Neighborhood Income Composition by Race and Income, 1990–2009

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Abstract

Residential segregation, by definition, leads to racial and socioeconomic disparities in neighborhood conditions. These disparities may in turn produce inequality in social and economic opportunities and outcomes. Because racial and socioeconomic segregation are not independent of each other, however, any analysis of their causes, patterns, and effects must rest on an understanding of the joint distribution of race/ethnicity and income among neighborhoods. In this article, we use a new technique to describe the average racial composition and income distributions in the neighborhoods of households with different income levels and race/ethnicity. Using data from the decennial censuses and the American Community Survey, we investigate how patterns of neighborhood context in the United States over the past two decades vary by household race/ethnicity, income, and metropolitan area. We find large and persistent racial differences in neighborhood context, even among households with the same annual income.

Introduction

For the last four decades, residential racial segregation in the United States has been slowly declining, yet it remains very high. At the same time, residential segregation by income, which was very low in 1970, has risen sharply (Logan 2011; Reardon and Bischoff 2011a; Watson 2009; Jargowsky 1996). Both of these trends are well-documented. Less well understood is how the two types of segregation interact. For example, how different are the neighborhoods of different race/ethnic groups with the same incomes? Does the decline in racial segregation coupled with the rise in income segregation lead to low-income black and Hispanic families living in higher or lower income neighborhoods than in the past?

Understanding the joint patterns of racial and socioeconomic segregation is important for two reasons. First, socioeconomic conditions may influence both neighborhood social processes and opportunities for social mobility. Income and racial segregation result in individuals of different socioeconomic backgrounds or different races/ethnicities living in neighborhoods that differ in their socioeconomic characteristics. To the extent that 1) segregation patterns lead to racial or socioeconomic disparities in neighborhood conditions and 2) neighborhood conditions affect opportunities and outcomes, it follows that segregation patterns may lead to racial or socioeconomic disparities in social mobility and well-being. Understanding racial disparities in neighborhood socioeconomic conditions is therefore essential to understanding how context shapes racial disparities in other dimensions.

Second, the policies and social forces that shape segregation do not shape racial and socioeconomic segregation independently. Indeed, racial and socioeconomic segregation patterns emerge from a complex interplay of many factors: racial disparities in income and wealth; racial differences in residential preferences, conditional on income; socioeconomic differences in residential preferences, conditional on race; the structure of the housing market; and patterns of racial prejudice and discrimination (Lareau and Goyette 2014; Krysan, Crowder and Bader 2014). Therefore, to fully understand the forces shaping racial and socioeconomic segregation patterns, it is necessary to consider

both together. Conventional descriptions of segregation, however, typically consider income and racial segregation separately.

Both of these concerns suggest the need for a detailed description of the joint patterns of racial and socioeconomic context. This article is a step toward that aim. In particular, our goal here is to describe trends and patterns in racial and socioeconomic differences in neighborhood context over the last two decades. We use a set of newly developed methods to do so.

Prior Research on Neighborhood Socioeconomic Composition

Neighborhoods in the United States vary widely in both racial and socioeconomic composition, among many other dimensions. Sociological theory posits that neighborhood socioeconomic composition (often operationalized as median income, poverty rates, or a composite measure called "concentrated disadvantage"), in particular, affects a number of educational, social, health, and political processes and outcomes (Sampson, Morenoff, and Gannon-Rowley 2002; Leventhal and Brooks-Gunn 2000). Moreover, economic context may affect individuals both directly and through a variety of secondary contextual factors that are shaped in part by economic conditions, including social norms, collective efficacy and social control, and exposure to violence (Sampson, Raudenbush, and Earls 1997; Sampson, Morenoff, and Gannon-Rowley 2002; Harding 2010; Sharkey 2010; Gorman-Smith and Tolan 1998). Empirical research on the effects of neighborhood socioeconomic conditions is somewhat mixed. Studies of the Moving to Opportunity (MTO) program found little effect of neighborhood poverty levels on many child and family outcomes (Ludwig et al. 2013). A growing body of evidence, however, suggests that long-term exposure to neighborhood poverty has strong effects on cognitive and educational outcomes and teen pregnancy (Chetty et al, 2015; Harding 2010; Sampson, Sharkey, and Raudenbush 2008).

Several studies have examined the joint patterns of neighborhood racial and socioeconomic conditions. Research on how economic segregation differs by race or ethnicity (see, for example,

Jargowsky 1996; Watson 2009; Reardon and Bischoff 2011a; Wodtke 2013; Wodtke, Harding, and Elwert 2011) shows that income segregation among blacks and Hispanics (e.g., the extent to which middle- and low-income blacks and Hispanics live near one another) is higher than among whites and has increased more rapidly than among whites (Reardon and Bischoff 2011a; Bischoff and Reardon 2014). This research, however, does not describe the extent to which members of different racial groups are exposed to high- or low-income neighbors, regardless of race.

More relevant to our purposes here is research that explicitly measures racial differences in the exposure of households of different racial/ethnic groups to neighbors of various income levels. Black and Hispanic households are located, on average, in neighborhoods where the poverty rate is significantly higher than that of non-Hispanic whites (Firebaugh and Farrell 2012; Logan 2011). In particular, predominantly black neighborhoods, regardless of socioeconomic composition, continue to be spatially isolated in areas of severe disadvantage (Sharkey 2014). These racial disparities in neighborhood socioeconomic conditions persist even when comparing households of the same income. Although low-income households of all races are located disproportionately in low-income neighborhoods, the patterns are more pronounced for black and Hispanic households (Fry and Taylor 2012; Lichter, Parisi, and Taquino 2012; Logan 2011). This pattern of racial neighborhood disadvantage extends into the upper income categories for black and Hispanic minority households (Sharkey 2014). Logan (2011), for example, shows that the average affluent (earning more than $75,000 year) black or Hispanic household is located in a poorer neighborhood than the average lower-income (earning less than $40,000) white household. In part, these patterns are a result of the fact that U.S. metropolitan areas are substantially segregated by race, even when controlling for family income (Massey and Fischer 1999; Iceland and Wilkes 2006).

This body of research clearly shows that black and Hispanic households are located in more disadvantaged neighborhoods than white households with roughly similar levels of income. Nonetheless, most of this research relies on relatively broad categories of income (“poor,” “middle-class,” “affluent”)

that are not exactly comparable over time. This imprecision in the categorization of income limits the possibility of detailed descriptions of trends and patterns in racial differences in neighborhood socioeconomic context. We use newly developed methods to provide much more detailed and comparable measures of neighborhood income exposure.

Measuring Segregation and Neighborhood Context

There are many ways of describing differences in socioeconomic conditions across neighborhoods. A number of studies measure segregation in terms of the extent to which households of different incomes are evenly distributed among neighborhoods (Jargowsky 1996; Reardon and Bischoff 2011b; Watson 2009; also see Owens 2015, this volume). The advantage of measuring segregation this way is that it characterizes the degree of segregation along a spectrum ranging from complete evenness (every neighborhood has the same income distribution as the population as a whole) to complete unevenness (no one lives in a neighborhood with any one of a different income level). One disadvantage of this approach, however, is that it does not provide any concrete characterization of the typical neighborhood context of a given type of household. Summary measures of segregation, such as the Jargowsky's Neighborhood Sorting Index (NSI), Reardon and Bischoff's rank-order information theory index (*H*), and Watson's Centile Gap Index (CGI) provide no disaggregated information about the neighborhoods in which households of different income levels are located. Another disadvantage of the evenness measures is that it is not clear that they are useful for simultaneously describing joint racial and socioeconomic segregation patterns; they typically are used to describe either income or racial segregation of the total population, or in each of several (racial/ethnic or income) groups.

An alternative is to characterize segregation in terms of the extent to which households of a given income level share neighborhoods with households of some other specific income level. The advantage of this approach is that it allows one to characterize the income distribution in the neighborhood of a typical

household of a specific type. For example, one might say that "the typical white, non-Hispanic household earning $28,000/year is located in a neighborhood where the median annual income is $39,500 and where the 10th and 90th percentiles of the income distribution are $11,700 and $83,200 per year." Such "exposure"-based approaches to measuring segregation are therefore both more concrete (because they describe the typical composition of neighborhoods) and more disaggregated or fine-grained (because they describe the typical neighborhoods of different types of households) than are summary evenness measures. Their drawback is that they do not provide a single summary statistic for describing segregation.[1]

Three features of publicly available census data hamper the measurement of income segregation. First, household income is reported categorically (in sixteen categories in the most recent census and the American Community Survey). Second, the number and location of the income categories have changed over time. And third, the income distribution itself changes over time (because of inflation or changing income inequality, for example), so that even stable income category definitions do not correspond to the same part of the income distribution at different times. These features pose a challenge for the consistent measurement of income segregation patterns. Existing research (e.g., Logan 2011; Massey and Fischer 2003) deals with these issues by trying to combine income categories into a small number of roughly comparable categories. We improve on this prior work by using smoothed interpolation methods and by measuring income in percentile ranks relative to the national income distribution.

Data

We use census tract household population counts from the 1990 and 2000 decennial censuses and the 2007–2011 American Community Survey (ACS; for convenience we refer to the ACS data as "2009"). The

[1] For more on the distinction between evenness and exposure-based approaches to measuring segregation, see Massey and Denton (1988).

data provide information on household characteristics, including income (measured categorically), race, and ethnicity (for details on the data see the appendix). We operationalize neighborhoods as tracts. Because census data typically do not provide full cross-tabulations of race/ethnicity by income, we use an iterative proportional fitting (IPF) algorithm to estimate tract-specific race-by-Hispanic-by-income category cross-tabulations (Beckman, Baggerly, McKay 1996) (for details see appendix).

Estimation of neighborhood income exposure measures

For each geographical area of interest (metropolitan areas, or the United States as a whole), our goal is to estimate a set of average cumulative distribution functions, each of which describes the average income distribution in the neighborhoods of those of a given income level and race/ethnicity. Because census data do not provide information on individuals' exact income or the exact income of their neighbors, we cannot observe these functions directly from the data. Instead, we estimate them from the parameters of a constrained multidimensional polynomial regression model (for details, see appendix; Reardon, Townsend, Fox 2014).

National patterns of neighborhood income composition

We begin by examining how average neighborhood income distributions vary as a function of one's own household income. Figure 1 provides a simple representation of this. Along the horizontal axis is a household's own income, expressed in terms of percentiles of the national household income distribution. On the vertical axis is median neighborhood household income, also expressed in terms of percentiles of the national income distribution. Both axes also show selected corresponding dollar figures (in 2008 dollars) for reference. The line indicates the median household income in the neighborhood of the average U.S. household at a given income level in 2009. For example, the average household with an income at the 25th percentile of the national income distribution (roughly $27,000) is located in a

neighborhood where the median household income is at the 43rd percentile of the national income distribution (roughly $43,000). Similarly, the average household with an income at the 75th percentile is located in a neighborhood where the median income is at the 56th percentile.

FIGURE 1

Neighborhood Median Income, by Household Income, All Households in United States, 2009

The steepness of the line in Figure 1 can be thought of as an intuitive measure of segregation: a flat line would mean there is no association between one's own income and the median income of one's neighborhood (i.e., all households are located, on average, in neighborhoods with the same median income); a steep line would imply a strong association. Note also that the slope of the line (averaged over the income range) has a theoretical maximum value of one. The average slope of the line in Figure 1 is roughly 0.3, which gives some sense of the magnitude of household income segregation in the United States relative to its theoretical maximum.

With this in mind, it is apparent from Figure 1 that segregation in the upper half of the income distribution is more pronounced than at the lower end: the neighborhoods where middle-class families live are more economically similar to those where the poor live than to those where the rich live. The difference in neighborhood median income between households at the 10th and 50th percentiles of the income distribution is 8.6 percentile points, compared to 15.6 percentile points between households at the 50th and 90th percentiles.[2] Thus, the segregation of the affluent is greater than the segregation of the poor, a finding consistent with prior research (Reardon and Bischoff 2011b; Bischoff and Reardon 2014). Note that this finding is not an artifact of using income percentiles; in fact, the difference in steepness would be even more pronounced if the Y-axis were scaled in terms of dollars or logged dollars,

[2] These numbers can be found in the appendix, Table A1.

rather than in terms of percentiles of the income distribution.[3]

The patterns in 1990 and 2000 (not shown in Figure 1, but reported in appendix Table A1) are very similar to those of 2009. Segregation of the poor declined modestly in the 1990s, by about 9 percent, and changed little in the 2000s. Segregation of the affluent declined as well in the 1990s, but only by 6 percent, before rebounding to its 1990 level in 2009.

The absence of substantial change in these patterns from 1990 to 2009 would seem to contradict the trend reported by Bischoff and Reardon (2014), who found that economic segregation increased by roughly 10 percent in the 2000s. There are three potential reasons for this discrepancy. First, Bischoff and Reardon describe average within–metropolitan area trends among the 117 largest metropolitan areas in the United States; our findings here, in contrast, describe trends in the nation as a whole. When we examine average within–metropolitan area trends (see Table 2), we find trends similar to Bischoff and Reardon's, at least with respect to the segregation of the affluent from the middle class. Second, Bischoff and Reardon report trends in income segregation among families; we report segregation among all households (families and nonfamily households combined). Owens (2014) finds that income segregation grew much more sharply from 1990 to 2009 among families with school-age children than among childless families and households; this suggests that the difference between our results and those of prior research may in part be due to differences in the trends among family and nonfamily households. Third, our trends are based on measures of exposure as opposed to the evenness measures that Bischoff and Reardon use, though this is unlikely to produce a substantial difference in trends.[4] The first two reasons

[3] To see this, note that the typical family at the 90th percentile of the income distribution is in a neighborhood with a median income of roughly $75,000, one-and-half times larger than the neighborhood median income (roughly $50,000) of typical family at the 50th percentile. The difference in neighborhood median incomes between families at the 10th and 50th percentiles of the income distribution is much smaller (median income is roughly $42,000 in poor families' neighborhoods, compared to $50,000 in middle-class families' neighborhoods).

[4] Trends in evenness and exposure measures of segregation tend to differ when the population composition changes over time (Reardon and Owens 2014). However, because we define income in percentile ranks, the population composition remains unchanged (a uniform distribution) across time, so evenness and exposure trends

likely account for the observed differences in trends.

National patterns of neighborhood racial composition

We next examine how the patterns evident in Figure 1 differ by race. First, however, it is informative to describe the typical racial composition of the neighborhoods of households of different races and incomes.[5] Figure 2 shows the average racial composition of the neighborhoods where households of different races and incomes reside. Each panel of the figure shows, for households of a given race, the average racial composition (summing to 100 percent on the vertical axis) of the neighborhoods of households of different income levels (on the horizontal axis).

FIGURE 2

Average Neighborhood Racial Composition, by Household Income and Race, 2009

Figure 2 makes evident that the racial composition of one's neighborhood depends much more on one's race than on one's income. Indeed, for all four racial/ethnic groups shown, the racial composition of neighborhoods depends remarkably little on one's household income. For example, white households—whether poor or affluent—are typically located in neighborhoods that are roughly 80 percent white. Black and Hispanic households, in contrast, are typically located in neighborhoods that are 40–50 percent white and 30–50 percent black or Hispanic. Even affluent black and Hispanic households typically are located in neighborhoods that are less than 50 percent white and that are 30–40 percent black or Hispanic. The patterns are similar for Asian households, which tend to locate in neighborhoods that are roughly 50–55 percent white and 20–25 percent Asian, regardless of income. In sum, Figure 2

are unlikely to differ substantially.

[5] Patterns of neighborhood racial composition for all households are shown in appendix Figure A1.

illustrates the severity of racial residential segregation in the U.S., even controlling for household income. These disparities in neighborhood racial composition foreshadow the economic disparities in neighborhood context discussed below.

Racial differences in average neighborhood income composition

Next, consider neighborhood socioeconomic composition by race and household income. The top panel of Figure 3 has the same axes as Figure 1, but shows one line for each race/ethnic group: Asian, white, Hispanic, and black. The panel below the figure indicates the proportion of the population made up of each group across the income distribution. The most notable feature of Figure 3 is that, conditional on having the same income, Asian and white households are typically located in neighborhoods with much higher median incomes than Hispanic and black households. The differences are substantial and relatively constant across the income distribution. This does not imply that all white and Asian households live in neighborhoods with higher median household incomes than all black and Hispanic households of the same income. On average, however, they do.

FIGURE 3

Neighborhood Median Income, by Household Income and Race, All Households in United States, 2009

One way to compare the neighborhood conditions of households of different racial/ethnic groups is to examine the vertical distance between the lines in Figure 3. Table 1 reports trends from 1990 to 2009 in specific values associated with the lines in Figure 3 (columns 1–4), as well as the vertical differences between the lines for each group and that of whites (columns 5–7). For Asians and whites at the 10th percentile of the national income distribution (i.e., those earning about $13,000/year), the median household income in their neighborhoods is above the 40th percentile of the national income

distribution in all three time periods (roughly $45–48,000/year in 2009), while it is around the 30th percentile (roughly $32,000) for blacks and 35th percentile ($36,000) for Hispanics. More directly: neighborhood median income for poor black and Hispanic households is roughly two-thirds that of equally poor white and Asian households.

Similar patterns hold for households at the 50th and 90th percentiles of the national income distribution. The largest absolute changes over time occurred for black households. Black households at the 10th percentile in 2009 are located in neighborhoods with median incomes almost 3 percentile points higher than in 1990. Similarly, for black households at the 50th percentile, neighborhood median income increased half of a percentile point, and for blacks at the 90th percentile, neighborhood median income increased over 3 percentile points since 1990. At the 10th percentile, all groups experienced positive change between 1990 and 2009.[6] At the 90th percentile, however, only blacks and Hispanics experienced an increase in neighborhood median income.

The final three columns of Table 1 quantify the differences in the neighborhood median incomes of blacks, Hispanics, and Asians with whites at various income levels. In general, the patterns evident in Figure 3 are stable across years: conditional on household income, black and Hispanic households are in neighborhoods with median incomes substantially lower than white households; Asian households are in higher-income neighborhoods. These patterns have changed relatively little over time, save for a moderate reduction in the white-black gap in neighborhood median incomes. For affluent black and white households, for example, the difference in neighborhood median income declined by a third (from 11 to 7 percentage points) between 1990 and 2009.

[6] It may seem logically impossible that all groups could live, on average, in higher-income neighborhoods in 2009 than in 1990, given that income is measured in percentile ranks. Nonetheless the patterns in Table 1 are real; they result from the facts that the Hispanic and (to a lesser extent) black shares of the population have grown, and these groups' incomes have risen modestly relative to whites. Given these trends, it is logically possible for all group median incomes to rise even while the national median income stays—as it must—exactly at the 50th percentile of the income distribution.

TABLE 1

Neighborhood Median Income, by Household Income and Race, 1990–2009

The steepness of the lines in Figure 3 indicates the degree of income segregation within each group. In the upper half of the income distribution, the degree of segregation is higher for all groups; the difference in neighborhood median income between the 90th and 50th percentile income households is at least 12 percentile points for all groups. The trends over time are consistent with those reported by Bischoff and Reardon (2014): we find that segregation in the upper half of the income distribution increased sharply among black households and modestly among Hispanic households from 2000–2009 (see Table A2 in the appendix for detail).

The level and steepness of the lines shown in Figure 3 give a sense of group differences in neighborhood conditions and segregation, conditional on household income. Another way to describe these differences is to examine the horizontal distance between the lines. Read this way, Figure 3 illustrates that blacks and Hispanics must have household incomes that are substantially higher than those of white or Asian households to live in neighborhoods with the same median income. For example, the income of a household at the 10th percentile of the national income distribution in 2009 is $11,800. Figure 3 shows that white households at this income level lived, on average, in neighborhoods where the median income was roughly $45,000. The income of black households that corresponds to this same average neighborhood median income level is roughly $60,000, five times the income of whites living in comparable neighborhoods. For Hispanic households, the corresponding income is roughly $45,000, 3.7 times that of whites. In other words, the average white household, earning $11,800, lives in a neighborhood with a similar income distribution to the average Hispanic household earning $45,000 and the average black household earning $60,000. Table A3 in the appendix shows these differences in more

detail; in particular, it shows that these disparities narrowed slightly in the 1990s, but grew again to their 1990 levels by 2009.

Metropolitan variation in average neighborhood income composition

The figures and tables thus far describe patterns of neighborhood socioeconomic composition in the United States as a whole. However, these patterns may differ substantially across the country because of differences in local income distributions and patterns of residential segregation. Figure 4 shows average neighborhood median income, by household income, for the ten largest U.S. metropolitan areas for 2009.[7] The lines in this figure are analogous to those in Figure 1, but are shown for each metropolitan area separately. Among these ten metropolitan areas, the lines vary considerably in both their levels and their slopes.

FIGURE 4

Metropolitan Variation in Neighborhood Median Income, by Household Income, Ten Largest Metropolitan Areas by Population, 2009

For example, note that households in the Washington-Arlington-Alexandria, DC-VA-MD-WV metropolitan area (henceforth referred to as Washington, DC) are located in neighborhoods with very high average median incomes, relative to similar income families in other large U.S. metropolitan areas. In fact, even the poorest households in Washington, DC, are typically located in neighborhoods where the average median income is above the 55th percentile of the national income distribution. In contrast, poor households in the Dallas, TX, metropolitan area are typically located in neighborhoods with lower median

[7] In our data, metropolitan areas are defined using metropolitan division codes, and these areas are ranked according to their total populations in 2010. For statistics on the largest fifty metropolitan areas, see appendix Table A4.

incomes than their similar income counterparts in other large metros. In part, this variation is a result of the fact that the income distributions vary considerably among metropolitan areas; there are comparatively few poor households in the Washington, DC metropolitan area; as a result, many of the poor there live in relatively middle-class neighborhoods. But metropolitan areas also vary considerably in the degree of income segregation. Note, for example, the steepness of the line for the Dallas metropolitan area in comparison to the flatness of the line for the Minneapolis-St. Paul metropolitan area: low-income households in Dallas are located in poorer neighborhoods than in any other of the largest ten metros, but high-income households in Houston are located in more affluent neighborhoods than their counterparts do in any other metropolitan area except Washington, DC.

Table 2 reports summary statistics for the 250 U.S. metropolitan areas with the largest household populations. In 2009, these metropolitan areas contained 78 percent of all households in the United States and 93 percent of all households in metropolitan areas. Table 2 shows the mean and standard deviation, across metropolitan areas, of neighborhood median income for the average 10th, 50th, and 90th percentile income households. The means are, on average, similar to the national means from appendix Table A1, but there is considerable variation among metropolitan areas. The standard deviation of the means ranges from 6.6 to 8.9 percentile points. In 2009, for example, the neighborhood median income of households with incomes at the 10th percentile of the national income distribution ranged from the 25th percentile (for metropolitan areas two standard deviations below the mean metropolitan area) to the 58th percentile (for those two standard deviations above the mean).

Table 2 also reports the average slope of the association between household and neighborhood income, using the 10th-to-50th and 50th-to-90th percentile differences as above. On average, the within metropolitan area 10th-to-50th percentile slopes are lower than the 50th-to-90th percentile slopes, but not by nearly so much as in the national patterns (compare to appendix Table A1). The variation across metropolitan areas is substantial in comparison to the average slope: in 2009 the 95 percent intervals of

the 10th-to-50th and 50th-to-90th slopes are (2.4, 13.4) and (3.0, 17.6), respectively. The association between household and neighborhood income is as much as six times greater in the most segregated metropolitan areas than in the least segregated areas. Average within-metropolitan area upper-tail income segregation appears to have increased significantly from 1990 to 2009, with most of this change happening since 2000, a trend that is consistent with the findings of Bischoff and Reardon (2014).

TABLE 2

Metropolitan Variation in Neighborhood Median Income, by Household Income, 250 Largest Metropolitan Areas by Population, 1990–2009

Table 3 disaggregates the information in Table 2 by race/ethnic group. Similar to Table 1, the first four columns report the average neighborhood median income, averaged across metropolitan areas, by race/ethnic group, year, and household income percentile. The means here are similar to those in Table 1, and are relatively stable across time, with the exception of significant increases of 1.6 and 4.0 percentile points in the neighborhood median incomes of low- and high-income black households, respectively, from 1990–2009. Note also that there is substantial variation among metropolitan areas in the average neighborhood median incomes, particularly for high-income households and non-white households. In other words, for high-income non-white households, one's exposure to high-income neighbors is very dependent on the metropolitan area in which one lives.

TABLE 3

Metropolitan Variation in Neighborhood Median Income, by Household Income and Race, 250 Largest Metropolitan Areas by Population, 1990–2009

The last three columns of Table 3 report the average black-white, Hispanic-white, and Asian-white differences in neighborhood median income. Across metropolitan areas, black households are typically located in neighborhoods where the median income is consistently 7 to 12 percentile points below that of similar income white households. For Hispanic households, the difference is generally 5 to 8 percentile points. These within-metropolitan area racial differences vary considerably among places. Indeed, there are some metropolitan areas where black and Hispanic households are typically located in neighborhoods with median incomes 20 to 30 percentile points lower than their similar income white counterparts. In other metropolitan areas, there are essentially no racial differences in neighborhood median income.

The pattern of white-Asian differences is particularly notable here. Recall that Figure 3 and Table 1 show that, nationally, the average Asian household is in a neighborhood with a significantly higher median income than a similar-income white household. Within metropolitan areas, however, this is not true, suggesting that much of the pattern evident in Figure 3 is due to the fact that Asian households, in general, are concentrated in metropolitan areas with high median incomes. Within the average metropolitan area, however, the typical low- or middle-income Asian household is in a neighborhood with slightly lower median income than the typical white household of the same income. For high-income households, there is little or no difference within metropolitan areas between white and Asian households in neighborhood median incomes.

Discussion

The findings described here are far from a complete description of how neighborhood income is associated with household income and race/ethnicity, and how these associations vary across place and time. Nonetheless, several key patterns are evident.

First, middle-class households are typically located in neighborhoods that are more similar to

those of low-income households than to those of high-income households. That is, high-income households are more segregated from middle-class and poor households than low-income households are from the middle class and the rich. This pattern is consistent with the findings in Reardon and Bischoff (2011b) and Bischoff and Reardon (2014).

Second, income segregation at the national level—at least as measured by the strength of the association between household and neighborhood median income—has changed little over the last two decades, even as income segregation within metropolitan areas grew by almost 10 percent during the 2000s (see Tables A1 and 2). This increase was driven entirely by the increase in the segregation of affluence. Recall that Bischoff and Reardon (2014)'s finding that both segregation of affluence and segregation of poverty grew by roughly 10 percent in the 2000s is based on measures of economic segregation among families. Because income segregation has increased much more among families with children than among households without children (Owens 2014), our household income segregation measures may not capture the trends in family segregation of poverty that Bischoff and Reardon (2014) described.

Third, there is substantial variation among metropolitan areas in these patterns of neighborhood economic composition. Our findings demonstrate that the income distribution in one's neighborhood is not only a function of one's own income, but also of the metropolitan area where one lives. Low-income households in the Washington, DC, or Minneapolis, MN, metropolitan areas, for example, are typically located in neighborhoods similar to those of middle- or higher-income households in Atlanta, GA, Los Angeles, CA, and other metropolitan areas. As a result, children growing up in poor households in metropolitan areas like Washington and Minneapolis may have, on average, more access to high-quality schools and other forms of opportunity than equally poor (or middle-class) children in metropolitan areas like Atlanta or Los Angeles. If neighborhood context affects opportunities for social mobility, this variation might help to explain some of the geographic variation in economic mobility rates that Chetty et al (2014)

have reported.

Fourth, even among households with the same annual income, there are sizable racial/ethnic differences in neighborhood income composition. Black middle-class households (with incomes of roughly $55–$60,000), for example, are typically located in neighborhoods with median incomes similar to those of very poor white households (those with incomes of roughly $12,000). For Hispanic households the disparity is only slightly smaller. Moreover, even high-income black and Hispanic households do not achieve neighborhood income parity with similar-income white households.

These large racial disparities in neighborhood income composition are at least partly due to patterns of racial segregation. As is evident in Figure 2, black and Hispanic middle-class households tend to be located in neighborhoods that contain much larger proportions of black and Hispanic residents, respectively, than the neighborhoods of similar-income white households. Because average black and Hispanic households' incomes are substantially lower than white households' incomes, racial residential segregation will tend to lead to disparities in neighborhood economic context. These patterns of racial and economic segregation are also partly due to racial differences in wealth. White households have, on average, greater wealth than black households (Oliver and Shapiro 2006), enabling them to afford housing in higher-income neighborhoods than similar-income black households. However, as Sharkey (2008) shows, wealth differences alone do not explain the disproportionate concentration of black households in high-poverty neighborhoods. Other factors, such as differences in household structure, lingering racial discrimination in the housing market, the location of affordable and subsidized housing, and residential preferences, likely also play a role (for a thorough discussion of the factors that lead to segregation, see Krysan, Crowder, and Bader 2014).

Fifth, some racial disparities in neighborhood income distributions, particularly the black-white disparity, appear to have narrowed modestly in the last two decades. Among low-income households, the black-white difference in neighborhood median income declined by more than 10 percent from 1990 to

2009; among high-income families it declined by one-third. Nationally, Hispanic-white differences in neighborhood median income widened in the 1990s and narrowed in the 2000s, resulting in only modest declines over the whole time period. Within metropolitan areas, however, Hispanic-white disparities increased, on average, by roughly 20 percent from 1990 to 2009, meaning that in many metropolitan areas, particularly those with smaller Hispanic populations, the gaps in neighborhood context grew substantially. These changes, however, are small relative to the magnitude of persistent racial inequality in neighborhood income distributions.

The racial disparities in neighborhood income distributions are particularly troubling because these are differences that are present even among households with the same incomes. If long-term exposure to neighborhood poverty negatively affects child development, educational success, mental health, and adult earnings (and a growing body of research suggests it does, as noted above), then these large racial disparities in exposure to poverty may have long-term consequences. They mean that black and Hispanic children and families are doubly disadvantaged—both economically and contextually—relative to white and Asian families. Not only do black and Hispanic households have lower average incomes than do white and Asian households, but their lower incomes do not—for reasons beyond the scope of this article—result in access to the same neighborhoods as those of equally low-income white households.

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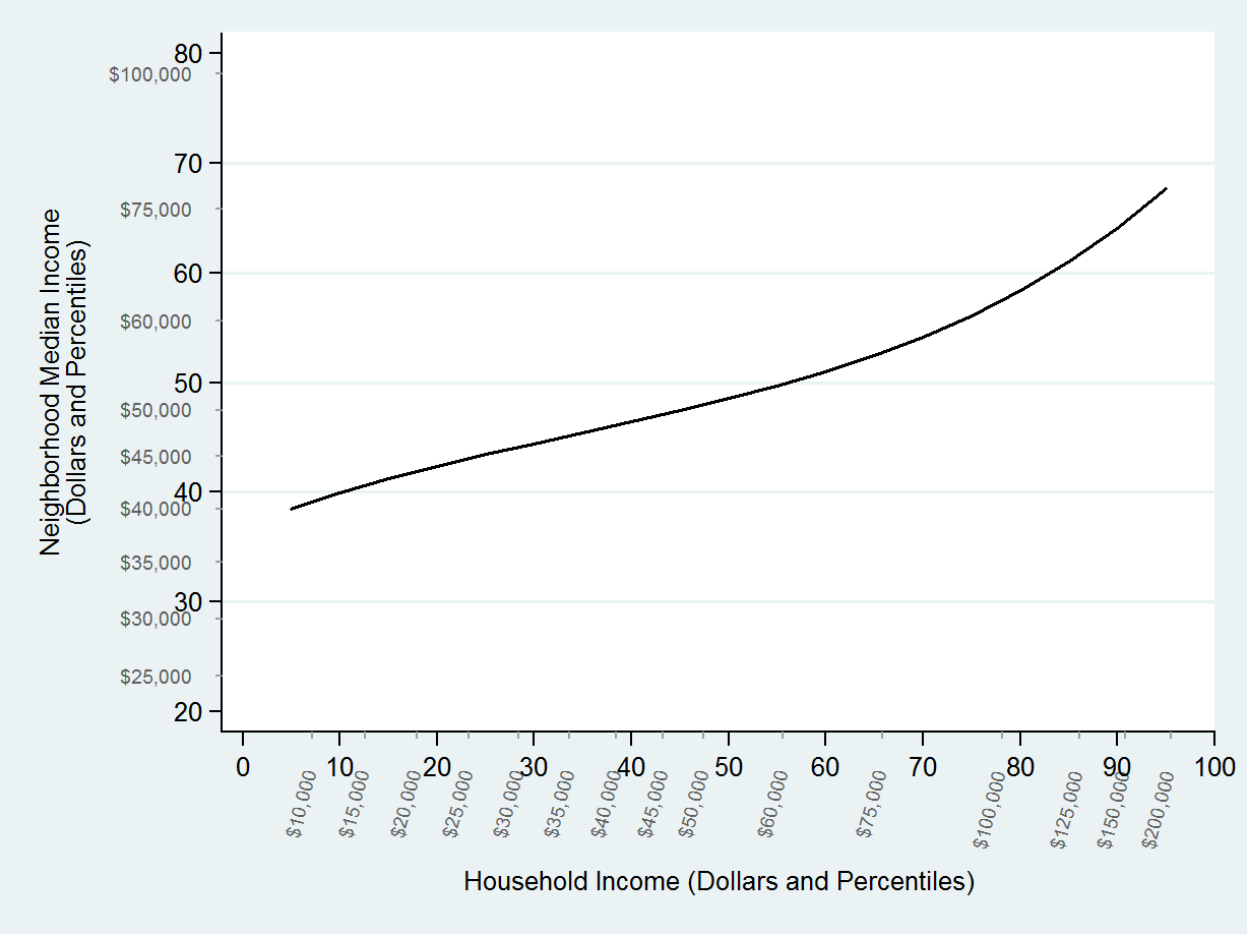
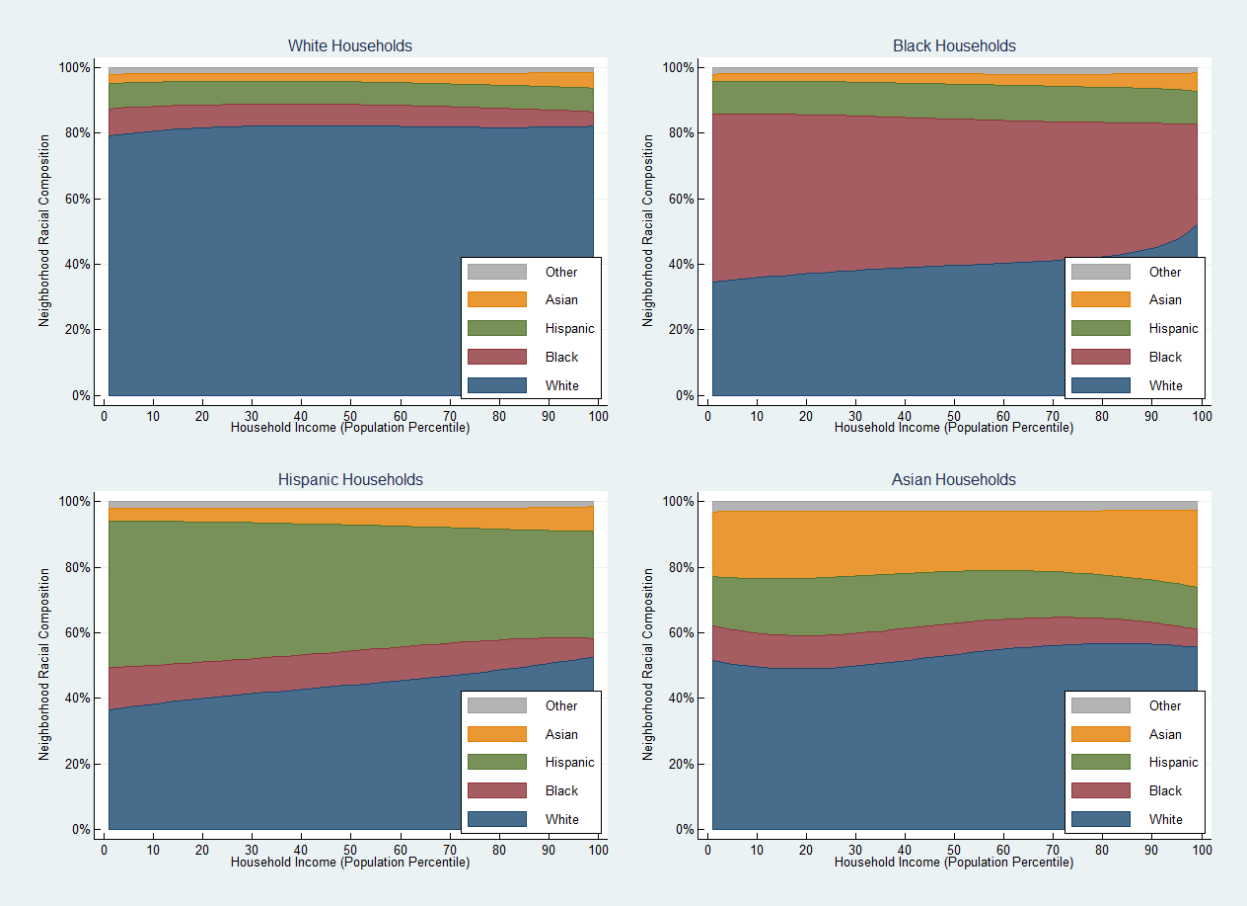
Figure 1. Neighborhood Median Income, by Household Income, All Households in U.S., 2009



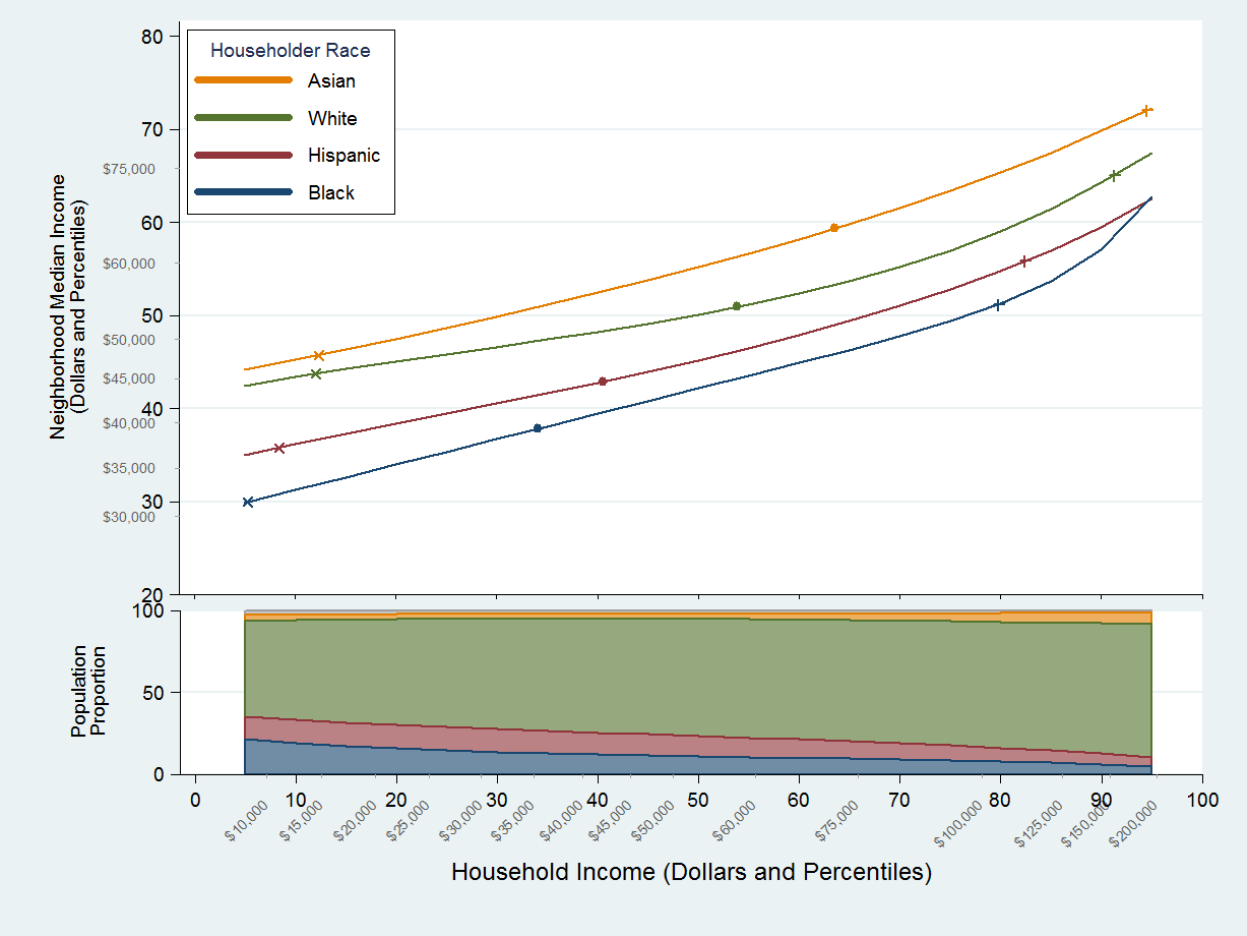
Note. Figure 1 presents neighborhood median household income, conditional on own household income, for all households in the U.S. for the year 2009 (actually the average of years 2007-2011). The *x*-axis indicates household income; the *y*-axis indicates median household income in the neighborhood of a typical household of a given income. For both axes, the percentiles and dollar figures are taken from the national household income distribution. As an example of how to read the table, consider households earning $60,000/year (roughly the 56th percentile of the household income distribution). Such households live, on average, in neighborhoods where the median household income is about $53,000, roughly the 50th percentile of the national household income distribution.

Figure 2. Average Neighborhood Racial Composition, by Household Income and Race, 2009



Note. Figure 2 presents neighborhood racial composition, conditional on income, separately for households of each of four racial groups. The *x*-axis indicates household income (measured in each figure in terms of percentiles of the national income distribution of all households); the *y*-axis describes average neighborhood racial composition. As an example of how to read the table, consider a white household (top left) at the 50th percentile of the national income distribution. For this household, the neighborhood is comprised of roughly 1 percent Other, 2 percent Asians, 8 percent Hispanics, 7 percent blacks, and 82 percent whites.

Figure 3: Neighborhood Median Income, by Household Income and Race, All Households in U.S., 2009



Note. The top panel of Figure 3 shows neighborhood median household income, conditional on own household income and race/ethnicity, for all households in the U.S. for the year 2009. The *x*-axis is own household income; the *y*-axis is neighborhood median household income. For both axes, the percentiles and dollar figures are taken from the national household income distribution. The markers on the lines indicate the 10th, 50th, and 90th percentiles of each racial/ethnic group's household income distribution. The bottom panel shows the national population racial composition, by household income. As an example of how to read the table, consider White households at the 50th percentile of the national white household income distribution (shown by the green circular marker). The *x*-axis indicates that such households earn roughly $60,000, and are at the 56th percentile of the national income distribution. The *y*-axis indicates that such families live, on average, in neighborhoods where the median income is about $55,000, slightly above the median of the national distribution. The bottom line of the figure indicates that black households earning the same $60,000 typically live in neighborhoods whose median income is about $45,000, roughly the 43rd percentile of the national income distribution. Finally, the bottom panel shows that, among households earning $60,000, roughly 10% are black, 10% are Hispanic, 75% are white, and 5% are Asian.

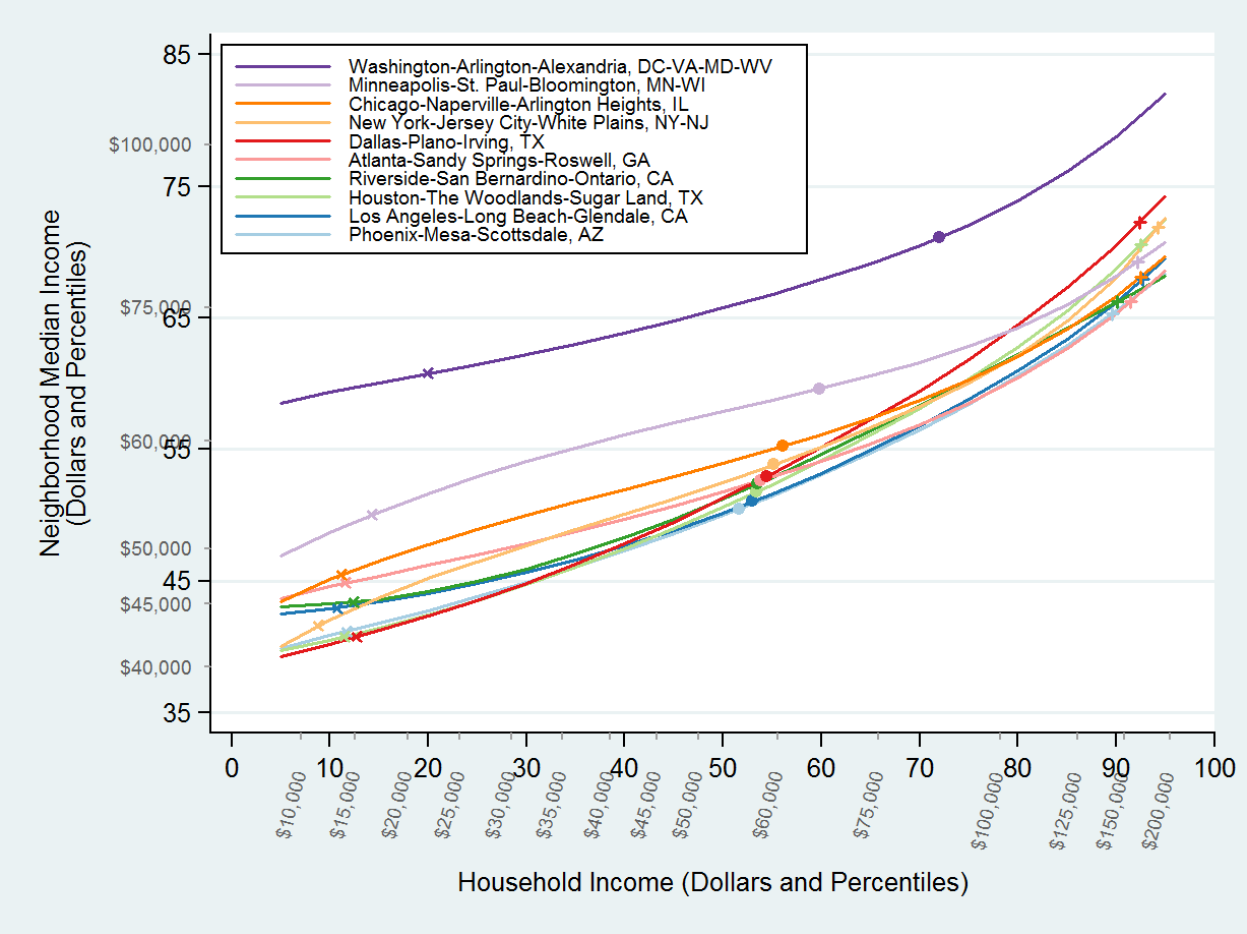
Table 1. Neighborhood Median Income, by Household Income and Race, 1990-2009

Neighborhood Median Income, by Household Income and Race, 1990-2009

	Neighborhood Median Income				Difference from White		
Households at 10th Percentile Income	White	Black	Hispanic	Asian	Black	Hispanic	Asian
1990	42.2	28.4	34.5	42.5	-13.8	-7.7	0.3
2000	43.3	31.0	35.2	43.4	-12.3	-8.1	0.1
2009	43.4	31.3	36.2	45.3	-12.1	-7.2	1.9
Change, 1990-2009	1.2	2.9	1.6	2.8	1.7	0.5	1.6
Households at 50th Percentile Income	White	Black	Hispanic	Asian	Black	Hispanic	Asian
1990	50.0	41.7	45.1	55.2	-8.3	-4.9	5.3
2000	50.2	41.7	44.2	54.4	-8.6	-6.1	4.2
2009	50.1	42.2	45.2	55.2	-7.9	-4.9	5.1
Change, 1990-2009	0.1	0.5	0.1	0.0	0.4	0.0	-0.1
Households at 90th Percentile Income	White	Black	Hispanic	Asian	Black	Hispanic	Asian
1990	64.8	53.8	59.1	70.2	-10.9	-5.7	5.5
2000	64.2	53.7	56.7	69.1	-10.5	-7.5	4.9
2009	64.3	57.1	59.5	69.8	-7.2	-4.8	5.6
Change, 1990-2009	-0.5	3.2	0.4	-0.4	3.7	0.9	0.1

Note. Table 1 reads, for example, "White households at the 10th percentile of the national income distribution in 1990 lived in neighborhoods where the median income was at the 42.2 percentile of the national income distribution. In 1990, black households at the 10th percentile of the national income distribution lived in neighborhoods where the median income was 13.8 percentile points lower than that of white households with incomes at the 10th percentile of the national income distribution."

Figure 4: Metropolitan Variation in Neighborhood Median Income, by Household Income, Ten Largest Metropolitan Areas by Population, 2009



Note. Figure 4 is analogous to Figure 1, but shows a separate line for each of the ten largest U.S. metropolitan areas. It presents neighborhood median household income, conditional on own household income, by metropolitan area for the year 2009. The *x*-axis indicates household income; the *y*-axis indicates median household income in the neighborhood of a typical household of a given income. For both axes, the percentiles and dollar figures are taken from the national household income distribution (not from each metropolitan area). The markers on the lines indicate the 10th, 50th, and 90th percentiles of each metropolitan area's own household income distribution. As an example of how to read the figure, consider households in Minneapolis-St. Paul Bloomington, MN-WI at the 60th percentile of the national income distribution (roughly $66,000). These households typically live in neighborhoods of the Minneapolis-St Paul metropolitan area with median incomes of roughly $64,000, about the 59th percentile of the national income distribution.

Table 2. Metropolitan Variation in Neighborhood Median Income, by Household Income, 250 Largest Metropolitan Areas by Population, 1990-2009

Metropolitan Variation in Neighborhood Median Income, by Household Income, 250 Largest Metropolitan Areas by Population, 1990-2009

		Neighborhood Median Income			Difference in Neighborhood Median Income	
Year		Households at 10th Percentile Income	Households at 50th Percentile Income	Households at 90th Percentile Income	Between 10th and 50th Percentiles	Between 50th and 90th Percentiles
1990	Mean	41.7	49.4	58.8	7.7	9.3
	(Standard Deviation)	(8.2)	(7.5)	(8.9)	(3.2)	(3.5)
2000	Mean	42.2	49.7	58.8	7.5	9.1
	(Standard Deviation)	(7.5)	(7.1)	(8.5)	(2.9)	(3.5)
2009	Mean	41.5	49.3	59.7	7.9	10.3
	(Standard Deviation)	(7.4)	(6.6)	(7.9)	(2.8)	(3.7)
Change in Mean 1990-2009		-0.2	-0.1	0.9	0.1	1.0**
Change in SD 1990-2009		-0.7	-0.9	-1.1	-0.4	0.2

Note. Each cell in Table 2 is computed by first estimating, within each of the largest 250 metropolitan areas, the neighborhood median income for households at a given percentile of the national income distribution. The cells show the (unweighted) mean and standard deviation of these metropolitan area-specific neighborhood median incomes. The upper left cells of the table, for example, are read as follows: "In the average metropolitan area in 1990, households at the 10th percentile of the national income distribution live, on average, in neighborhoods where the median income is at the 41.7th percentile of the national income distribution. The standard deviation (across metropolitan areas) of neighborhood median income for 10th percentile households is 8.2 percentile points." Similarly, the cells in the top of the fourth column read "In the average metropolitan area in 1990, households at the 50th percentile of the national income distribution live in neighborhoods where the median income is 7.7 percentile points higher than that of households at the 10th percentile of the national income distribution. The standard deviation of this difference is 3.2 percentile points." Stars on the estimated changes in means indicate the *p*-value associated with the *t*-test of the null hypothesis that the average change in means from 1990-2009 was zero (*** p<0.001 ** p<0.01 * p<0.05).

Table 3. Metropolitan Variation in Neighborhood Median Income, by Household Income and Race, 250 Largest Metropolitan Areas by Population, 1990-2009

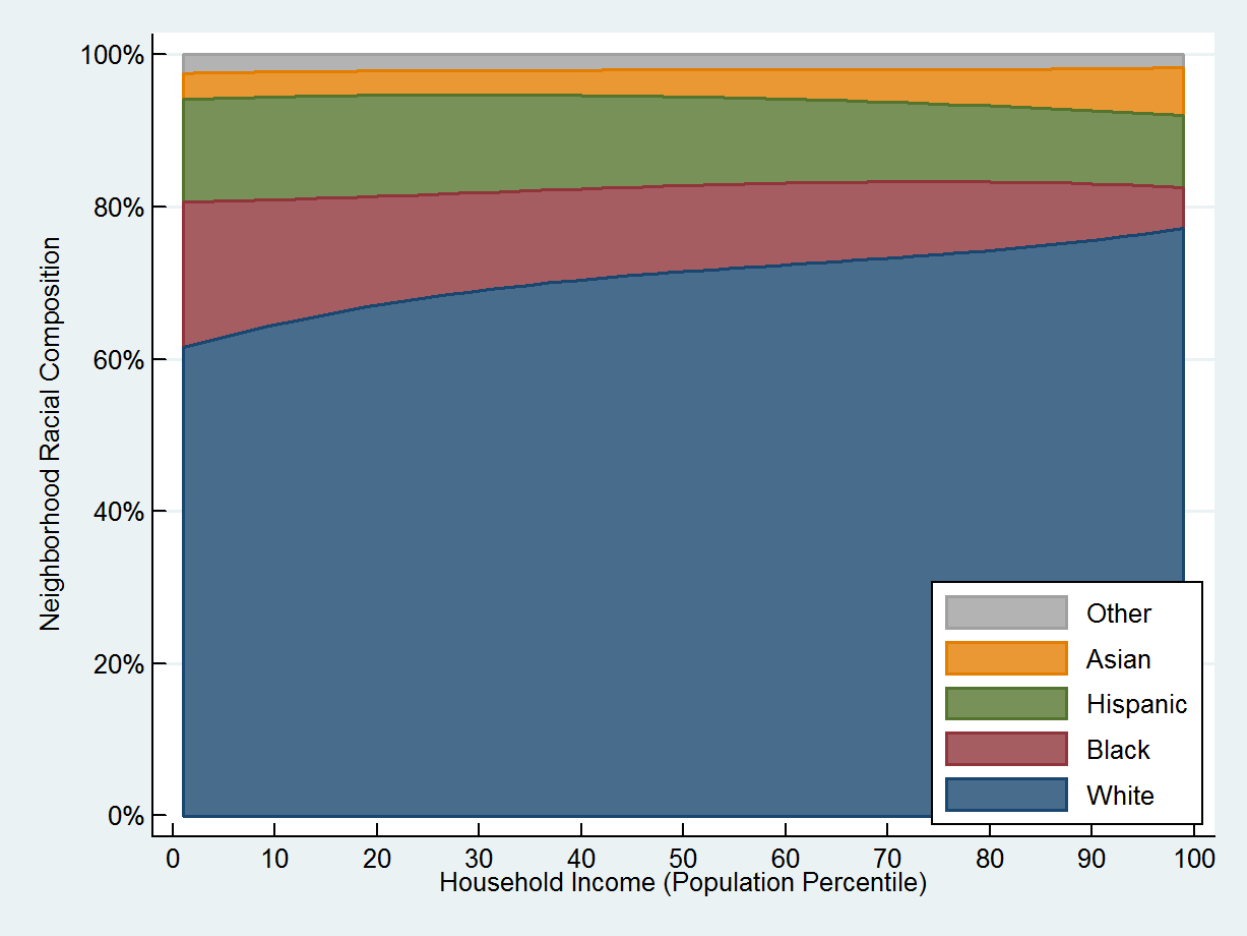
Metropolitan Variation in Neighborhood Median Income, by Household Income and Race, 250 Largest Metropolitan Areas by Population, 1990-2009

		Neighborhood Median Income				Difference from White		
Households at 10th Percentile Income		White	Black	Hispanic	Asian	Black	Hispanic	Asian
1990	Mean	45.0	32.7	38.3	41.4	-12.3	-6.6	-3.5
	(Standard Deviation)	(8.3)	(9.0)	(8.5)	(11.2)	(7.0)	(6.9)	(7.7)
2000	Mean	45.7	34.3	38.5	41.2	-11.4	-7.2	-4.5
	(Standard Deviation)	(7.6)	(8.2)	(7.7)	(9.8)	(6.3)	(5.9)	(6.0)
2009	Mean	45.5	34.3	37.7	41.3	-11.3	-7.9	-4.2
	(Standard Deviation)	(7.8)	(8.1)	(7.3)	(9.8)	(6.3)	(5.7)	(6.2)
Change in Mean, 1990-2009		0.6	1.6*	-0.7	-0.1	1.0	-1.2*	-0.7
Change in SD, 1990-2009		-0.5	-0.9	-1.2	-1.4	-0.7	-1.2	-1.5
Households at 50th Percentile Income		White	Black	Hispanic	Asian	Black	Hispanic	Asian
1990	Mean	51.0	41.5	45.8	49.2	-9.6	-5.2	-1.9
	(Standard Deviation)	(7.5)	(8.2)	(7.0)	(8.8)	(5.9)	(5.6)	(5.7)
2000	Mean	51.5	42.1	44.8	49.2	-9.4	-6.7	-2.3
	(Standard Deviation)	(7.3)	(7.5)	(6.5)	(8.0)	(5.2)	(4.8)	(4.1)
2009	Mean	51.6	42.3	44.7	50.3	-9.3	-6.9	-1.3
	(Standard Deviation)	(7.0)	(7.8)	(6.2)	(7.8)	(5.4)	(4.7)	(4.8)
Change in Mean, 1990-2009		0.6	0.8	-1.1	1.1	0.3	-1.7***	0.5
Change in SD, 1990-2009		-0.5	-0.5	-0.9	-0.9	-0.5	-0.9	-0.9
Households at 90th Percentile Income		White	Black	Hispanic	Asian	Black	Hispanic	Asian
1990	Mean	59.1	49.0	54.4	59.9	-10.1	-4.8	0.8
	(Standard Deviation)	(9.2)	(12.5)	(11.1)	(11.9)	(9.9)	(8.7)	(7.7)
2000	Mean	59.7	50.5	53.9	59.1	-9.2	-5.8	-0.6
	(Standard Deviation)	(8.7)	(10.0)	(8.8)	(9.4)	(9.3)	(6.9)	(4.8)
2009	Mean	60.2	53.0	55.2	60.3	-7.2	-5.0	0.1
	(Standard Deviation)	(8.1)	(11.2)	(10.9)	(9.6)	(8.7)	(7.9)	(6.1)
Change in Mean, 1990-2009		1.1	4.0***	0.8	0.4	2.9***	-0.3	-0.7
Change in SD, 1990-2009		-1.0	-1.2	-0.2	-2.2	-1.2	-0.8	-1.6

Note. Each cell in Table 3 is computed by first estimating, within each of the largest 250 metropolitan areas, the neighborhood median income for households of a given race/ethnicity at a given percentile of the national income distribution. The cells show the (unweighted) mean and standard deviation of these metropolitan area-specific neighborhood median incomes. See note below Table 2 for example of how to read the table. Stars on the estimated changes in means indicate the *p*-value associated with the *t*-test of the null hypothesis that the average change in means from 1990-2009 was zero (*** p<0.001 ** p<0.01 * p<0.05).

Appendix A. Additional Figures and Tables

Figure A1. Average Neighborhood Racial Composition, by Household Income, 2009



Note. Figure A1 describes the average neighborhood racial composition, conditional on income, for all households in 2009. The *x*-axis indicates household income; the *y*-axis indicates the average racial composition of neighborhoods. As an example of how to read the table, consider households at the 50th percentile of the national income distribution. Such households live, on average, in neighborhood comprised of roughly 2 percent Other, 4 percent Asians, 11 percent Hispanics, 11 percent blacks, and 72 percent whites.

Table A1. Neighborhood Median Income, by Household Income, 1990-2009

Neighborhood Median Income, by Household Income, 1990-2009

	Neighborhood Median Income			Difference in Neighborhood Median Income	
Year	Households at 10th Percentile	Households at 50th Percentile	Households at 90th Percentile	Between 10th and 50th Percentiles	Between 50th and 90th Percentiles
1990	39.0	48.7	64.5	9.7	15.8
2000	40.0	48.8	63.5	8.8	14.8
2009	39.9	48.5	64.1	8.6	15.6
Change, 1990-2009	0.9	-0.2	-0.4	-1.1	-0.2

Note. Table A1 reads, for example, as follows: "Households at the 10th percentile of the national income distribution in 1990 lived in neighborhoods where the median income was at the 39th percentile of the national income distribution." "In 1990, households at the 50th percentile of the national income distribution lived in neighborhoods where the median income was 9.7 percentile points higher than households at the 10th percentile of the national income distribution."

Table A2. Difference in Neighborhood Median Income, by Race, Various Income Percentiles, 1990-2009

Difference in Neighborhood Median Income, by Race, Various Income Percentiles, 1990-2009

	Difference in Neighborhood Median Income				Difference from White		
Difference Between Households at the 10th and 50th Percentiles of the Income Distribution	White	Black	Hispanic	Asian	Black	Hispanic	Asian
1990	7.8	13.3	10.6	12.7	5.5	2.8	4.9
2000	6.9	10.7	9.0	11.0	3.7	2.0	4.1
2009	6.7	10.9	9.0	10.0	4.2	2.3	3.3
Change, 1990-2009	-1.1	-2.4	-1.6	-2.7	-1.3	-0.5	-1.7
Difference Between Households at the 50th and 90th Percentiles of the Income Distribution	White	Black	Hispanic	Asian	Black	Hispanic	Asian
1990	14.8	12.1	14.0	15.0	-2.7	-0.8	0.2
2000	14.0	12.0	12.6	14.6	-2.0	-1.4	0.7
2009	14.2	14.9	14.3	14.6	0.7	0.1	0.4
Change, 1990-2009	-0.6	2.7	0.3	-0.4	3.4	1.0	0.2

Note. The first four columns of Table A2 read, for example, as follows: "White households at the 50th percentile of the national income distribution in 1990 live in neighborhoods where the median income is 7.8 percentile points higher than white households at the 10th percentile of the national income distribution." These differences can be interpreted as the average slopes, between specific percentiles, of the lines shown in Figure 3, and so are measures of within-race group income segregation. The last three columns describe the racial differences in these slopes. The read, for example, as follows: "In 1990, the difference in the difference between white and black households at the 50th and 10th percentiles of the national income distribution was 5.5 percentile points."

Table A3. Household Income Required to Have a Neighborhood Median Income Equivalent to that of White Households' of Various Income Percentiles, by Race, 1990-2009

Household Income Required to Have a Neighborhood Median Income Equivalent to that of White Households of Various Income Percentiles, by Race, 1990-2009

		Income Required (Relative to White)		
Year	10th Percentile of Income Distribution	Black	Hispanic	Asian
1990	$10,761	5.0	3.7	0.9
2000	$13,557	4.8	3.5	1.0
2009	$11,822	5.0	3.7	n/c
Change, 1990-2009		-0.1	0.0	n/c

Year	50th Percentile of Income Distribution	Black	Hispanic	Asian
1990	$51,413	2.0	1.5	0.7
2000	$52,208	2.0	1.7	0.8
2009	$52,537	1.8	1.5	0.6
Change, 1990-2009		-0.2	0.0	-0.1

Year	90th Percentile of Income Distribution	Black	Hispanic	Asian
1990	$127,680	n/c	n/c	0.7
2000	$136,282	n/c	n/c	0.7
2009	$146,243	n/c	n/c	0.7
Change, 1990-2009		n/c	n/c	0.0

Note. Table A3 indicates at what income level households of a given race/ethnicity live, on average, in neighborhoods with the same median income as do white households at the specified percentile of the income distribution. Values greater than one indicate that the non-white group requires a higher income than white households to have the same neighborhood median income. The top row, for example, indicates that in 1990, the 10th percentile of the income distribution was $10,761. In that year, black households with incomes 5.0 times that amount (roughly $54,000) lived, on average, in neighborhoods with median income equal to that of the neighborhoods of white households with incomes of $10,761. "n/c" indicates that the value could not be computed because it is below the 1st or exceeds the 99th percentile of the income distribution.

Table A4. Metropolitan Variation in Differences in Neighborhood Median Income, for Various Percentiles of Own Income, by Race, 50 Largest Metropolitan Areas by Population, 1990-2009

Metropolitan Variation in Differences in Neighborhood Median Income, for Various Percentiles of Own Income, by Race, 50 Largest Metropolitan Areas by Population, 2009

	Neighborhood Median Income			Difference in Neighborhood Median Income	
Metropolitan Area	Households at 10th Percentile Income	Households at 50th Percentile Income	Households at 90th Percentile Income	Between 10th and 50th Percentiles	Between 50th and 90th Percentiles
New York-Jersey City-White Plains, NY-NJ	42.1	52.5	68.0	10.4	15.6
Los Angeles-Long Beach-Glendale, CA	42.9	50.2	66.2	7.3	16.0
Chicago-Naperville-Arlington Heights, IL	45.1	53.9	66.6	8.8	12.7
Houston-The Woodlands-Sugar Land, TX	40.5	50.6	68.7	10.1	18.1
Atlanta-Sandy Springs-Roswell, GA	44.6	51.8	65.3	7.2	13.5
Washington-Arlington-Alexandria, DC-VA-MD-WV	59.4	65.7	78.8	6.4	13.0
Dallas-Plano-Irving, TX	40.2	51.3	70.5	11.1	19.2
Riverside-San Bernardino-Ontario, CA	43.2	51.2	66.2	8.0	15.0
Phoenix-Mesa-Scottsdale, AZ	40.8	50.0	65.5	9.2	15.5
Minneapolis-St. Paul-Bloomington, MN-WI	48.7	57.9	68.2	9.2	10.3
San Diego-Carlsbad, CA	49.2	54.1	69.6	4.9	15.5
Anaheim-Santa Ana-Irvine, CA	58.8	60.5	74.4	1.7	13.9
Nassau County-Suffolk County, NY	69.3	72.2	76.4	2.9	4.1
St. Louis, MO-IL	41.1	50.4	63.3	9.3	12.9
Tampa-St. Petersburg-Clearwater, FL	38.1	44.8	56.7	6.7	11.9
Baltimore-Columbia-Towson, MD	46.6	58.1	71.9	11.5	13.8
Seattle-Bellevue-Everett, WA	52.7	59.6	70.0	6.9	10.4
Oakland-Hayward-Berkeley, CA	52.4	59.8	74.9	7.3	15.1
Denver-Aurora-Lakewood, CO	44.3	53.3	70.2	9.1	16.9

Miami-Miami Beach-Kendall, FL	33.6	42.8	58.2	9.3	15.4
Warren-Troy-Farmington Hills, MI	46.6	53.6	66.6	7.0	13.0
Newark, NJ-PA	50.0	61.5	75.0	11.4	13.5
Pittsburgh, PA	38.8	46.4	58.4	7.6	12.0
Cambridge-Newton-Framingham, MA	56.2	62.6	72.0	6.4	9.5
Portland-Vancouver-Hillsboro, OR-WA	46.5	52.4	62.0	5.9	9.6
Charlotte-Concord-Gastonia, NC-SC	40.8	48.5	62.9	7.7	14.4
Fort Worth-Arlington, TX	42.0	51.0	66.6	9.0	15.6
Sacramento--Roseville--Arden-Arcade, CA	46.6	53.4	66.5	6.8	13.2
San Antonio-New Braunfels, TX	37.1	46.8	64.5	9.7	17.7
Orlando-Kissimmee-Sanford, FL	41.8	46.9	58.3	5.1	11.4
Cincinnati, OH-KY-IN	39.8	50.8	63.9	11.0	13.1
Philadelphia, PA	32.3	42.1	58.2	9.7	16.1
Cleveland-Elyria, OH	35.5	47.2	61.2	11.7	14.0
Kansas City, MO-KS	40.9	51.4	67.2	10.5	15.8
Las Vegas-Henderson-Paradise, NV	43.2	51.1	63.1	8.0	12.0
Montgomery County-Bucks County-Chester County, PA	60.4	64.3	74.0	4.0	9.7
Columbus, OH	38.4	49.4	66.6	10.9	17.3
Indianapolis-Carmel-Anderson, IN	38.7	48.8	64.6	10.1	15.8
Boston, MA	50.3	59.3	69.1	9.1	9.8
San Jose-Sunnyvale-Santa Clara, CA	65.0	67.8	78.4	2.8	10.6
Detroit-Dearborn-Livonia, MI	30.8	41.6	60.3	10.7	18.7
Fort Lauderdale-Pompano Beach-Deerfield Beach, FL	40.0	47.7	63.0	7.7	15.3
Austin-Round Rock, TX	42.0	52.7	68.7	10.7	16.0
Virginia Beach-Norfolk-Newport News, VA-NC	45.1	53.3	65.3	8.2	12.0
Nashville-Davidson--Murfreesboro--Franklin, TN	39.9	48.5	62.7	8.6	14.2
Providence-Warwick, RI-MA	42.7	52.2	63.0	9.6	10.7
Milwaukee-Waukesha-West Allis, WI	37.7	50.0	65.1	12.3	15.1
San Francisco-Redwood City-South San Francisco, CA	55.1	65.1	74.8	10.0	9.7

Jacksonville, FL	41.9	49.7	60.8	7.7	11.1
Memphis, TN-MS-AR	33.0	45.9	62.9	13.0	17.0

Note. Table A4 reads, for example, "Households at the 50th percentile of the national income distribution in 2009 who live in the New York metropolitan area live in neighborhoods where the median income is the 52.5th percentile of the national income distribution. In the New York metropolitan area, the difference in neighborhood median income between the average household at the 10th and 50th percentiles of the income distribution is 10.4 percentile points."

Appendix B. Census and American Community Survey Data

We use data from the 1990 and 2000 decennial censuses as well as the 2007-2011 American Community Survey (ACS). For both sources, we utilize tract-level data. We refer to the ACS data as 2009 data, the middle year of the 5-year time period during which the data were collected. The variables that are pertinent to our analyses include counts of households in various income and racial/ethnic categories.

Both the census and ACS data provide estimates of the number of people of a race/ethnicity in a given income category by tract, but the income categories in the data vary by year. In 1990, income by race/ethnicity is reported in nine categories: less than $5,000; $5,000-$9,999; $10,000-$14,999; $15,000-$24,999; $25,000-$34,999; $35,000-$49,999; $50,000-$74,999; $75,000-$99,999; $100,000 or more. For 2000 and 2009, income by race/ethnicity is reported in 16 categories: less than $10,000; $10,000-$14,999; $15,000-$19,999; $20,000-$24,999; $25,000-$29,999; $30,000-$34,999; $35,000-$39,999; $40,000-$44,999; $45,000-$49,999; $50,000-$59,999; $60,000-$74,999; $75,000-$99,999; $100,000-$124,999; $125,000-$149,999; $150,000-$199,999; $200,000 or more.

Race/ethnicity categories are mostly uniform across the census and ACS data. In 1990, the race categories include American Indian or Eskimo or Aleut, Asian or Pacific Islander, Black, White, and other. For 2000 and 2009, the race categories include Asian, Black, Native American or Alaska Native, Pacific Islander, White, multi-race, and other. To simplify the race categories, American Indian is collapsed into the other category in 1990, and in 2000 and 2009, we add the Pacific Islander category to Asian, and add Native American or Alaska Native and multi-race to the other category. The only ethnicity categories across all waves of data are Hispanic and Non-Hispanic Whites, but the latter is not available in 1990.

While the race categories are mutually exclusive, the proportion of Hispanic and Non-Hispanic within a race is unknown (with the exception of Whites in 2000 and 2009: we can determine Hispanic Whites by subtracting Non-Hispanic White counts from White). To execute our methodology properly, we need to divide the income data in mutually exclusive groups. We therefore need a cross-tabulation of

race by ethnicity to generate five mutually exclusive race/ethnicity categories: non-Hispanic Asian, non-Hispanic Black, Hispanic, non-Hispanic White, and non-Hispanic other, where the Hispanic group includes Hispanics of any race. To estimate these cross-tabulations, we use an iterative proportional fitting (IPF) process, which requires that we have a (higher-level geography) secondary data source with the desired cross-tabulations. This process is described in Appendix C below.

We use Public Use Microdata Sample (PUMS) data to provide this secondary estimate (Ruggles 2010). PUMS data include survey responses from a 5% sample of the population across Public Use Microdata Areas (PUMAs). Like the census and ACS data, PUMS data is available for each year that we wish to estimate exposure measures, contains race and ethnicity data by household, and provides household income estimates; unlike the census and ACS data, PUMS data allows for the disaggregation of race counts into Hispanic and Non-Hispanic categories for all years and all races. Using PUMA-tract crosswalks generated at each decennial census, we link PUMS data to tract-level household income data. PUMAs generally have 100,000 people in them, and as such, are considerably larger than tracts. Despite this drawback, PUMAs do provide household income data by race and Hispanic status, and we are able to match over 99% of tracts to PUMAs.

Appendix C. Iterative Proportional Fitting (IPF) Procedures

Our problem is a common one for researchers wanting to analyze data for small geographic areas: we seek to estimate mutually exclusive race/ethnicity by income counts at the tract-level but have incomplete data, while we have complete data at a larger geographic area, the PUMA. One relatively straightforward way to overcome this challenge is to use a technique called Iterative Proportional Fitting (IPF).

IPF is a heuristic method that begins with a known cross-tabulation at a higher level of geography and then adjusts it so that it conforms to known marginal (univariate) distributions for a lower level of geography. In our case, we have race-by-Hispanic-by-income cross-tabulations at the PUMA level, but only race marginals and Hispanic marginals for each income category in the Census data. We therefore perform the IPF process to construct a race-by-Hispanic cross-tabulation separately for each income category in each census tract. The procedure we carried out is described in detail below.

The first step of the procedure is to seed, or start, the census tract table with PUMA-level data that is proportional to the tract-level population.[8] The ultimate cross-tabulation we would like to construct is a 4x2 table (Asian, Black, White, and other by Hispanic, non-Hispanic), so a copy of this cross-tabulation from the PUMA data is entered into the seed table and then scaled to the census tract household population. All census tracts that belong to the same PUMA will receive the same seed data for a given income category. At this point, neither the row marginals nor the column marginals in the seed table will match the known marginals from the census tract. The next step is to adjust the cells so that the sum of the cells in each row equals the census tract row marginal. This is accomplished by multiplying each row by a unique constant. After this adjustment, the row marginals in the seed table should equal the true row marginals, but the column marginals may not. The next step is to multiply each column by a unique constant so that the sum of the cells in each column equals the census tract column

[8] PUMA-level data is constructed by weighting survey responses by household weights.

marginals. This process repeats iteratively until the absolute magnitude of cell adjustments is very small or the specified number of iterations has been performed. Beckman, Baggerly and McKay (1996) find that the procedure converges in 10-20 iterations. We perform 16 iterations in our IPF procedure. The IPF process yields an estimate of the true population proportions that, in the absence of other information about the true population, will maintain the odds ratios from the sample (seed) table. That is, the resulting constrained maximum entropy estimate from the IPF procedure is our best estimate of tract-level race-by-Hispanic income distributions given the information we have.

For 1990, we estimate a 4x2 table as described above. For 2000 and 2009 data, we modify the above procedure slightly. In those years, the census data provides us with non-Hispanic white counts in each income category, and, since white counts are also given, we can compute, via subtraction, Hispanic white counts in each income category. We are then able to treat these cells as 'known' and do not put them through the IPF process. Therefore, in 2000 and 2009, we use the IPF procedure to construct a 3x2 table (Asian, Black, other by Hispanic) for each income category in every census tract rather than a 4x2 table.

The change in reported categories allows us to perform a validation check of the IPF procedure. We ignore the availability of non-Hispanic white income counts in 2000, and use the IPF procedure to estimate the full 4x2 table in that year. We then compare the IPF-estimated Hispanic white and non-Hispanic white counts to the known counts provided in the 2000 Census data. The IPF estimates closely match the observed counts, providing some validation of the IPF procedure.

A second exception to the IPF process pertains to census tracts that do not have PUMA data. As mentioned in the data appendix, in very rare cases, a census tract will not have PUMA data associated with it. This occurs only in the 2009 data for 128 tracts, which is 0.24% of census tracts. In such cases, there is no way to seed the tract-level table, so the IPF procedure cannot be performed. Instead, we make some simplifying assumptions that allow us to keep these data in our data set. From the total

households in a given income category, we subtract the count of Asians, Hispanics, others, and non-Hispanic whites and call the remainder non-Hispanic blacks. This arithmetic assumes that there are no Hispanic Asians, and it also potentially allocates too few households to our non-Hispanic black count by virtue of "double subtracting" households that are Hispanic-other. Though the approach is not ideal, the assumptions are reasonable given the data limitations and affect very few tracts. We run our analyses excluding the tracts for which there is no PUMA data and the results are robust to this exclusion.

By the end of the IPF procedure, we have constructed the data set that we need to compute our exposure measures. Namely, we have a data set for each year of data that includes counts of non-Hispanic Asian households, non-Hispanic Black households, Hispanic households, non-Hispanic White households, and non-Hispanic other households in all income categories for all census tracts.

Appendix D. Methods for Estimating Exposure Functions

We begin by defining a function that describes the average exposure of members of g with incomes less than or equal to p to members of group h with incomes less than or equal to q. This function is denoted $F_g^h(p, q)$:

$$F_g^h(p, q) = \sum_i \frac{t_{gi(\leq p)}}{T_{g(\leq p)}} \cdot \frac{t_{hi(\leq q)}}{T_i}$$

where i indexes neighborhoods, and t represents counts, and p and q are in percentiles (scaled from 0 to 1). In words, the function is a weighted average of the proportion of households in a neighborhood who belong to group h and have incomes less than or equal to q, where the weight is the proportion of members of group g with incomes less than or equal to p in the metropolitan area (or other geography) who live in neighborhood i. We cannot compute this function directly for all values of p and q because the data do not provide households' exact income or the exact income of their neighbors. In other words, we don't observe the various counts $t_{gi(\leq p)}$ and $t_{hi(\leq q)}$, except for values of p or q that are defined by the income categories in the data. For example, we could compute the value of the function in 2009 for the exposure of whites with incomes less than or equal to $10,000 to blacks with incomes less than or equal to $14,999 since these incomes are both upper bounds of two of the income categories reported in 2009. In 1990, we can compute $F_g^h(p, q)$ for $25 \cdot 81 = 2{,}025$ combinations of g, h, p, and q (since there are 5 population groups and 9 income categories). In 2000 and 2009, we can compute $F_g^h(p, q)$ for $25 \cdot 256 = 6{,}400$ combinations of g, h, p, and q (since there are 5 population groups and 16 income categories). We use these observed points to fit a four-dimensional polynomial surface to these (2,025 or 6,400, depending on the year) computed values.

The $F_g^h(p, q)$ function has certain properties that impose constraints on the parameters of the polynomial surface (see Reardon, Fox, Townsend 2014 for full details and derivations). Some constraints relate the parameters for the parts of the surfaces pertaining to different values of g and h to one

another. Another constraint requires that if the polynomial surface is of order A in p, then it must be of order $A+1$ in q. We fit the model using $A=3$. Thus, we fit $F_g^h(p,q)$ using a constrained linear regression model of the form

$$F_g^h(p,q) = \sum_g \sum_h \sum_{a=0}^{3} \sum_{b=0}^{4} D_{gh} \beta_{ab}^{gh} p^a q^b.$$

where D_{gh} is an indicator of whether a particular observation pertains to the exposure of group g to group h. The R^2 from these models is over 0.999 in all three years, indicating that the model fits the observed data extremely well.

However, the $F_g^h(p,q)$ functions are not actually what we ultimately want; we want a function that describes the average exposure of members of g with incomes *of exactly* p to members of group h with incomes less than or equal to q. This function, denoted $f_g^h(p,q)$, is defined as:

$$f_g^h(p,q) = \sum_i \frac{t_{gi(p)}}{T_{g(p)}} \cdot \frac{t_{hi(\leq q)}}{T_i}$$

Note that

$$F_g^h(p,q) = \frac{\int_0^p f_g^h(r,q)\rho_g(r)dr}{\int_0^p \rho_g(r)dr}.$$

where $\rho_g(r)$ is the income density function for group g. If we denote the cumulative income distribution function for group g as

$$R_g(p) = \int_0^p \rho_g(r)dr,$$

then we can compute

$$f_g^h(p,q) = \frac{\frac{d}{dp}\left[R_g(p) \cdot F_g^h(p,q)\right]}{\rho_g(p)}.$$

We estimate $R_g(p)$ from the data using a constrained 4th-order polynomial (constrained so that $R_g(0) = 0$ and $R_g(1) = 1$), and compute $\rho_g(p) = \frac{d}{dp}R_g(p)$. Now, given our estimates of $R_g(p)$ and $F_g^h(p,q)$, we estimate $f_g^h(p,q)$ as

$$\hat{f}_g^h(p,q) = \frac{\frac{d}{dp}\left[\hat{R}_g(p) \cdot \hat{F}_g^h(p,q)\right]}{\hat{\rho}_g(p)}.$$

Once we have $\hat{f}_g^h(p,q)$, we compute the percentiles of the average group h neighborhood income distribution by numerical interpolation.

Finally, note that $f_g^h(p,1)$ describes the racial composition of the average neighborhood of a household in group g with income p. So we get Figure 2 in the text by drawing the functions $\hat{f}_g^h(p,1)$ for all g and h, and stacking them.

Appendix References

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