linear regression with an Epanechnikov kernel and a bandwidth set to 5 that is fit on both sides of zero. The dashed line is a global fourth order polynomial with an intercept shift at zero. All series use the one-third of the sample not used to estimate the tipping points. Unweighted uses the tipping points estimated using no weights, Population Weighting uses estimates calculated adjusting for tract-level total population in the base period.

Table 1 Census Tract Summary Statistics by City (Population Weighted)

Panel A: 1930s-1940

Means	Minority Share 1930s	ΔWhite 30s-40	ΔMinority 30s-40	N
Boston	2.87	-1.70	0.37	128
Chicago	7.66	-0.14	0.70	893
Louisville	15.85	11.72	0.79	89
New York	4.96	4.03	1.88	2559
Philadelphia	11.47	1.79	2.14	354
Washington DC	27.31	23.78	11.05	95

Panel B: 1970-1980

Means	Minority Share 1970	ΔWhite 70-80	ΔMinority 70-80	N
Boston	5.70	-6.40	3.55	784
Chicago	22.82	-8.32	8.91	1984
Louisville	14.49	-0.15	1.72	221
New York	23.14	-12.86	7.25	4195
Philadelphia	19.88	-6.56	3.11	1179
Washington DC	27.91	-9.86	8.63	854

Panel C: 2000-2010

Means	Minority Share 2000	ΔWhite 00-10	ΔMinority 00-10	N
Boston	19.26	-3.14	6.79	989
Chicago	40.69	-2.46	5.97	2196
Louisville	16.94	3.86	6.39	314
New York	46.55	-3.17	6.13	4449
Philadelphia	29.38	-2.48	7.32	1462
Washington DC	44.70	0.21	14.40	1319

Note. $\Delta White$ indicates the unconditional mean change in the white population from the base period to the next as a share of the total population in the base year. The share is multiplied by 100 for readability. Beginning with 1970, "White" is defined as anyone who is defined as white, non-Hispanic in the census. Panel B uses imputed estimates of the white, non-Hispanic population calculated from 1980 figures; see Section 3 for details. $\Delta Minority$ indicates the unconditional mean change in the non-white population from the base period to the next period as a share of the total population in the base period. The share is multiplied by 100 for readability. The summary statistics are weighted by base period tract-level population. The unit of observation is a census tract.

Table 2 Percent change in white population from the base year total population over the distribution of the base year share minority

Panel A: 1930s-1940

Share Black 1930s	Mean	SD	N
$0 \le Share < 1$	5.37	23.39	2782
$1 \le Share < 5$	2.97	26.39	706
$5 \le Share < 10$	-3.06	24.30	161
$10 \le Share < 20$	1.08	31.97	161
$20 \le Share < 30$	-6.29	25.43	78
$30 \le Share < 40$	-7.02	20.53	46
$40 \le Share < 50$	-11.31	37.36	24
$50 \le Share < 100$	-3.62	11.24	160

Panel B: 1970-1980

Share Minority 1970	Mean	SD	N
$0 \le Share < 1$	-0.40	39.81	162
$1 \le Share < 5$	-3.32	37.25	2942
$5 \le Share < 10$	-10.04	36.26	1033
$10 \le Share < 20$	-20.24	34.81	568
$20 \le Share < 30$	-28.80	28.05	252
$30 \le Share < 40$	-32.82	30.22	205
$40 \le Share < 50$	-29.57	38.42	124
$50 \le Share \le 100$	-11.81	14.52	864

Panel C: 2000-2010

Share Minority 2000	Mean	SD	N
$0 \le Share < 1$	8.39	34.14	5
$1 \le Share < 5$	5.44	17.59	763
$5 \le Share < 10$	1.76	18.62	1134
$10 \le Share < 20$	-1.92	19.35	1483
$20 \le Share < 30$	-4.16	17.77	802
$30 \le Share < 40$	-7.97	19.18	596
$40 \le Share < 50$	-8.71	16.76	437
$50 \le Share < 100$	-2.02	12.55	2461

Note. Percent Change in White Population indicates the unconditional mean change in the white population from the base period to the next as a share of the total population in the base period. The means and standard deviations (SD) are multiplied by 100 for readability. Beginning with 1970, "White" is defined as anyone who is defined as white, non-Hispanic in the census. Panel B uses imputed estimates of the white, non-Hispanic population calculated from 1980 figures; see Section 3 for details. Summary statistics are weighted by base period population. The unit of observation is a census tract.

Table 3 Estimates of Tipping Points

		Boston	Chicago	Louisville	New York City	Philadelphia	Washington, DC
1930s-1940	Unweighted	0.6	1.4	38.8	3.2	0.1	15.4
	Pop Weighted	0.6	1.1	38.8	1.7	27.7	8.2
	N	84	545	54	1688	227	55
1970-1980	Unweighted	0.9	4.4	2.5	10.6	12.8	2.9
	Pop Weighted	4.3	4.4	15	10.6	13.6	6.7
	N	503	1154	137	2426	706	473
1980-1990	Unweighted	2.5	14.6	20.8	15.3	30.3	14.6
	Pop Weighted	2.5	14.6	11.9	15.3	30.3	19.6
	N	627	1151	163	2246	849	685
1990-2000	Unweighted	5.1	5.5	26.3	12.6	19.0	16.5
	Pop Weighted	5.1	12.7	5.5	14.6	19.2	17.5
	N	616	1100	193	2074	833	698
2000-2010	Unweighted	4.9	8.0	10.1	9.1	20.8	24.2
	Pop Weighted	6.0	8.0	10.1	9.1	20.8	24.2
	N	596	1004	191	1806	794	619

Note. Tipping points were estimated using the structural break method described in detail in Equation (7) found in Section 2.2. The unit of observation is the census tract. Pop Weighted uses weighted estimates calculated using tract-level total population in the base period. Common tracts from 1970-2010 were created from the Longitudinal Tract Database and were based on the tract alignment in 2010. Estimates used a random two-thirds subsample of all tracts.

Table 4 **Regression Discontinuity Models for Population Changes around the Candidate Tipping Point over various periods**

	White Population		Minority Population		Total Population	
	(1)	(2)	(3)	(4)	(5)	(6)
	Unweighted	Population Weighted	Unweighted	Population Weighted	Unweighted	Population Weighted
Tipping Point	-9.363*	-7.506	-0.558	0.541	-9.921*	-6.965*
(1930s-1940)	(4.413)	(4.330)	(0.650)	(1.022)	(3.992)	(3.383)
R-Squared	0.111	0.164	0.156	0.256	0.109	0.177
N	1,374	1,374	1,374	1,374	1,374	1,374
Tipping Point	-16.945***	-7.129***	5.776***	6.170***	-11.179**	-0.958
(1970-1980)	(4.893)	(2.273)	(1.688)	(1.859)	(5.387)	(2.311)
R-Squared	0.262	0.209	0.237	0.367	0.222	0.148
N	3,075	3,075	3,074	3,074	3,074	3,074
Tipping Point	-10.023***	-2.607	0.630	1.811*	-9.460**	-0.799
(1980-1990)	(3.088)	(1.646)	(1.295)	(1.074)	(3.673)	(1.738)
R-Squared	0.138	0.098	0.191	0.249	0.117	0.082
N	3,417	3,417	3,415	3,415	3,415	3,415
Tipping Point	-7.807***	-3.370**	0.533	2.389***	-7.284**	-0.981
(1990-2000)	(2.651)	(1.341)	(1.257)	(0.916)	(3.363)	(1.648)
R-Squared	0.095	0.105	0.117	0.242	0.050	0.044
N	3,570	3,570	3,568	3,568	3,568	3,568
Tipping Point	-3.847**	-2.557***	0.621	2.366***	-3.238	-0.181
(2000-2010)	(1.507)	(0.979)	(1.770)	(0.630)	(2.933)	(1.219)
R-Squared	0.080	0.103	0.104	0.205	0.060	0.066
N	3,583	3,583	3,578	3,578	3,578	3,578

Note. The unit of observation is a census tract and the sample is the one-third of observations not used to estimate tipping points pooled from all six cities. Dependent variables are the change in the relevant population as a percentage (0-100) of the census tract's base year population. Independent variables include Tipping Point, an indicator variable if the tract is beyond the city-specific tipping point in the base year, CSA fixed effects, and a quartic polynomial in the deviation in the tract's minority share from the candidate tipping point. For the 1930s-1940 regression, it also includes the population density in the base year. For the remaining regressions, it instead includes the unemployment rate, log of the mean family income, housing vacancy rate, renter share, fraction of homes in single-unit buildings, and fraction of workers who commute using public transit, all of which were measured in the base year. Standard errors are clustered by CSA. Population weighting weighed observations by the tract population in the base year.
* p<0.10, ** p<0.05, *** p<0.01

APPENDIX

Appendix A: Robustness of Tipping Point Estimates Across Search Space

The estimated tipping points shown in Table 3 was based on the empirical specification found in Equation (7) of Section 2.2. The procedure specified that the tipping point was determined by the value of m^{*}_{c,t_0} that maximized the R^2 within an interval of 0 to 50% for all tracts in a city that did not exceed a 60% minority share in the base year. As a robustness check, we assessed the tipping points under different maximum minority shares and searched for a tipping point along an interval that was 10 percentage points less than the maximum minority share for the 1930-40 period and similarly for the 1970-80 period. For consistency, we used the same two-thirds subsample used to calculate the tipping points in Table 3 for each city. The results are shown in Tables 5 and 6.

From these tables, it is apparent the 1930s results are stable for Boston, Chicago, New York City, and Washington DC, yet there is substantial variation in the results for Louisville and Philadelphia, depending on the sample size used. In the case of Philadelphia, the unweighted tipping points were stable and just the population weighted estimates varied, while the results for Louisville varied substantially. As stated in the main paper, we believe that the results for Louisville are sensitive due to the smaller sample size and the historical neighborhoods that contained alley homes. These neighborhoods were technically integrated due to blacks residing in alley slum dwellings with the whites residing in homes on the main streets. The inclusion of these neighborhoods may be increasing the tipping points although in this case, the results may be misleading.

For a further robustness check, Table 6 provides the estimated tipping points for the 1970-80 period. The results indicate that city-level estimates of tipping are more robust, likely due to the larger number of tracts available since 1970 and the increased homogeneity of characteristics in the tracts due to efforts by the Census Bureau to standardize the definition of a tract. The estimated tipping points did not change with the exception of the unweighted estimates for Louisville when limiting the sample to only census tracts with a base period minority share no larger than 40 percent. We found similar robust results for the other cities in the later decades.

Table 5 Estimates of Tipping Points for 1930s-1940

		Boston	Chicago	Louisville	New York City	Philadelphia	Washington, DC
40%	Unweighted	0.6	1.4	7.6	3.2	0.1	15.4
	Pop Weighted	0.6	1.1	7.6	1.7	1.4	8.2
	N	83	540	53	1677	216	51
50%	Unweighted	0.6	1.4	38.8	3.2	0.1	15.4
	Pop Weighted	0.6	1.1	38.8	1.7	38.3	8.2
	N	84	543	54	1683	220	54
60%	Unweighted	0.6	1.4	38.8	3.2	0.1	15.4
	Pop Weighted	0.6	1.1	38.8	1.7	27.7	8.2
	N	84	545	54	1688	227	55
70%	Unweighted	0.6	1.4	43.5	3.2	0.1	15.4
	Pop Weighted	0.6	1.1	1.5	1.7	19.1	8.2
	N	84	553	57	1692	231	56
80%	Unweighted	0.6	47	43.5	3.2	0.1	15.4
	Pop Weighted	0.6	1.1	1.5	1.7	19.1	8.2
	N	84	556	58	1696	233	58

Note. Tipping points were estimated using the structural break method described in detail in Equation (7) found in Section 2.2 of the main paper. The unit of observation is the census tract. Pop Weighted uses weighted estimates calculated using tract-level total population in the base period. Common tracts from 1970-2010 were created from the Longitudinal Tract Database and were based on the tract alignment in 2010. Estimates used a random two-thirds subsample of all tracts.

Table 6 Estimates of Tipping Points for 1970-1980

		Boston	Chicago	Louisville	New York City	Philadelphia	Washington, DC
40%	Unweighted	0.9	4.4	15	10.6	12.8	2.9
	Pop Weighted	4.3	4.4	15	10.6	13.6	6.7
	N	496	1129	130	2283	673	457
50%	Unweighted	0.9	4.4	2.5	10.6	12.8	2.9
	Pop Weighted	4.3	4.4	15	10.6	13.6	6.7
	N	498	1144	136	2363	691	463
60%	Unweighted	0.9	4.4	2.5	10.6	12.8	2.9
	Pop Weighted	4.3	4.4	15	10.6	13.6	6.7
	N	503	1154	137	2426	706	473
70%	Unweighted	0.9	4.4	2.5	10.6	12.8	2.9
	Pop Weighted	4.3	4.4	15	10.6	13.6	6.7
	N	508	1169	139	2495	719	479
80%	Unweighted	0.9	4.4	2.5	10.6	12.8	2.9
	Pop Weighted	4.3	4.4	15	10.6	13.6	6.7
	N	511	1183	141	2587	731	491

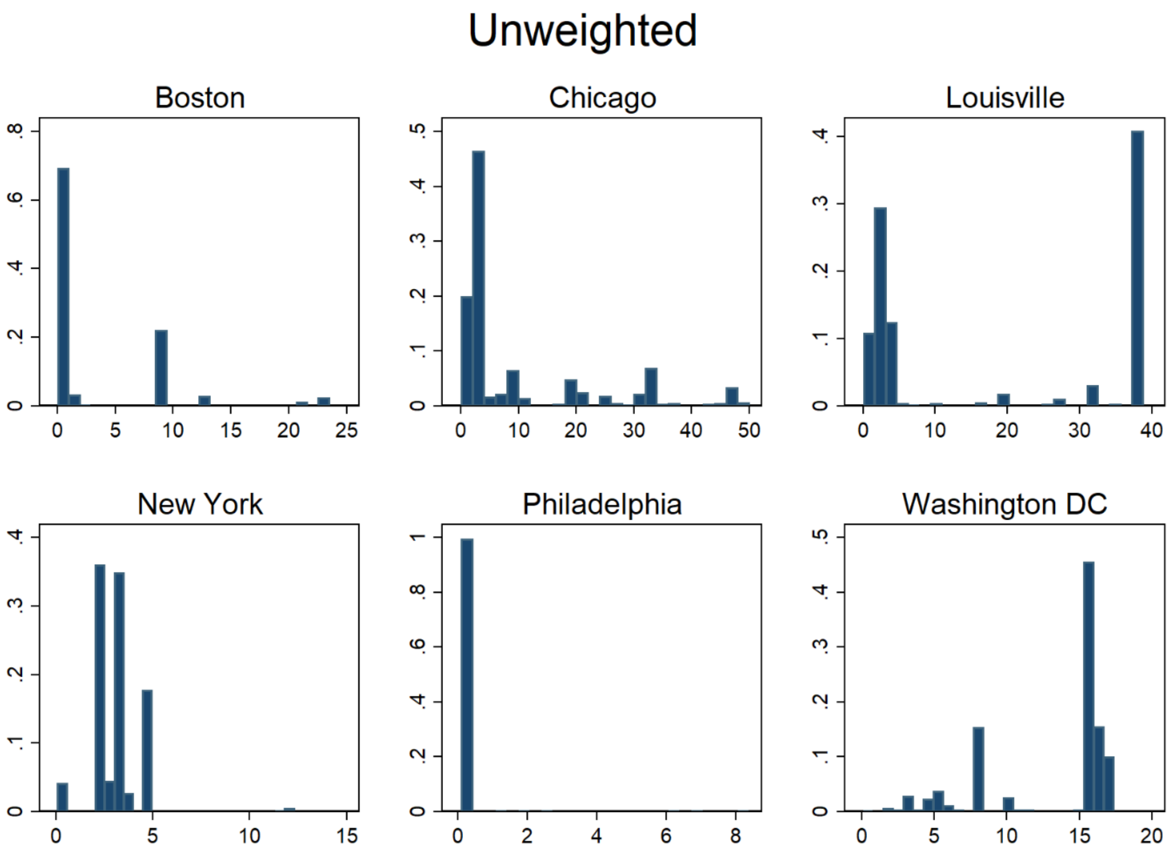
Note. Tipping points were estimated using the structural break method described in detail in Equation (7) found in Section 2.2 of the main paper. The unit of observation is the census tract. Pop Weighted uses weighted estimates calculated using tract-level total population in the base period. Common tracts from 1970-2010 were created from the Longitudinal Tract Database and were based on the tract alignment in 2010. Estimates used a random two-thirds subsample of all tracts.

Appendix B: Robustness of Tipping Point Estimates Across Search Space

In another robustness check, we ran a Monte Carlo simulation to estimate the distribution of possible tipping points given different samples. We took 1000 draws without replacement from our dataset to create different combinations for our two-thirds subsample. We then re-estimated the tipping points for each city separately for each draw and have plotted the distribution of the tipping points in the histograms below.

The Monte Carlo simulations of the 1930s data suggest that the distribution of the estimated tipping points found in Figures 7 (unweighted) and 8 (weighted) show greater relative variance than those found in the period 1970-1980 which are shown in Figures 9 (unweighted) and 10 (weighted). For example, the estimated tipping point in Chicago was predominately estimated to be less than five percent, yet a share of draws yielded an estimated tipping point nearing 50 percent. Likewise, for the unweighted tipping points, nearly all the estimates for Philadelphia were under 1 percent, but if we weighted census tracts by the base year population, 40 percent of the estimated tipping points were under one percent. However the spread of tipping points for Philadelphia had increased with some estimated at nearly 40 percent threshold. It is difficult to surmise an explanation of the variance across weighting schemes, the plausibility of a city-wide tipping point remaining under one percent should be further explored. A possible reason that we observe greater variance in in the tipping point distribution for the 1930-1940 in the Monte Carlo simulation is that the sample size for the census tracts in this period is significantly smaller than that of the 1970-1980. Nevertheless, the Monte Carlo simulation provides a method of verifying whether our tipping point estimate is estimated correctly.

Figure 7 **Distribution of Estimated Tipping Points for Unweighted Census Tracts in 1930s-1940**

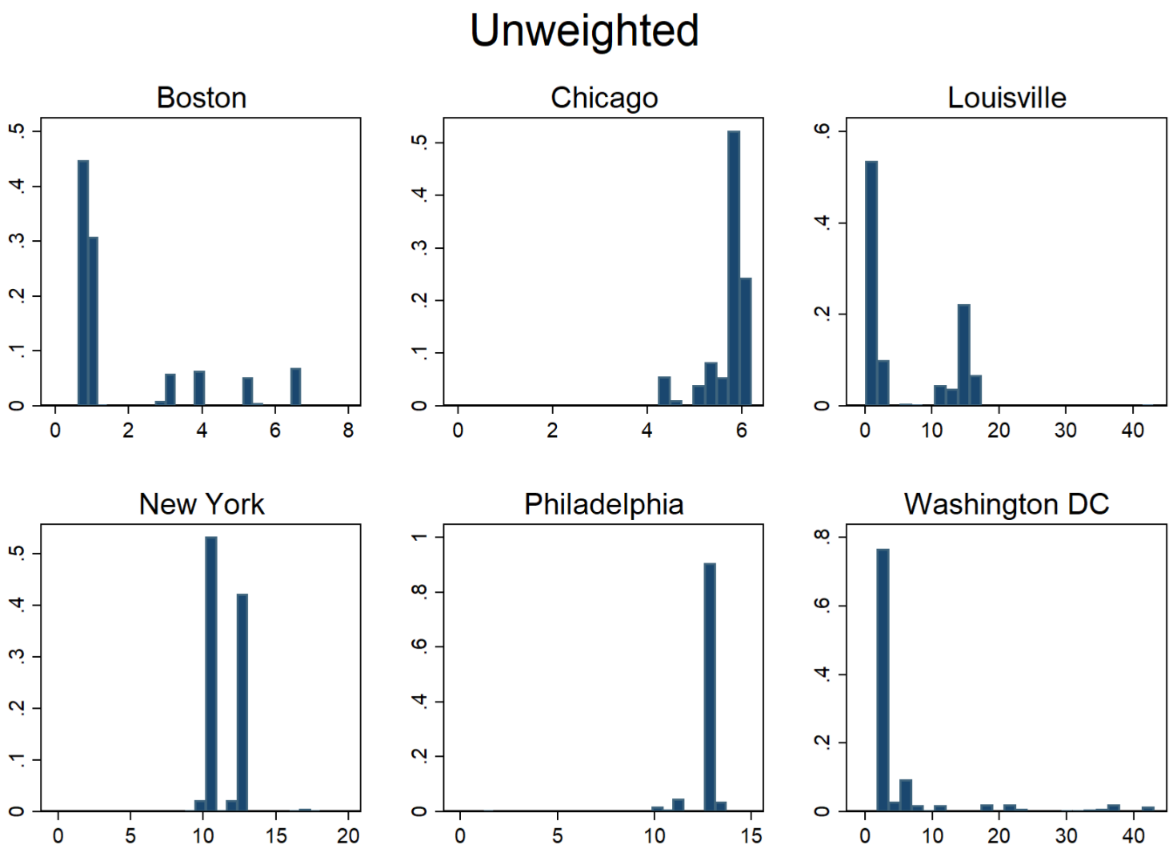


Note. X-axis is the minority share in the 1930s base period. Y-axis is the share of draws that have a tipping point within the bin. The bin width is one percentage point. Each draw contains a two-thirds sample from the city that was sampled without replacement. The unit of observation is the census tract.

Figure 8 Distribution of Estimated Tipping Points for Population Weighted Census Tracts in 1930s-1940

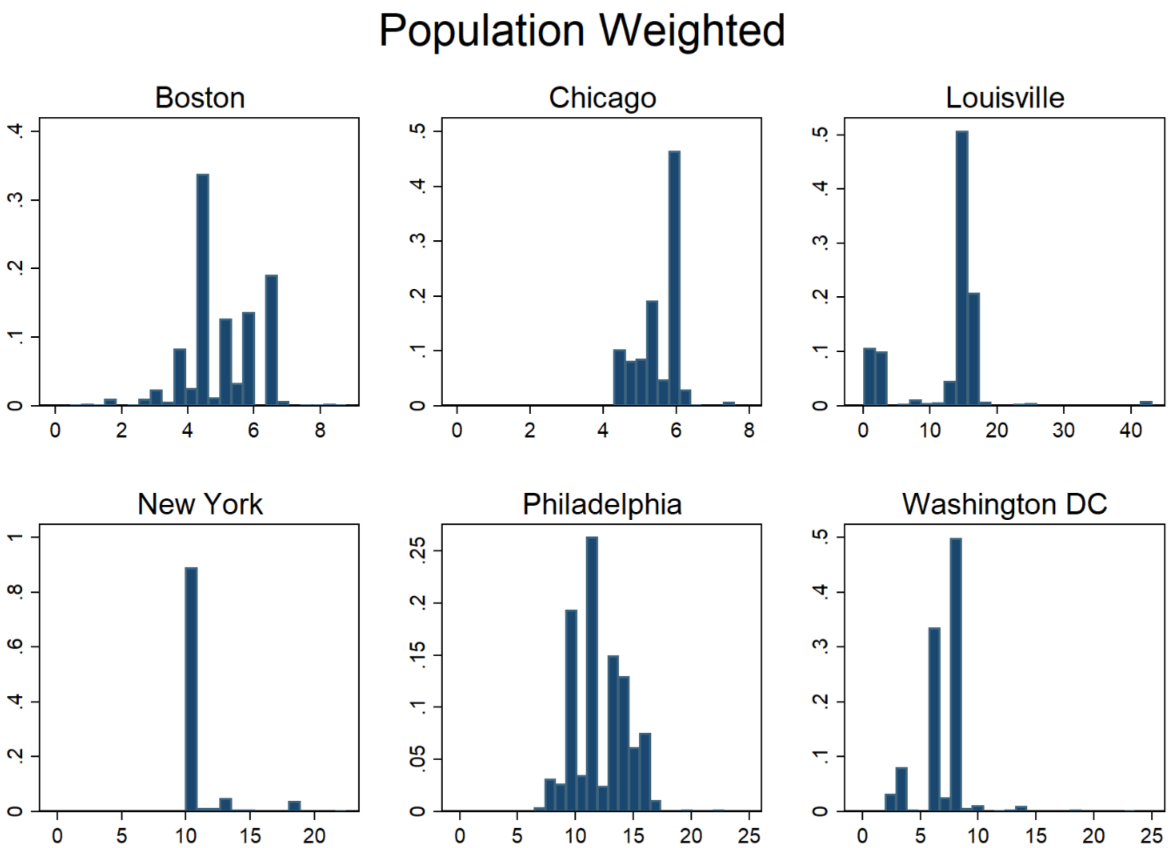
Note. X-axis is the minority share in the 1930s base period. Y-axis is the share of draws that have a tipping point within the bin. The bin width is one percentage point. Each draw contains a two-thirds sample from the city that was sampled without replacement. The unit of observation is the census tract. Tipping points were estimated using 1930s census tract population as weights.

Figure 9 Distribution of Estimated Tipping Points for Unweighted Census Tracts in 1970-1980



Note. X-axis is the minority share in the 1970 base period. Y-axis is the share of draws that have a tipping point within the bin. The bin width is one percentage point. Each draw contains a two-thirds sample from the city that was sampled without replacement. The unit of observation is the census tract.

Figure 10 **Distribution of Estimated Tipping Points for Population Weighted Census Tracts in 1970-1980**

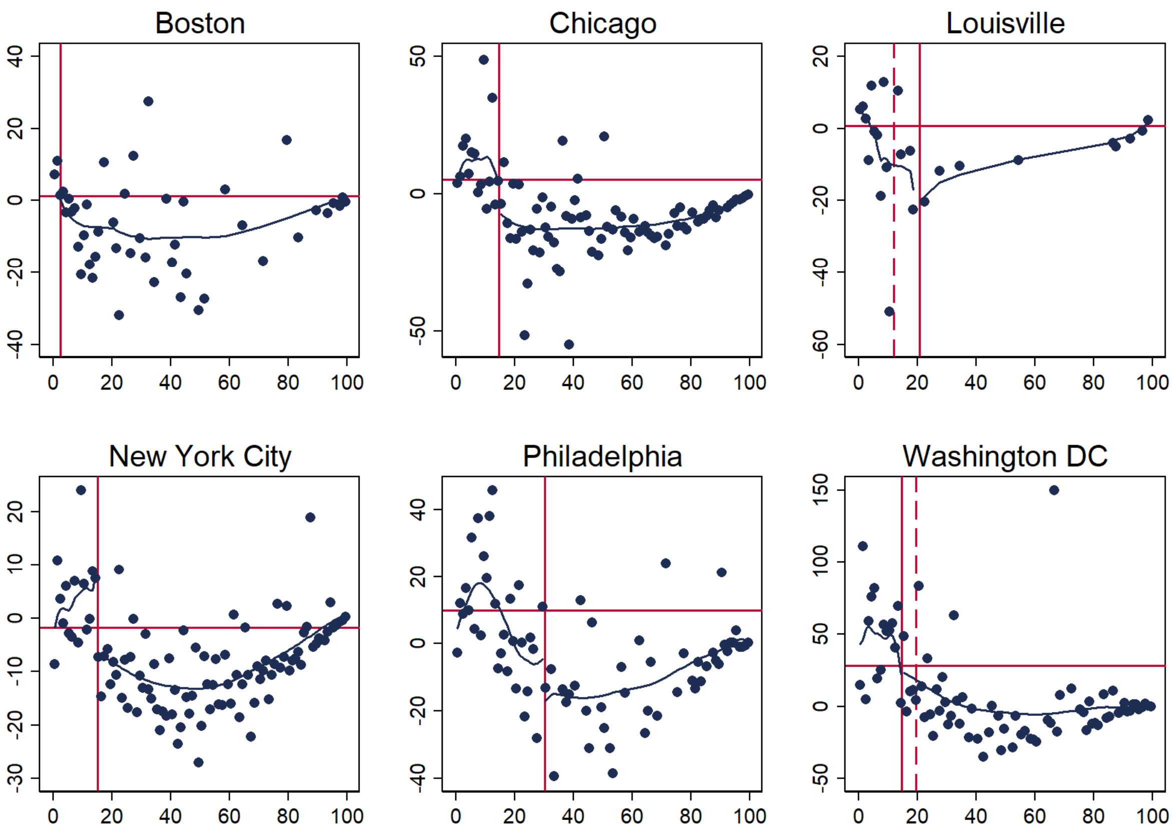


Note. X-axis is the minority share in the 1970 base period. Y-axis is the share of draws that have a tipping point within the bin. The bin width is one percentage point. Each draw contains a two-thirds sample from the city that was sampled without replacement. The unit of observation is the census tract. Tipping points were estimated using 1970s census tract population as weights.

Appendix C: Changes to Neighborhoods in Six Cities from 1980 through 2010

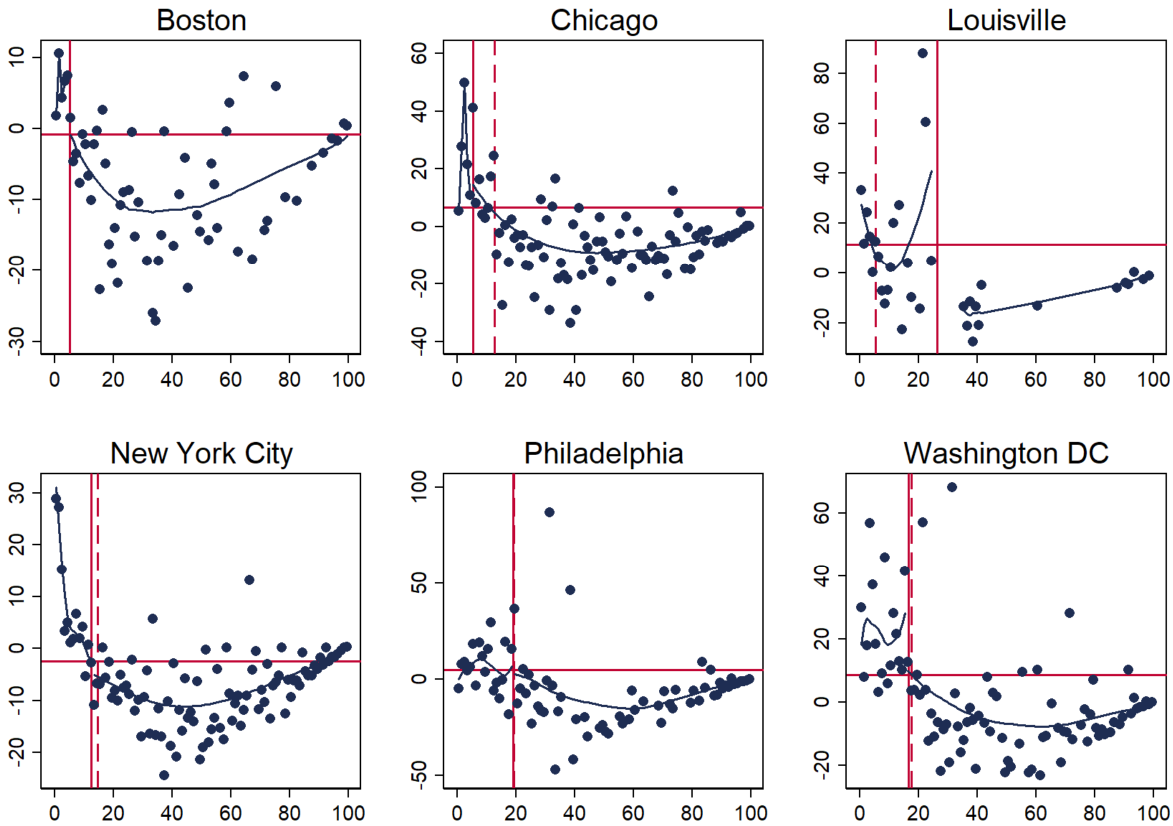
We extend the analysis of Figures 3 and 4 through to 2010. Each figure plots on the x-axis the share of minorities in a census tract in the base year. Each dot represents all tracts within $\pm$0.5 percentage points of the midpoint. The y-axis represents the mean change in the tract-level white population over the decade with the figures highlighting each city in the 1930s and 1970s respectively. To understand whether the white population fell after the estimated tipping points, we have also plotted the unweighted and weighted tipping points for each graph as solid and dashed vertical lines respectively. The solid curve is a local linear regression with a tricube weighting function and a bandwidth of 0.8. The local linear regression was estimated on both sides of the unweighted tipping points and are used to visualize any trend in the data.

Figure 11 Changes to Neighborhoods in Six Cities for the period 1980 – 1990



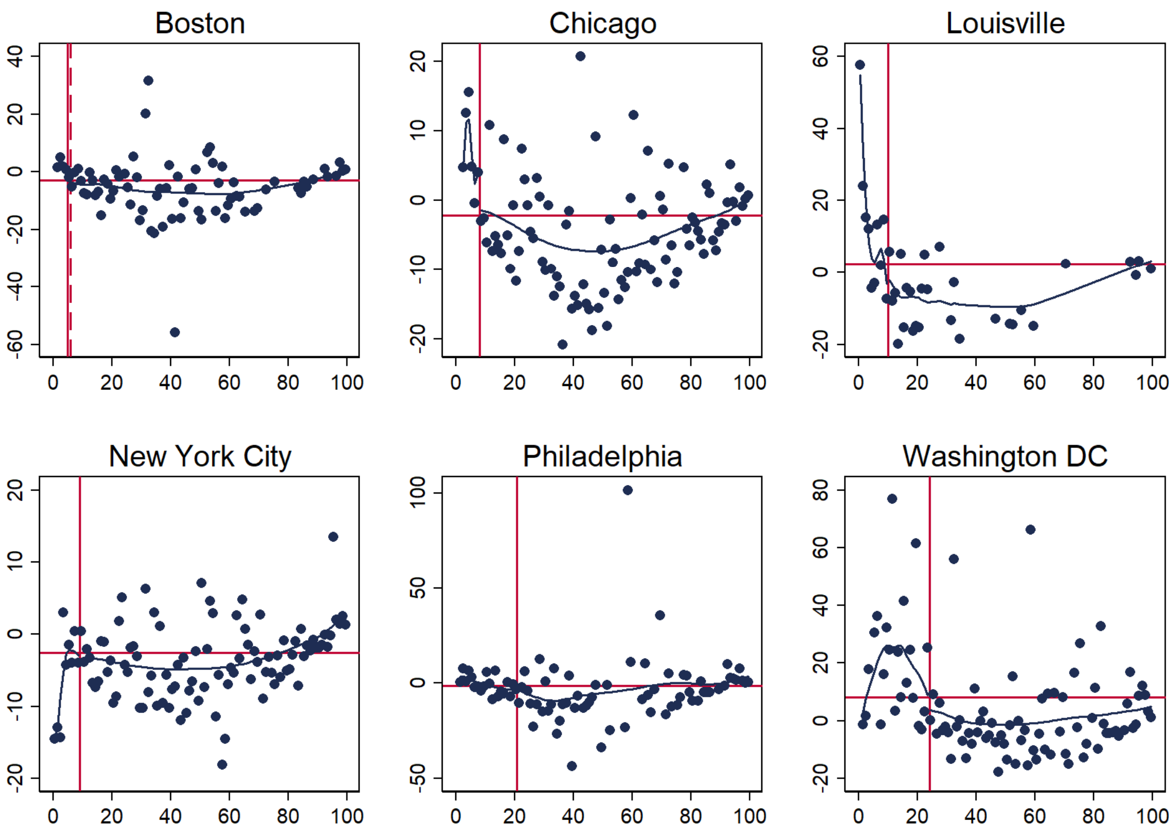
Note. The scatter plot displays on the y-axis, the mean change in the tract-level white, non-Hispanic population over the decade as the percent of the total population in the base year population. The x-axis represents the share of the black and "other" race in the census tract in the base year. Each dot represents all tracts within a width of a ± 0.5 percentage points from the midpoint. The solid vertical line is the tipping point estimated using structural break method described in Card, Mas and Rothstein (2008) using no weights. The dashed vertical line, if visible, uses population in the base period when estimated the tipping points. All series use two-thirds of the sample. The horizontal line depicts the unconditional mean change in the white population over the decade.

Figure 12 **Changes to Neighborhoods in Six Cities for the period 1990 – 2000**



Note. The scatter plot displays on the y-axis, the mean change in the tract-level white, non-Hispanic population over the decade as the percent of the total population in the base year population. The x-axis represents the share of the black and "other" race in the census tract in the base year. Each dot represents all tracts within a width of a ± 0.5 percentage points from the midpoint. The solid vertical line is the tipping point estimated using structural break method described in Card, Mas and Rothstein (2008) using no weights. The dashed vertical line, if visible, uses population in the base period when estimated the tipping points. All series use two-thirds of the sample. The horizontal line depicts the unconditional mean change in the white population over the decade.

Figure 13 **Changes to Neighborhoods in Six Cities for the period 2000 – 2010**



Note. The scatter plot displays on the y-axis, the mean change in the tract-level white, non-Hispanic population over the decade as the percent of the total population in the base year population. The x-axis represents the share of the black and "other" race in the census tract in the base year. Each dot represents all tracts within a width of a ± 0.5 percentage points from the midpoint. The solid vertical line is the tipping point estimated using structural break method described in Card, Mas and Rothstein (2008) using no weights. The dashed vertical line, if visible, uses population in the base period when estimated the tipping points. All series use two-thirds of the sample. The horizontal line depicts the unconditional mean change in the white population over the decade.

Appendix D: Robustness of Regression Discontinuity Models

We checked the robustness of the regression discontinuity results by re-running the results without the city-level fixed effects. The results are found below in Table 7. Like the results in the main paper, we continued to include a quartic polynomial in the deviation in the tract's minority share from the candidate tipping point in all tracts. For the 1930s regressions, we included the population density in the 1930s. For the remaining regressions, we included the unemployment rate, log of the mean family income, housing vacancy rate, renter share, fraction of homes in single-unit buildings, and fraction of workers who commute using public transit, all of which were measured in the base year. Standard errors were clustered by city in the 1930s and by CSA in the remaining regressions. We used the one-third sample not used to estimate the tipping points found in Table 3.

Table 7 **Regression Discontinuity Models for Population Changes around the Candidate Tipping Point over various periods (Excluding city-level fixed effects)**

	White Population		Minority Population		Total Population	
	(1)	(2)	(3)	(4)	(5)	(6)
	Unweighted	Population Weighted	Unweighted	Population Weighted	Unweighted	Population Weighted
Tipping Point	-8.270	-7.569	0.255	1.496	-8.016	-6.074
(1930s-1940)	(5.473)	(5.308)	(0.767)	(0.971)	(5.468)	(4.605)
R-Squared	0.079	0.087	0.093	0.203	0.068	0.072
N	1,374	1,374	1,374	1,374	1,374	1,374
Tipping Point	-15.403***	-7.620***	1.335	7.472***	-14.067***	-0.147
(1970-1980)	(3.983)	(2.099)	(1.208)	(1.661)	(4.316)	(2.105)
R-Squared	0.260	0.201	0.207	0.350	0.218	0.145
N	3,075	3,075	3,074	3,074	3,074	3,074
Tipping Point	-12.113***	-2.411	-0.189	1.344	-12.385***	-1.071
(1980-1990)	(3.184)	(1.638)	(1.321)	(1.113)	(3.817)	(1.758)
R-Squared	0.110	0.087	0.163	0.229	0.081	0.063
N	3,417	3,417	3,415	3,415	3,415	3,415
Tipping Point	-7.284***	-5.052***	1.337	3.220***	-5.958*	-1.832
(1990-2000)	(2.510)	(1.292)	(1.078)	(0.939)	(3.098)	(1.565)
R-Squared	0.082	0.094	0.100	0.213	0.042	0.038
N	3,570	3,570	3,568	3,568	3,568	3,568
Tipping Point	-3.842**	-3.065***	1.566	3.226***	-2.364	0.146
(2000-2010)	(1.494)	(0.976)	(1.673)	(0.645)	(2.801)	(1.208)
R-Squared	0.051	0.084	0.075	0.177	0.026	0.042
N	3,583	3,583	3,578	3,578	3,578	3,578

Note. The unit of observation is a census tract and the sample is the one-third of observations not used to estimate tipping points pooled from all six cities. Dependent variables are the change in the relevant population as a percentage (0-100) of the census tract's base year population. Independent variables include Tipping Point, an indicator variable if the tract is beyond the city-specific tipping point in the base year and a quartic polynomial in the deviation in the tract's minority share from the candidate tipping point. For the 1930s-1940 regression, the results include the population density in the base year. For the remaining regressions, it instead includes the unemployment rate, log of the mean family income, housing vacancy rate, renter share, fraction of homes in single-unit buildings, and fraction of workers who commute using public transit, all of which were measured in the base year. Standard errors are clustered by CSA. Population weighting weighed observations by the tract population in the base year.
* p<0.10, ** p<0.05, *** p<0.01