Spatial Sorting within Cities*

Victor Couture Jessie Handbury

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Abstract

We study changing trends in within-city sorting by education over the last 40 years. We show that neighborhoods closest to the centers of large U.S. cities rose from having the lowest levels of college attainment in 1980 to the highest in 2017. We discuss the determinants of changes in sorting patterns, focusing on the role of transportation technology and income growth. We outline various consequences of the recent urbanization of college graduates on neighborhood amenities, house prices, and segregation. We highlight the tendency of college graduates to cluster into select central neighborhoods, likely limiting opportunities for interactions across educational lines.

Urban America features wide variation in income, education, and racial composition across neighborhoods of the same city. One's residential neighborhood determines life outcomes ranging from employment (Bayer et al., 2008) and arrest for violent crime (Chyn, 2018) to social mobility (Chetty et al., 2018). The likelihood that a child of low-income parents grows up to be high-income depends more on the neighborhood than on the county they grew up in. Rich families tend to live in locations offering the best opportunities for them and their children, who can later afford to reside in similarly high-opportunity neighborhoods. The sorting of high-income households into high-opportunity areas of cities has likely contributed to the dramatic growth in income inequality over the past 50 years (Fogli and Guerrieri, 2019).[1]

Why do rich and poor households live in different neighborhoods? The rich can outbid the poor for housing in the most desirable neighborhoods. The rich also have stronger preferences for certain neighborhood characteristics. High-income individuals incur higher time cost of travel (Small and Verhoef, 2007), and they have stronger preferences for neighborhood characteristics like school quality (Bayer et al., 2007), crime rates (Ellen et al., 2019), access to jobs (Su, 2022), and access to non-tradable services like restaurants, gyms, and personal services (Couture and Handbury, 2020).

The neighborhoods most sought after by different types of households has changed over time. In the past century, the location choice of college-educated households has ebbed and flowed away

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[1] Diamond and Gaubert (2021) survey the related literature on between-city sorting and inequality.

from and towards city centers, from the suburbanization of the early and mid-20th century, to the urban revival of the late 20th and early 21st century, to the post-pandemic era showing early signs of renewed suburban attractiveness.

In this paper, we discuss these changes in within-city sorting. We first document two trends. First, the share of college graduates living near city centers grew between 1980 and 2017, with particularly steep growth between 2000 and 2010 explained mostly by the changing location choices of young, white college graduates. Second, over the same period, within-city spatial sorting by college attainment sharpened: as college attainment rates grew nationally, the gap in college attainment across neighborhoods widened.

These reversals of fortune have many causes. We focus on the role of transportation technology and income growth in generating the income sorting pattern in place through the mid-20th century, with the rich and educated living in the suburbs, and its subsequent reversal at the turn of the 21st century.[2] We argue that the mass production of cars, a transportation technology that allows for lower density living by removing the need to walk to and from transit stops, contributed to suburbanizing households rich enough to afford them in the early to mid-20th century (Glaeser et al., 2008). By the late 20th century, rising income inequality, which made the rich even richer, contributed to re-urbanizing richer households, by raising their cost of time spent traveling and making the density of amenities and jobs downtown more attractive to them (Couture et al., 2019).

We finally discuss the consequences of this evolution in sorting patterns. A neighborhood's demographic composition affects the amenities available to its residents and their cost of living. Changes in demographic composition therefore induce changes in amenities that can amplify neighborhood sorting. For instance, school funding improves when new high-income residents boost the tax base in a school district, in turn attracting more high-income families. A nascent literature quantifies the impacts of these dynamics in neighborhood amenities and house prices on welfare inequality. A related literature considers how spatial sorting today affects future inequality (Fogli and Guerrieri, 2019), building off empirical evidence that the demographic composition of the neighborhood where a child grows up correlates with their income in adulthood (Chetty and Hendren, 2018a,b). We investigate the relationship between college urbanization and neighborhood segregation and show that college graduates tend to cluster into certain neighborhoods. This local sorting behavior may limit the potential for urban revival to foster interactions amongst different demographics and impact inter-generational mobility.

The remainder of the paper proceeds as follow. Section 1 presents data on shifting spatial sorting patterns over the past 40 years. Section 2 describes the forces underlying these changing sorting patterns. Section 3 discusses the implications of spatial sorting for social mobility and income inequality.

[2]We discuss the role of race as well. Baum-Snow and Hartley (2020) show that preferences for neighborhood characteristics vary by race as well.

1 Changes in Socio-Economic Spatial Sorting (1980-2017)

In this section we document the evolution of spatial sorting by education level from 1980 to 2017. We focus on changes in the share of college graduates living at different distances from the city center. We highlight a striking reversal in where college graduates chose to live within the largest U.S. cities: throughout the 20th century, they had been suburbanizing, but from 1990 onward, they rapidly moved back downtown. We further show that America's urban revival had a strong age and racial bias, with young and white college graduates experiencing much larger changes in their propensity to live downtown than any other demographic group.

1.1 Who lives near the city center?

We first characterize spatial sorting within U.S. cities since 1980. Technically, we define cities using Core-Based Statistical Areas (CBSAs), geographic areas designed to contain sets of contiguous counties tied to urban centers by commuting. We do not know exactly where each household resides in each CBSA, or city, but the Census provides data on the number of households and individuals (both in aggregate, and by education level, age, and race) that reside in small areas called Census tracts. Census tracts are defined to contain around 4000 households. We sometimes refer to Census tracts as "neighborhoods."[3]

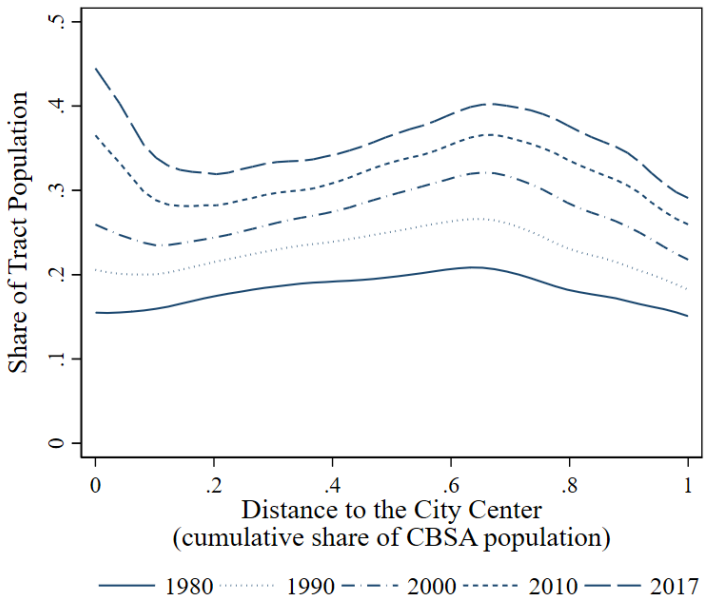
We start by looking at household sorting along one dimension, by distance to the center. We fix the center of each city at the coordinates of its City Hall, as defined in Holian (2019). We normalize the distance of each tract to the city center as a number between 0 (at the center) and 1 (at the periphery). Specifically, we measure a tract's distance to the city center as the share of the 2000 CBSA population living in tracts whose centroid are at the same distance or closer to the city center than that tract. The tract whose centroid is furthest from the city center in a given CBSA has a distance of 1, while the tract whose centroid is closest to the city center has a distance close to 0 (equal to that tract's own share of the 2000 CBSA population).

Figure 1 shows the share of college graduates in the population living at different distances from the city center of the 100 largest cities in the U.S., for each decade since 1980. Three distinct patterns emerge from the figure. First, the average college share rose steadily from 1980 to 2017, at all distances from the city center. This reflects both that the U.S. population is becoming more educated over this time period, and that college graduates are increasingly concentrated in large cities (Moretti, 2012).

Second, there was a sharp increase in the share of college graduates living near city centers. In 1980, the innermost neighborhoods had the lowest college share. From 1990 to 2000, there was a small uptick in the share of college graduates living downtown, which accelerated rapidly from 2000 to 2010. By 2017, the initial 1980 sorting patterns had entirely reversed, and the innermost neighborhoods had the highest college-educated shares.

[3]The boundaries of CBSAs and Census tracts shift over time. To avoid the contamination of our results by changes in CBSA and tract boundaries, we fix the boundaries of CBSAs and tracts to their 2010 definitions.

Figure 1: College Share by Distance to City Center



Notes: This figure plots the college-educated share of the Census tract population by distance to the city center in each decade from 1980 to 2017. Each line is a nonparametric kernel regression of Census tract-level demographic data from the largest 100 cities, defined as the Core-Based Statistical Areas (CBSAs) with the highest populations in 2000. Each kernel regression observation is weighted by tract population. Distance is measured as the share of the city residents that live at least as close to the city center, which is 0 at the center and 1 at the furthest point in the metropolitan area.
Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019).

Finally, there was a sharpening of spatial sorting by education from 1980 to 2017. In 1980 the college share gradient by distance to city centers is almost flat. By 2017, there is considerably more variation in college shares by distance to city centers, with an almost ten percentage points gap between the highest shares near city centers, and the lowest shares in the inner suburbs.

Before further unpacking these trends in specific cities and by demographic group within the college-educated population, we make two notes. First, we use college attainment as a measure of resident socio-economic status, but find qualitatively similar patterns in neighborhood resident income. Appendix Figure A.1 shows that the evolution of median neighborhood income at different distances to city centers is qualitatively similar to that of neighborhood college share (Figure 1). There was a substantial uptick in income near city centers, especially in the later period from 2010 to 2017. This uptick for income, however, was smaller than that for education, and the highest income neighborhoods are still in the suburbs as of 2017.[4]

Second, these college urbanization trends are happening against a backdrop of continuing suburbanization of the general U.S. population. In fact, Appendix Figure A.2 shows that population growth was lowest near city centers. The population of the most central neighborhoods in the

[4]One explanation for this difference between sorting by education and income is that the college-educated moving downtown tend to be young (see Figure 2a), and therefore earn lower incomes.

largest 100 cities grew by around 8 percent between 1980 and 2017, and by over 60 percent in neighborhoods at the periphery.

1.2 Who is moving downtown?

We now break down the college-educated into finer demographic groups and identify a significant age and racial bias in America's urban revival (Baum-Snow and Hartley, 2020; Couture and Handbury, 2020). Panel A of Figure 2 shows that between 2000 and 2017 (2000 is the earliest year for which tract-level population data by age and education is available), the vast majority of college share growth near city centers is accounted for by the youngest cohort of college graduates aged 25-34. For the older college-educated cohort aged 45-64, we find almost no change in sorting patterns between 2000 to 2017. Panel B of Figure 2 shows that the uptick in college graduate shares downtown is overwhelming driven by white college graduates, with smaller increase for Hispanics. Remarkably, Black college graduates display the opposite sorting patterns; with fastest growth in the inner suburbs.[5]

1.3 Where are college graduates moving downtown?

In general, the urban revival that we document here is a large city phenomenon, but it is not unique to a few big cities. Reproducing Figure 1 separately for each of the 12 largest cities in the U.S., we find a substantial uptick in the share of college graduates living near city centers in all cities except Los Angeles. New York, Chicago, Washington DC, and Houston experience particularly sharp rises in the downtown college share. When we replicate this exercise for the next 12 largest cities, we find more exceptions to these sorting patterns.[6,7]

Within the central areas of big cities, urban revival was not evenly distributed. Figure 3 maps this process in two individual cities, Chicago and Philadelphia. Specifically, the figure shows how the college-educated population was sorted across Census tracts in each city in 1980 and 2017. The shading of each tract reflects deviation from each city's aggregate college share in that year. Tracts with the highest college shares are in darker blue, and tracts with the lowest college shares are in darker red. The solid black boundaries indicate each city's downtown area, consisting of the tracts closest to the city center containing 10 percent of the city's population in 2000.

Within downtowns, we see clusters of neighborhoods with relatively high college shares (shaded in blue) in both 1980 and 2017. We also see clusters of highly educated neighborhoods in the suburbs of each city. In between these blue central and peripheral regions, there is a red 'donut' of neighborhoods with lower college graduate shares. These donut-like patterns became more

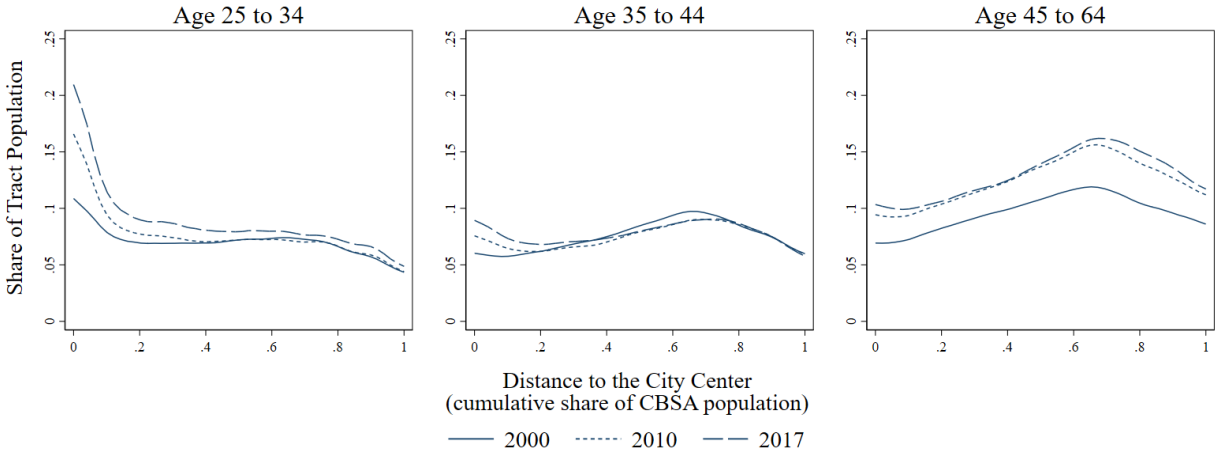
[5] We note that even though white college graduates saw the strongest change in sorting patterns, the downtown of large cities is becoming less white from 2000 to 2017, in line with general trends in the U.S. population.

[6] See Appendix Figures A.3 and A.4.

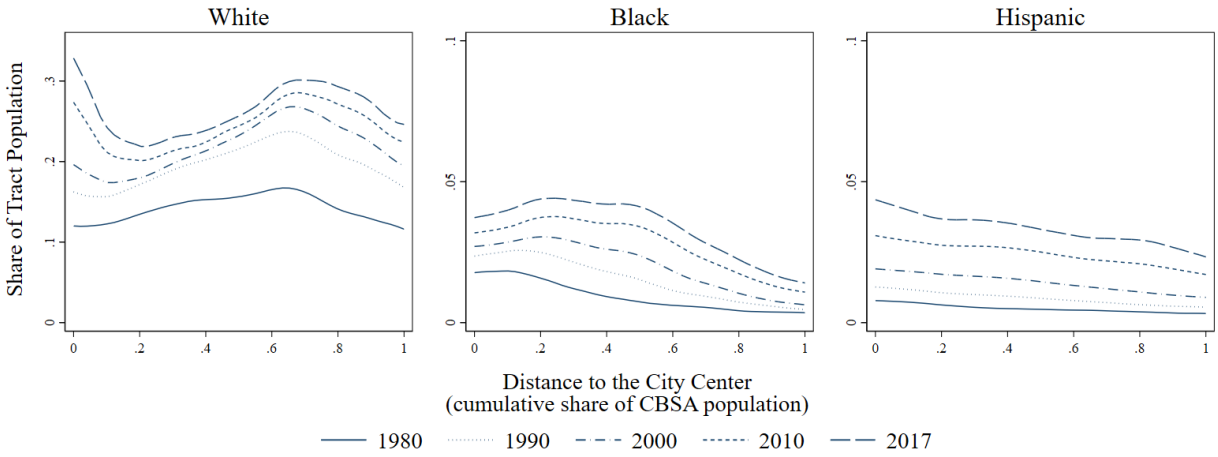
[7] As shown in Couture and Handbury (2020), many cities that did not experience rising overall college share downtown still experienced rising share of *young* college graduates. For instance, the paper documents that from 2000 to 2010, 23 of the 25 largest cities in the United States saw faster growth in young college graduates downtown than in the rest of the CBSA, with Riverside and Detroit being the only two exceptions.

Figure 2: College Share by Distance to City Center, Demographic Breakdowns

(a) Share of Tract Population by Age Group, College-Educated



(b) Share of Tract Population by Race, College-Educated



Notes: This figure plots the share of the Census tract population in given demographic groups by distance to the city center. Panel 2a displays what fraction of the Census tract population is both college-educated and within the specified age group. Panel 2b displays what fraction of the Census tract population is both college-educated and the specified race or ethnicity. The categories are not exclusive: both non-Hispanic white and Hispanic white residents are classified as white, and Hispanic residents of any race are classified as Hispanic. Each line is a nonparametric kernel regression of Census tract-level demographic data from the largest 100 cities, defined as the Core-Based Statistical Areas (CBSAs) with the highest populations in 2000. Each kernel regression observation is weighted by tract population. Distance is measured as the share of the city residents that live at least as close to the city center, which is 0 at the center and 1 at the furthest point in the metropolitan area.

Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)

pronounced from 1980 to 2017.

Relative to Figure 1 that shows changes in neighborhood sorting along only one dimension (distance to city center), Figure 3 offers a two-dimensional picture of where college graduates live over time in these two cities. The growth in college share from 1980 and 2017 was not evenly distributed across neighborhoods at the same distance from the city center. Only a select group of downtown neighborhoods saw large increases in their college share relative to the city mean. These "gentrifying" neighborhoods were often adjacent to existing 1980 enclaves of college graduates (Guerrieri et al., 2013). College shares rose in these neighborhoods both because college residents moved in and non-college-educated residents moved out.[8] These non-college-educated incumbents tended to move to neighborhoods with relatively low college shares in 1980. As a result, initially low college share neighborhoods fell even further behind the city average college share between 1980 and 2017 (indicated by their deepening shade of red in the maps).

This sorting of college graduates and non-college graduates into different neighborhoods increased the variance in educational attainment across neighborhoods. Qualitatively, this shift is reflected in the sharper color contrast between the red and blue neighborhoods in the maps over time. Quantitatively, the gap in the college share between the 75th percentile and 25th percentile of Census tracts increased from 0.18 to 0.34 in Chicago and from 0.19 to 0.33 in Philadelphia, from 1980 to 2017. These interquartile differences are representative of that observed overall in the largest 100 CBSAs.[9] In section 3, we further investigate the link between urban revival and the segregation of the non-college educated.

In summary, we found that while the general U.S. population continued to suburbanize, college graduates bucked this trend and displayed rising propensity to live near city centers from the 1990s onward. This urban revival reversed decades of suburbanization of the college educated, and represents a sharpening in sorting by education within cities, driven almost entirely by younger cohort of white college graduates. We now turn to investigating the forces that may explain these changes in sorting patterns.

2 Forces Behind Spatial Sorting

How do rich and poor households choose where to live? This section describes the forces that determine spatial sorting by income. We focus on how changes in transportation technology (LeRoy and Sonstelie, 1983; Glaeser et al., 2008) and changes in the income distribution (Couture et al., 2019) can explain the evolution of spatial sorting patterns documented in Section 1.

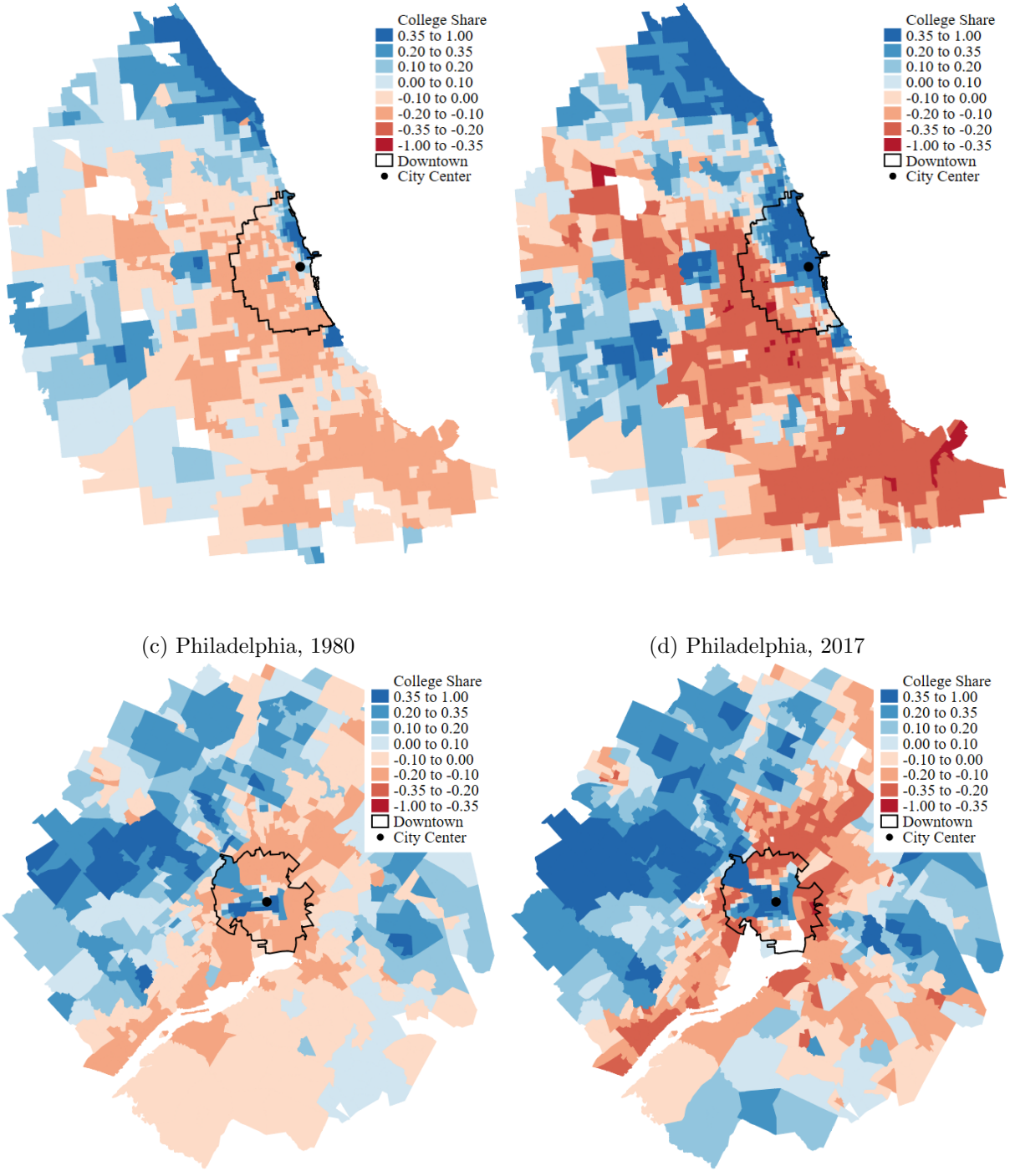
[8] Appendix Figure A.2 shows that, between 1980 and 2017, the population in neighborhoods at the center of the largest 100 cities grew by less than it did in the suburbs, even as the population of college graduates in these neighborhoods increased. A literature starting with Ellen and O'Regan (2011) shows that gentrification occurs more via adjustments in replacement patterns than via displacement: low-income residents of gentrifying neighborhoods are, in general, no more likely to move than low-income residents of non-gentrifying neighborhoods but, when they do move, they are more likely to be replaced by new high-income residents than by new low-income residents.

[9] The interquartile range within the 100 largest CBSAs increased from 0.17 to 0.31.

Figure 3: Variation in College Share Across Census Tracts

(a) Chicago, 1980

(b) Chicago, 2017



(c) Philadelphia, 1980

(d) Philadelphia, 2017

Notes: This figure maps the share of Census tract residents who are college educated relative to the CBSA average. The black dot shows the city center. The solid black boundaries delineate each city's downtown area, consisting of the tracts closest to the city center containing 10 percent of the city's population in 2000. The maps show the tracts in Chicago and Philadelphia comprising the 60 percent of the city's population that live closest to the city center. The tract college-educated shares are demeaned using the share of the CBSA population that is college-educated.

Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)

The availability of transportation technologies like cars, trains, and bicycles is a natural candidate to explain household location choices. Indeed, cities primarily exist to reduce physical distance between people and facilitate interactions. Glaeser (2020) and Heblich et al. (2020) show how innovation in transportation, from horse-drawn ominibus to steam- and electric-powered urban railways, shaped the modern city in the 19th century. These early public transit systems, by allowing individuals to live farther from where they worked, saw the emergence of the familiar city structure in which an urban core with high job density is surrounded by residential suburbs. Changes in the income distribution, for instance rising inequality, are also natural candidates to explain changes in spatial sorting. We expect travel costs and travel preferences (e.g., the type of venues visited) to change as households get richer or poorer. To illustrate the key determinants of sorting within cities, we present a simple model of a city in which travel costs determine the location choices of different income groups. We also discuss existing empirical evidence in support of the model's prediction.

2.1 Baseline: Monocentric City Model

We start by establishing baseline theoretical sorting patterns within a monocentric city. We model a linear city in which individuals belonging to different income groups choose where to live. All jobs and amenities are at the city center, so the cost of commuting to work and of consuming amenities rise with distance to the city center, as in Brueckner et al. (1999). Each individual commutes once to the city center to work. There are three income groups: high income, middle income, and low income. Travel preferences vary by income in two different ways. First, higher income individuals have a stronger taste for urban amenities, so the number of amenity trips rises with income. Second, higher income individuals have higher value of time, so the cost of commuting to work or of traveling to consume amenities rises with income.[10]

Before describing a graphical representation of sorting patterns in this model, we briefly review the empirical evidence in support of the model assumptions. Couture and Handbury (2020) show that urban amenities, specifically non-tradable services like restaurants, bars, gyms, and personal services, are the key factor attracting young college graduates towards city centers. In reality, not all jobs and amenities are located downtown, but the density of jobs and non-tradable service amenities is highest near city centers (Couture and Handbury, 2020). We use the 2009 National Household Transportation Survey (NHTS) to verify our assumption that higher income households take more trips to non-tradable services.[11] Appendix Figure A.5 reports that in large CBSAs, working age individuals with annual household income above $100,000 take 40 percent more trips to non-tradable services than individuals with household income around $50,000, and almost twice as many trips as individuals with household income around $15,000. Finally, a large empirical literature, reviewed in Small and Verhoef (2007), finds that value of travel time rises roughly

[10] Our informal discussion of this model ignores issues of housing size and quality. Implicitly, we are assuming that each individual consumes one unit of housing.

[11] In the NHTS the average working age individual takes about as many trips to non-tradable services as they take work-related trips, so both types of trips are important.

proportionally with wages, consistent with our assumption that higher income individuals have higher value of time.[12]

These assumptions about travel costs and preferences determine each income group's willingness to pay to live at different distances from the city center. In turn, these willingness-to-pay functions determine sorting patterns, i.e., which income group lives closer to the city center. In the canonical monocentric city model, willingness to pay, as a function of distance to city center, is called the "bid-rent" function. This terminology illustrates how different groups 'bid' for housing at different locations in the city. In equilibrium, each location in the city is inhabited by the income group with the highest bid-rent function (willingness to pay) at that location.

Panel A of Figure 4 depicts the bid-rent function of each income group in the baseline model described above. The x-axis is distance from the city center, and the y-axis is willingness to pay (bid-rent function) to live at each location. Given our assumption that all jobs and amenities are at the city center, the bid-rent function declines with distance to the city center in exact proportion to the increase in travel costs from longer commute and amenity trips.[13] That decline is unambiguously steeper for higher income individuals, who have higher travel costs per unit distance (higher value of time), and who take more trips to the city center to consume amenities.

Each location is inhabited by the group with the highest willingness to pay to live there, so sorting patterns by income in this baseline model are strictly monotonic. That is, high income individuals live closest to the city center, and low income individuals live furthest, with middle-income individuals living in-between. These baseline monotonic sorting pattern are observed in many European cities (Brueckner et al., 1999), in the United States before the suburbanization era (see Lee and Lin (2018) for late 19th century income gradients within large US cities), and possibly also in ancient settings (Gupta and Halket, 2021).

In the next subsections, we use this model to investigate the deviations from these baseline monotonic sorting patterns observed in Figure 1.

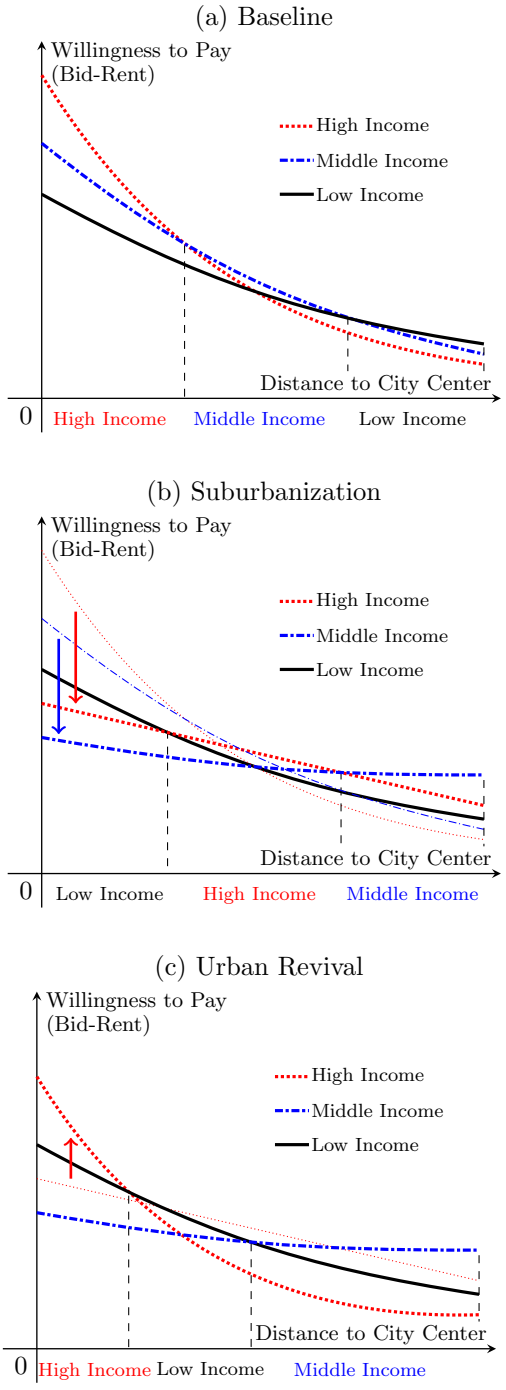
2.2 Suburbanization: Improvements in Transportation Technology

Before discussing the determinants of the college urbanization documented in section 1, it is useful to discuss the origins of the sorting patterns in place in the late 20th century, prior to urban revival. In particular, we show how changes in transportation technology contributed to the urbanization of poverty and the suburbanization of the rich in the 20th century. We focus on the impact of mass production of fast private motorized vehicles ("cars") in the early to mid-20th century. The car gave people the ability to live further from work, in lower density neighborhoods, unconstrained by the need to walk to and from transit stops. This new car transportation technology, however, was often only affordable to high- and middle-income households. Low-income households still relied on the slower public transit network, which was more developed near city centers with sufficient

[12] Murphy (2018) proposes a theory in which urban areas provide time and space saving non-tradable services to richer people.

[13] Specifically, the slope of the bid-rent function is the negative of travel costs per unit distance, multiplied by the total number of trips to the city center (work plus amenity trips).

Figure 4: Sorting Patterns by Income in the Monocentric City Model



Notes: The figure displays the bid rent functions (willingness to pay) of high-income, middle-income, and low-income individuals to live at different distances from the city center at location 0, under three scenarios described in this section. Panel (a) displays the baseline monotonic sorting pattern. Panel (b) shows the flattening of high- and middle-income residents' bid rent function following the introduction of the car in the early to mid-20th century. Panel (c) shows the steepening of high income residents' bid rent function as a result of top income growth in the late 20th century that made them richer.

population density to support transit stops within walking distance of jobs and residences (LeRoy and Sonstelie, 1983; Glaeser et al., 2008).

In the context of our model, lower travel costs for car-owning middle- and high-income individuals makes their bid-rent functions less steep relative to that of low-income households. So after this shift, depicted in Panel B of Figure 4, low-income households are willing to bid the most for housing near the city center. High- and middle-income households, who commute by cars, are willing to bid the most for housing in the near and far suburbs, respectively. Low-income individuals, who commute by slower public transit, move closest to the city center; there is an urbanization of poverty. Middle-income households are now furthest from city centers, with high-income households in between. We note that many mechanisms not in our model contribute to, reinforce, and amplify these sorting patterns. We discuss these forces, like locally-funded schools and crime, in section 3, as part of our discussion of the consequences of spatial sorting.

These sorting patterns are consistent with the data in Figure 1, which shows that in 1980, areas with the highest share of college graduates were near the mid-point of the city. Appendix Figure A.1 reports sorting by income instead of education and shows that, consistent with the theoretical sorting patterns described above, the median household income was lowest near city centers in 1980, and highest at about 65 percent of the total distance from city centers.[14]

2.2.1 Additional Surburbanization Forces

The suburbanization of the United States had a multiplicity of causes including improvements in transportation infrastructure, white flight, and income growth. A comprehensive review is beyond the scope of our paper, but we emphasize here that other improvements in transportation technology, beside the private car, contributed to the suburbanization of the US population.[15] At the turn of the 20th century, the earliest US suburbs were transit (e.g., street car) suburbs that predate widespread car adoption. In mid-century, the construction of the interstate highway system further contributed to suburbanizing residential locations (Baum-Snow, 2007), while the advent of trucking further suburbanized manufacturing employment (Mieszkowski and Mills, 1993).

White flight was another notable suburbanization force during the mid-20th century. Boustan (2010) shows that from 1940 to 1970, white households moved out of central cities, in part as a response to the in-migration of Black households, who were moving out of the rural South and into urban areas during the second wave of the Great Migration.

Finally, (Margo, 1992) shows that income growth contributed to post-war suburbanization, and Couture et al. (2019) offer a theory of how broad-based income growth from 1950 to 1980 - in the middle as opposed to the top of the income distribution - allowed a larger share of households to

[14] Our model does not allow for more than one income group to live in the same area. Couture et al. (2019) document 'U-shape' urbanization by income in every decade since 1970 (data from 1950 is incomplete), in which both high- and low-income households have a higher propensity to live downtown than middle-income households.

[15] Our article focuses on sorting by education and income, but a larger literature studies the suburbanization of the general US population in the 20th century. See Jackson (1987) for an authoritative history of suburbanization in the United States, and Mieszkowski and Mills (1993) for a review of the literature on the causes of suburbanization.

afford suburban housing.

2.3 Urban Revival: Top Income Growth

We now turn to explaining the urbanization of college-educated and high-income households in the late 20th and early 21st century, documented in section 1. In particular, we discuss the role of changes in the income distribution in urbanizing the rich. Looking across US cities, Couture et al. (2019) find a strong relationship between cities that experienced more top income growth, and cities in which the rich urbanized from 1990 to 2014. This finding suggests that top income growth at the national level contributed to urban revival in the United States. As inequality rose from the 1980s onward, the rich became even richer, and had correspondingly higher value of travel time, and higher demand for the shorter commutes and time saving non-tradable services available downtown. The existing empirical literature is largely consistent with the idea that newly-rich households moved to dense downtowns to save on travel costs. Baum-Snow and Hartley (2020) and Couture and Handbury (2020) find that the rising valuation of downtown amenity density was the key driver of the urbanization of college-educated and high-income households in the early 21st century. Su (2022) finds instead that the rising value of job density (shorter commutes) was more important.

In the context of our simple model, higher incomes translate into more trips to urban amenities, and higher value of travel time. Specifically, top income growth raises both the number of amenity trips and the travel costs per unit distance of high-income households. Both forces raise the valuation of high-income individuals for locations close to city centers where jobs and amenities are located. If the bid-rent function of high-income individuals becomes steep enough, they will live closest to the city center to save on travel costs, as shown in Panel C of Figure 4. Middle-income individuals still live furthest from to the center, with low-income people living in between.

These theoretical sorting patterns are consistent with the facts documented in Section 1. Figure 1 shows rapidly rising shares of college graduates near city centers from 1990 to 2017. By 2017, the highest share of college graduates is near city centers, and the lowest share is just outside of downtowns.[16] Education gradients vary by city - Figure A.3 shows gradients for the 12 largest cities - but many individual cities feature the "donut"-like sorting patterns derived from our model above.[17] In those cities, the highest income households live downtown, the lowest income households live in the inner suburbs, and middle-income households live in the outer suburbs. Taking again Chicago and Philadelphia as examples, Figure 3 shows the emergence of a dark blue area of high college shares around city centers from 1980 to 2017, surrounded by some of the least educated neighborhood in these cities, in dark red.

[16] Appendix Figure A.1 also shows rising household income near city centers from 1990 to 2017. These changes are not as pronounced for income as they are for education, likely because college graduates moving downtown tend to be young, and younger people have lower incomes.

[17] Glaeser et al. (2008) discusses the historical origin of these differences. For instance, New York City was built around public transit, and unlike Los Angeles, which was built around the car, it always retained a sizable share of richer households near its center in Manhattan.

2.3.1 Additional College Urbanization Forces

Additional forces contributed to the urbanization of college graduates in the late 20th and early 21st century, notably delayed family formation (Couture and Handbury, 2020; Moreno-Maldonado and Santamaria, 2021) and declining urban crime (Ellen et al., 2019).[18] Couture and Handbury (2020), show that young college graduates, who urbanized most rapidly over that time period, were ten percentage points more likely to be solo (unmarried and childless) in 2014 than in 1990. Solo individuals are by far the most urbanized family type, and they have the highest propensity to travel to non-tradable service amenities. In other words, the rising share of young college graduates who delay family formation to live solo is consistent with the rising urbanization rate of that group. Ellen et al. (2019) show that the richer and more educated individuals have higher valuations for low crime environments. As a result, declining central city crime from the 1990s onwards is consistent with the urbanization of the rich and college-educated. In section 3, we further discuss changes in crime rates as a consequence - rather than a cause - of within-city sorting.

2.4 Remote Work

We can also use the monocentric city model to predict how remote work may affect sorting patterns in the post-pandemic era. The ability to work from home reduces one's willingness to pay for downtown living, because it reduces the need to commute to city centers for work. In this sense, a rising propensity to remote work can be thought of as a change in transportation technology. If this "remote" transportation technology is disproportionately available to the college-educated (Bartik et al., 2020; Dingel and Neiman, 2020; Mongey et al., 2021), then it disproportionately flattens the bid-rent function of high income people, which pushes them away from city centers and towards the suburbs. Davis et al. (2021), Delventhal and Parkhomenko (2020), and Duranton and Handbury (2022) provide more complete treatments of what caused the recent rise in remote work, and of the impact remote work might have on spatial sorting in the future. We note here, however, that remote work has no direct effect on other model forces that urbanize high income households in our conceptual framework, namely the higher value of time and higher number of trips to urban amenities.

3 Consequences of Spatial Sorting

The mix of people who reside in a location impacts not only who gets to access the amenities available in each location, but what those amenities are and how much this access costs (i.e., how much it costs to live there). This section discusses a nascent literature studying the consequences of spatial sorting by education and income. We first review how within-city sorting impacts the welfare of rich and poor households, through both endogenous changes in amenities and housing

[18] Another plausible hypothesis is reverse white flight i.e., the idea younger cohorts of white college graduates have a greater taste for residing in minority neighborhoods (prevalent in downtowns) than older cohorts. We are not aware of formal tests of this hypothesis.

prices. We then discuss how the mix of residents in each local neighborhood itself matters, notably as a key determinant of social mobility. We then offer new evidence on whether the urbanization of college graduates was associated with greater residential mixing, and less segregation, by education.

3.1 Endogenous Amenities

As the demographic mix of residents in a neighborhood changes, so too do the amenities available there. Amenities catering to local tastes then attract further in-migration of residents with similar tastes, whereby amplifying spatial sorting patterns. For instance, the suburbanization of the rich in the mid-20th century likely led to better public schools there which, in turn, attracted further suburbanization of households that placed a high value on education (Mieszkowski and Mills, 1993). More generally, local financing of public goods may anchor richer households to suburban municipalities.

Privately-offered non-tradable amenities, such as restaurants, bars, gyms, private schools, and beauty salons, meanwhile, have played a more central role in explaining the urbanization of the rich and educated documented in section 1. These amenities have scale economies, so their availability correlates with residential population density. Downtowns offer foot traffic from both high residential density and daytime office workers, so they feature the densest, most diverse, and highest quality mix of these non-tradable service amenities (Couture and Handbury, 2020). College graduates, particularly the young college graduates whose shifting location choices have gentrified downtowns, spend more at and take more trips to these venues than other groups. The young-college bias towards these amenities has increased over time as this group earns higher incomes and delays marriage and childbearing (Couture and Handbury, 2020). With venues serving as meeting places, assortative matching in dating and friendship act as another mechanism endogenously reinforcing the urbanization of the rich and college-educated (Moreno-Maldonado and Santamaria, 2021). A common approach to model these endogenous amenities is, in fact, to assume a taste for residing in neighborhoods with high shares of college graduates (Diamond, 2016). This preference for neighborhoods with high college shares captures both opportunities for interaction - which we return to below - as well as the endogenous amenities, either private or public, that arise in high socio-economic status neighborhoods.

A third type of endogenous amenity that responds to and, in turn, attracts high-income college graduates is a reduction in disamenities like crime and pollution. Ellen et al. (2019), for example, argue that the decline in central city crime from 1990 to 2012 has attracted college graduates, generating further neighborhood change.

The feedback effects between amenity growth and spatial sorting patterns are quantitatively large. Su (2022) and Berkes and Gaetani (2019) study different drivers of gentrification (rising value of time for the rich and demand for knowledge workers) in different spatial sorting models. Both find that endogenous amenities account for over half of the overall effect of their hypothesized mechanism on spatial sorting patterns.

3.2 Increasing Living Costs

The purchasing power of richer households not only transforms neighborhood amenities but, given housing supply constraints, also drives up the cost of housing and commercial real estate. As higher-income households moved to supply-constrained city centers, downtown neighborhoods have become less affordable for low-income households and perhaps also less attractive to these households as businesses catering to a lower income clientele exit, and businesses catering to the tastes of the new, more educated residents enter. This 'gentrification' process has attracted a lot of attention in the popular press for its potentially negative impacts on incumbent residents.

Some of the new amenities in gentrifying neighborhoods bring positive value for all residents, including low-income incumbent households. This includes improvements in school quality, reductions in crime, and the entry of businesses that cater to a wide clientele (e.g., grocery stores). However, Ding et al. (2016), Brummet and Reed (2019), and Dragan et al. (2020) find that incumbent low-income residents tend to leave gentrifying urban neighborhoods escaping increasing prices by moving to lower-priced neighborhoods and, in the long run, do not benefit from neighborhood change in gentrifying neighborhoods.[19]

The arrival of college graduates' spending power into supply-constrained central city neighborhoods has also had broader spillover effects, increasing housing costs throughout the central city, including in non-gentrifying neighborhoods. Couture et al. (2019) and Su (2022) estimate that real income inequality increased by between 20 and 35 percent more than nominal income inequality as a result of gentrification-related growth in housing costs between 1990 and 2010. Some of this price growth is enjoyed by incumbent households that own properties in gentrifying neighborhoods (Brummet and Reed, 2019). Lower-income households, however, are less likely to own housing.[20]

3.3 Social Exposure and Segregation

Beyond affecting neighborhood amenities and housing prices, shifts in spatial sorting imply a change in the mix of people residing in different neighborhoods, and in opportunities for social interactions. While the immediate benefits of these interactions are hard to measure[21], a novel literature establishes how the demographics of the neighborhood a child grows up in impacts their long-run outcomes. Through this mechanism, spatial sorting may affect broader patterns of inter-generational mobility.

Chetty and Hendren (2018a,b) show that children who spend more time residing in higher-income commuting zones and counties tend to earn higher incomes, are more likely to attend college, and less likely to be teen parents later in life. Chetty et al. (2022) finds for poor Americans,

[19] (Baum-Snow et al., 2019) show that children exposed to gentrification in the suburbs see improvements in credit outcomes later in life. They posit that these benefits from suburban gentrification operate mostly through public schools.

[20] Households earning over $100,000 are twice as likely to own a home in 2001 as households earning below $10,000 (Herbert et al., 2005). Low income households may also struggle to afford property tax increases resulting from rising property values (Ding and Hwang, 2020; Fu, 2022).

[21] Ferreira and Wong (2020) use a survey to help parse the willingness-to-pay for social interactions separately from other physical amenities, such as restaurants.

the number of high socio-economic status friends is a robust predictor of social mobility, which is determined in large part by exposure to high income people within residential neighborhoods. Fogli and Guerrieri (2019) estimate that these dynamic effects of sorting exacerbate the growth in *nominal* income inequality – the gap between the incomes earned at the top and the bottom of the income distribution – induced by a permanent shock to the skill premium by more than 30%.

These long term neighborhood effects depend on the demographic composition of a child's immediate neighborhood. So we now turn to investigating whether the urbanization of the college-educated is associated with changes in how mixed different neighborhoods are, otherwise known as segregation.[22] The stylized facts of section 1 suggest an ambiguous relationship between changes in neighborhood segregation and changes in the sorting patterns of college graduates. Figure 1 and 2b show a sharp increase in the concentration of white college-educated individuals in certain regions of CBSAs, especially in areas close to city centers, which had initially large shares of non-college-educated and minority inhabitants. Figure 3, however, shows that college-educated newcomers' tended to cluster into the same select downtown neighborhoods, instead of evenly mixing with incumbent residents, casting doubt over whether urban revival resulted in more diverse neighborhoods.

To more formally investigate the link, if any, between urban revival and segregation, we return to data for the 100 largest CBSAs in the United States. We ask whether cities where college graduates urbanized more between 1980 and 2017 also saw decreases in how segregated college graduates were from non-college graduates across downtown neighborhoods over the same period. We measure the urbanization of college graduates as the change in the share of the college-educated population living downtown, divided by the share of the total population living downtown. There are many ways to measure segregation. Given recent evidence on the impact of high socio-economic status neighbors on social mobility (Chetty et al., 2022), we use two indexes that capture the proximity of non-college downtown residents to college-educated residents. We first measure the segregation of non-college educated downtown residents with an isolation index defined as the average share of non-college-educated residents, within the neighborhoods (Census tracts) that non-college-educated individuals live.[23]

Panel A of Figure 5 shows that from 1980 to 2017, the isolation of downtown non-college-educated residents declined in all but one of the largest 100 U.S. CBSAs. Looking across CBSAs, we find a strong negative relationship between changes in the urbanization of college graduates on the x-axis, and changes in the isolation of non-college educated downtown residents on the y-axis. In other words, between 1980 and 2017, non-college educated downtown residents experienced rising exposure to college graduates within their residential neighborhoods, and moreso in cities with higher rates of college urbanization.

These results are perhaps not surprising: (i) aggregate increases in college attainment rates left

[22] We are not aware of existing research systematically relating urban revival with segregation. In a closely-related inquiry, Freeman (2009) finds that some but not all measures of gentrification are associated with greater diversity within gentrifying neighborhoods.

[23] Note that the one minus the isolation index captures exposure to college-individuals.

non-college-educated individuals with fewer peers to live amongst in general (thus the nationwide decreases in the non-college isolation index) and (ii) large influxes of college graduates into certain downtowns also left non-college-educated downtown residents with fewer peers to live amongst (thus the negative correlation between the city-level isolation index and college urbanization rates). To control for these mechanical relationships, we turn to a measure of segregation normalized for changes in population shares.

Panel B replicates Panel A, but using the η^2 index as a measure of non-college-educated segregation. The η^2 index normalizes the isolation index to account for changes in the share of non-college-educated downtown residents, whereby adjusting for the mechanical factors that drive the decline in the isolation index in Panel A.[24] Here, we find a *positive* and significant relationship between changes in college-educated urbanization and the η^2 index indicating – as suggested in the maps for Philadelphia and Chicago in Figure 3 – that the urbanization of college graduates into downtowns was distributed in such a way as to generate more sorting by education, not less.[25]

To summarize, as the college-educated move downtown, the average non-college-educated residents experiences higher neighborhood exposure to college graduates. The normalized η^2 measure of segregation, however, suggests slightly rising segregation of non-college-educated downtown residents. The η^2 measure of segregation has no micro-foundation in terms of individual preferences, but these results are at least inconsistent with the notion that the young, white, college-educated individuals who drive urban revival were preferentially mixing with non-college-educated residents.[26,27]

4 Conclusion

The past century has seen the decline and subsequent revival of urban city centers as magnets for the college-educated. This urban revival reversed decades of suburbanization of the college educated, and represents a sharpening in sorting by education within cities, driven almost entirely by younger cohorts of white college graduates. As college graduates moved downtown, neighborhood amenities evolved to match their tastes, and rising house prices hurt local incumbent residents.

[24] Specifically, the η^2 index, using the notation in Graham (2018), is equal to $\frac{I-Q}{1-Q}$, where I is the isolation index, Q is the overall share of non-college educated in the population (i.e., isolation index under perfect integration) and 1 is the value of the isolation index under perfect segregation. So $I-Q$ is the excess isolation over perfect segregation, normalized by the excess isolation over perfect integration.

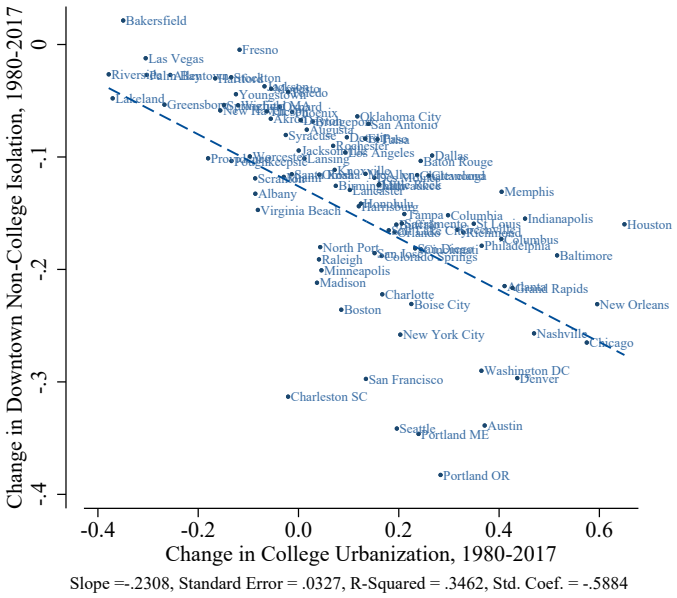
[25] We also replicate (not shown) Panel (b) using changes in a dissimilarity index instead of η^2, and we do not find any significant relationship with changes in the urbanization of college graduates.

[26] Appendix Figure A.6, we replicate Figure 5 but measuring non-college-educated segregation in the suburbs instead of downtown. In the suburbs, the associations between college urbanization and both measures of segregation in the suburbs are not statistically significant and at least one order of magnitude smaller than the associations between college urbanization and segregation downtown.

[27] Appendix Figure A.7 shows the association between college urbanization and Black segregation instead of non-college-educated segregation. We find that the urbanization of college graduates is associated with a decline in the isolation of Black downtown residents, but smaller in magnitude than the decline in non-college-educated isolation. The η^2 index for Black residents does not decline downtown or at the CBSA level. We conclude, that urban revival is unlikely to be an important factor driving the decline in Black segregation observed since 1970, which Glaeser and Vigdor (2012) attribute to reforms in government practice such as lending discrimination, and changing racial attitudes.

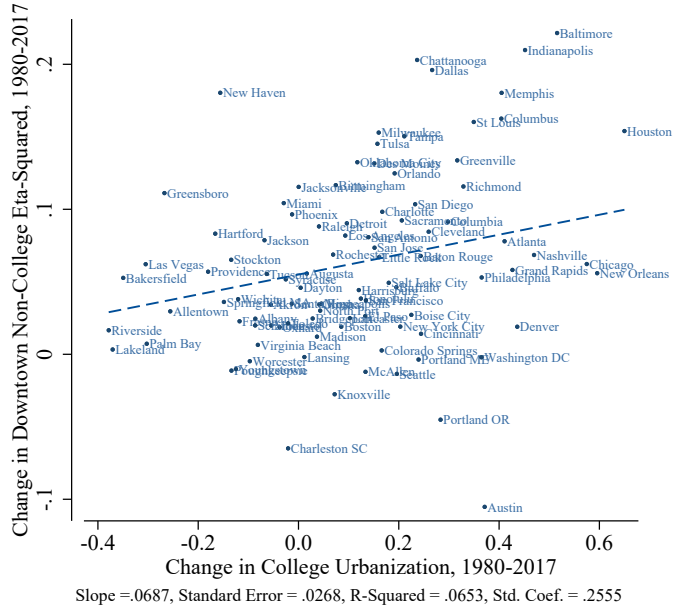
Figure 5: Changes in College Urbanization and Downtown Segregation, 1980-2017

(a) Non-College Isolation



Slope =-.2308, Standard Error = .0327, R-Squared = .3462, Std. Coef. = -.5884

(b) Non-College η^2



Slope =.0687, Standard Error = .0268, R-Squared = .0653, Std. Coef. = .2555

Notes: This figure plots changes in college urbanization and changes in segregation in the downtowns of the largest 100 cities, as ranked by CBSA total population in 2000. College urbanization is the share of the CBSA's college-educated population that lives downtown divided by the share of the CBSA's total population that lives downtown. Downtown is defined as the tracts closest to the center city that make up 10 percent of the CBSA population. The dashed line shows the results of a linear regression of change in the downtown non-college segregation index, either isolation or η^2, on the change in college urbanization, weighted by city population. The coefficient, standard error, R-squared, and standardized coefficient of the regression are reported beneath each panel.

Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)

Given the relationship between neighborhood demographics and social mobility, urban revival has, in theory, the potential benefit of exposing urban residents to more educated neighbors. Non-college exposure to college graduate within residential neighborhoods did rise in gentrifying downtowns. However, the tendency of college graduates to cluster into select downtown neighborhoods, instead of spreading evenly across neighborhoods, likely limited opportunities for interactions across educational lines.

The broad sorting trends that we document in this paper gathered momentum over decades, from a conjunction of driving forces and amplifying factors. We focused on changes in transportation technology and the income distribution, and noted the role of racial homophily, crime, and family formation in explaining the reversal of city center's fortunes over the last century.

Does the post-pandemic era herald another broad shift in sorting patterns? Whether the secular trends of top income growth and delayed family formation that drove urban revival will continue is hard to predict. One force that pulled college graduates into city centers over the past 40 years – the rising time costs of commuting – has likely vanished with the rising rates in remote work amongst college graduate. Urban rates of violent crime are also no longer declining. Further, the college urbanization was driven by young and white groups, which are declining in size. The growing demographics of older and minority groups likely still have a preference for suburban living. That said, downtowns retain their advantage in reducing travel costs to amenities and to other people. The strength of assortative matching and the appeal of urban venues as meeting places for dating and friendship amongst the young and educated is unlikely to diminish. At the tail end of the pandemic, it is still too early to tell whether there will be another reversal in sorting patterns over the coming decades.

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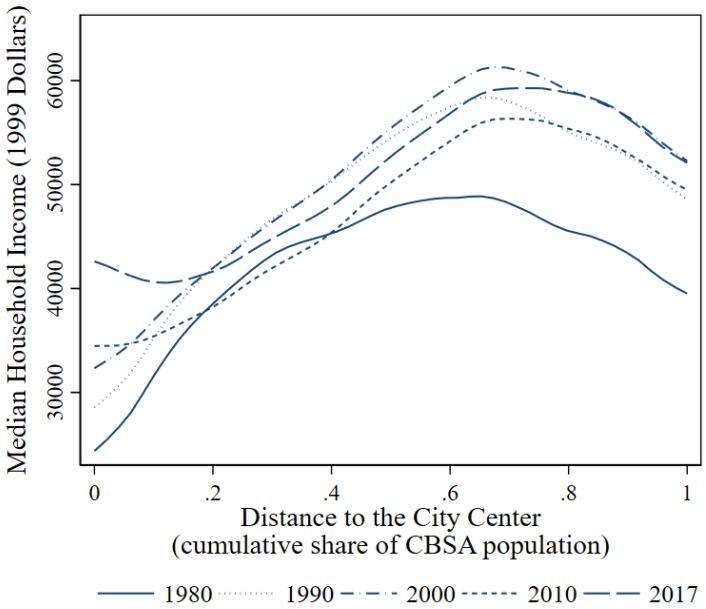
Appendix

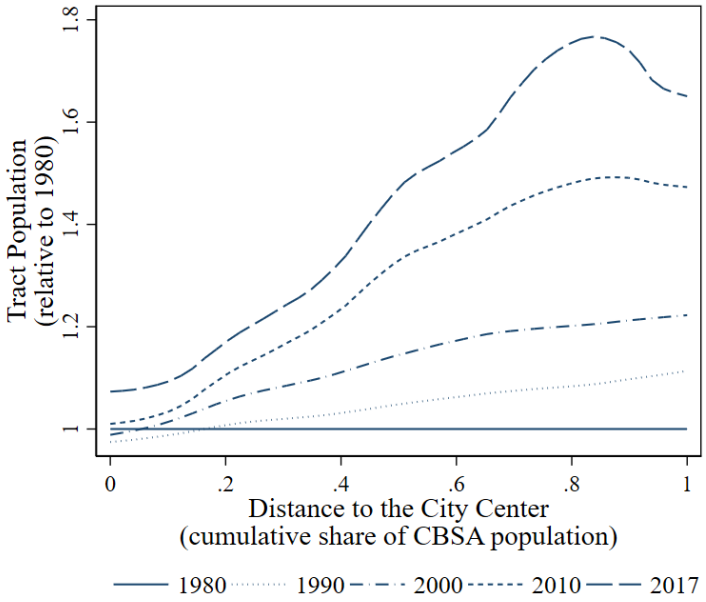
Figure A.1: Median Income by Distance to City Center



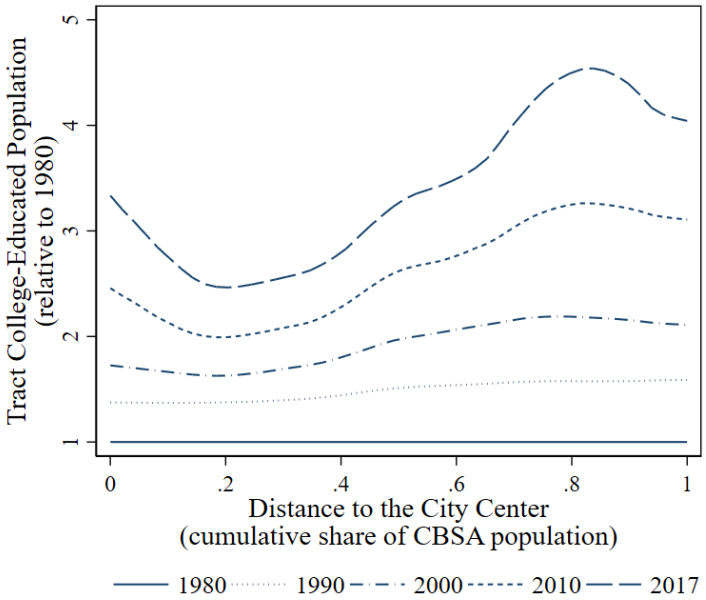
Notes: This figure plots real median household income by distance to the city center. Each line is a nonparametric kernel regression of Census tract-level demographic data from the largest 100 cities, defined as the Core-Based Statistical Areas (CBSAs) with the highest populations in 2000. Each kernel regression observation is weighted by tract population. Distance is measured as the share of the city residents that live at least as close to the city center, which is 0 at the center and 1 at the furthest point in the metropolitan area. For each year, income is converted to 1999 dollars using the Consumer Price Index.
Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)

Figure A.2: Population Growth

(a) All Residents



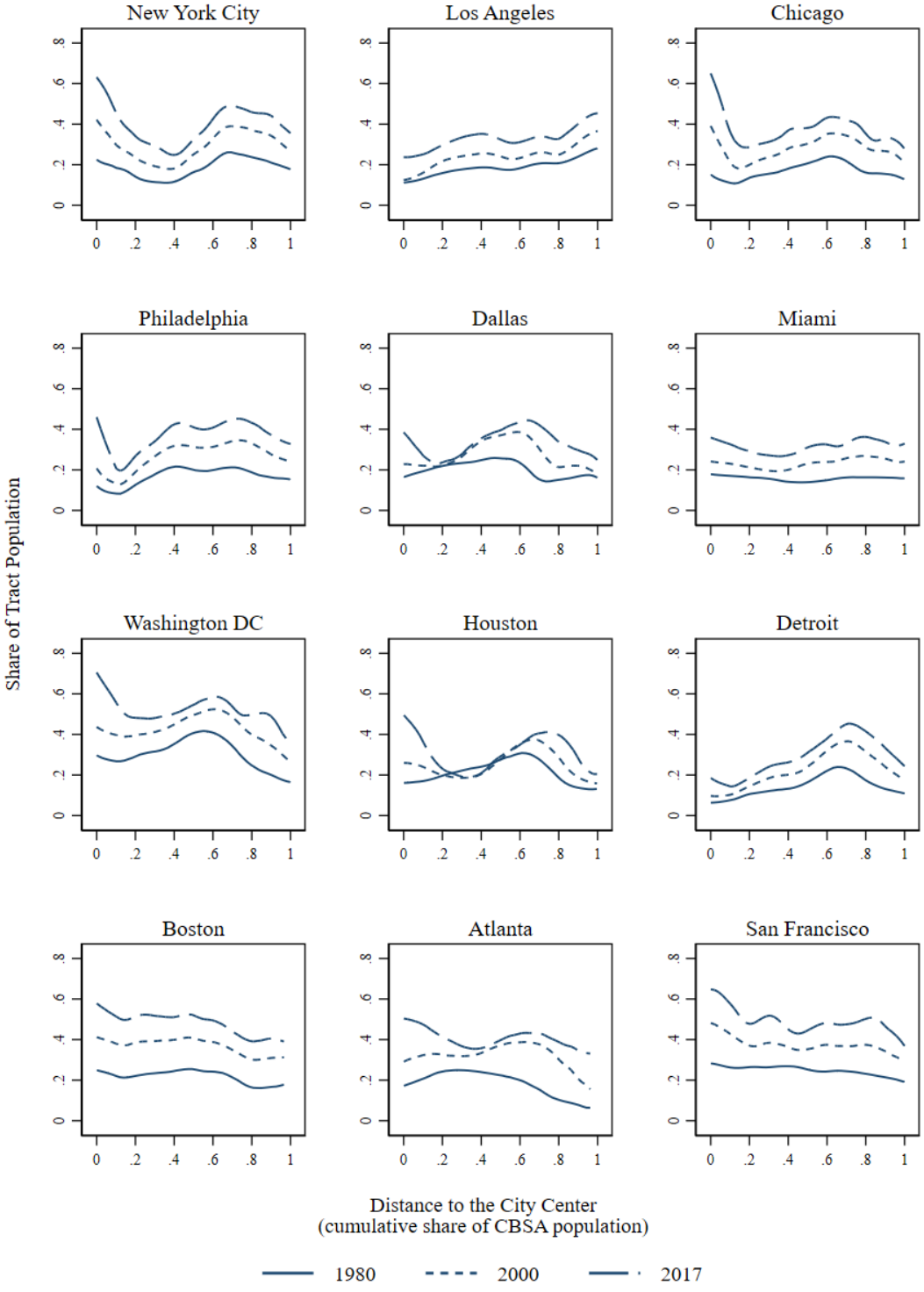
(b) College-Educated Residents



Notes: This figure plots population by distance to the city center. Panel (a) shows the tract population relative to 1980. Panel (b) shows the tract college-educated population relative to 1980. Each line is a nonparametric kernel regression of Census tract-level demographic data from the largest 100 cities, defined as the Core-Based Statistical Areas (CBSAs) with the highest populations in 2000. Each kernel regression observation is weighted by tract population. Distance is measured as the share of the city residents that live at least as close to the city center, which is 0 at the center and 1 at the furthest point in the metropolitan area.

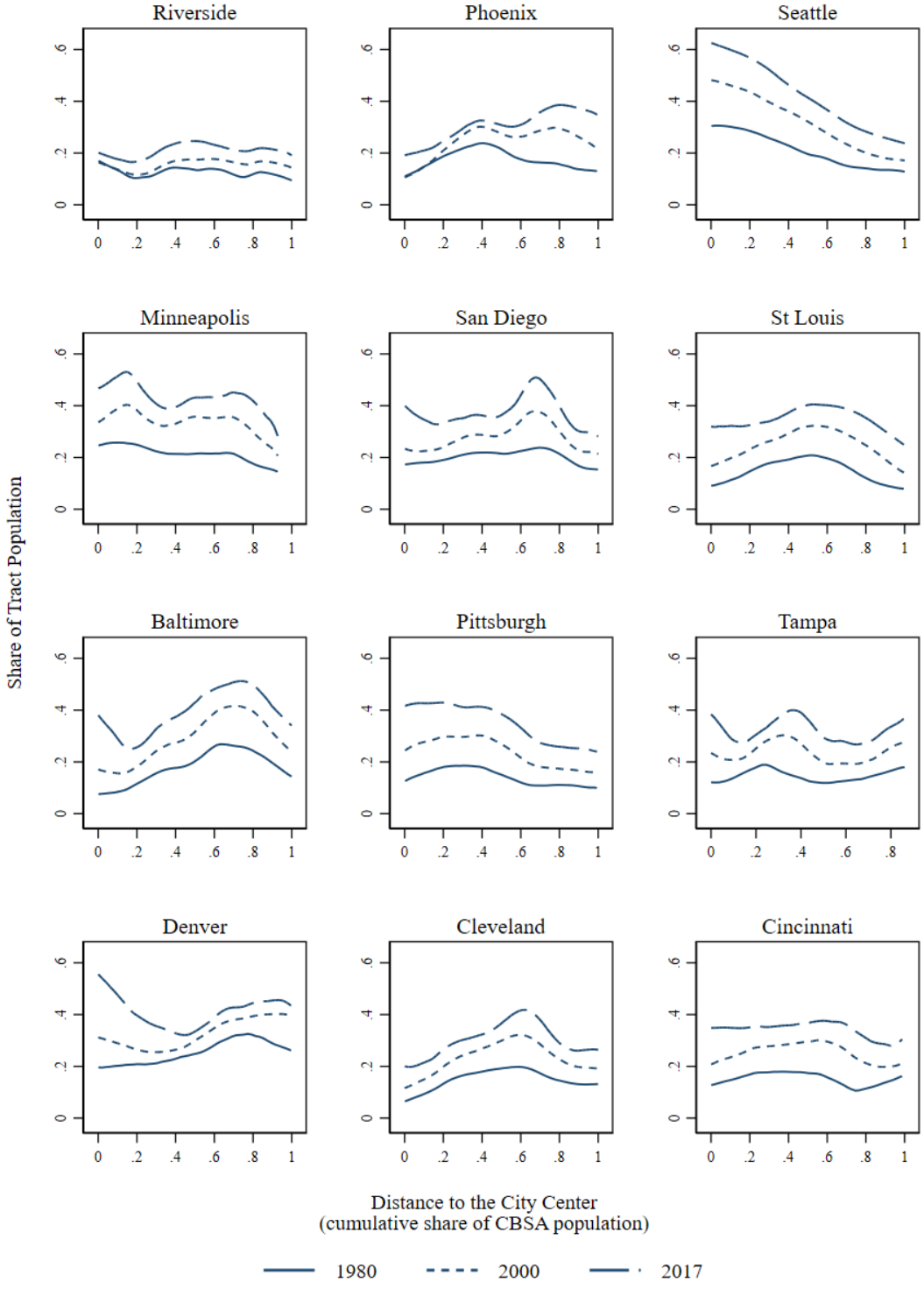
Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)

Figure A.3: College Share by Distance to City Center, Top 12 Cities



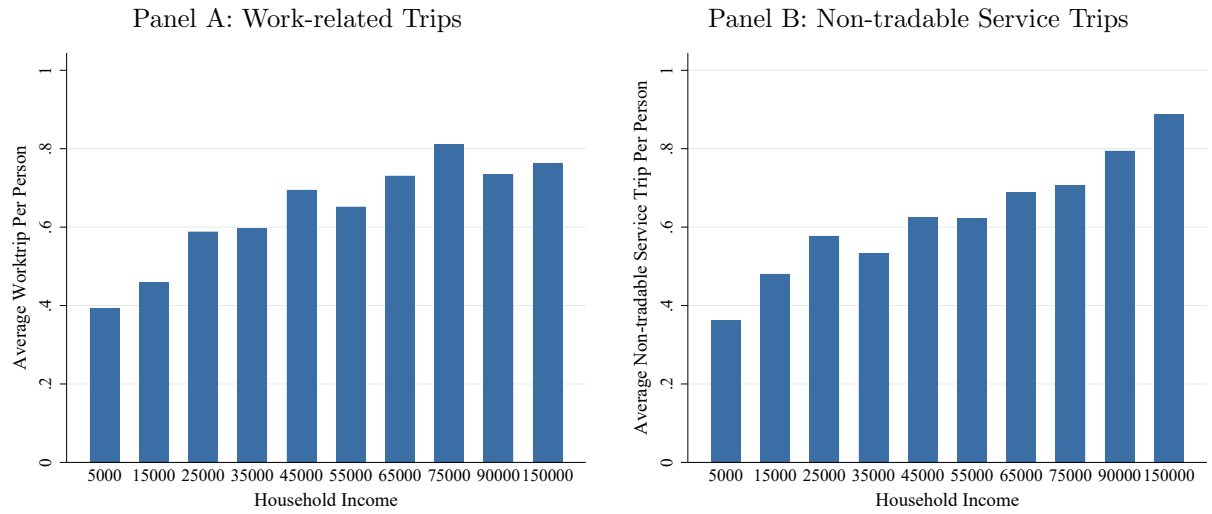
Notes: This figure plots the share of college-educated residents by distance to the city center across the 12 largest cities, as ranked by 2000 CBSA population. Each line is a nonparametric kernel regression of Census tract-level demographic data from the largest 100 cities, defined as the Core-Based Statistical Areas (CBSAs) with the highest populations in 2000. Each kernel regression observation is weighted by tract population. Distance is measured as the share of the city residents that live at least as close to the city center, which is 0 at the center and 1 at the furthest point in the metropolitan area.
Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)

Figure A.4: College Share by Distance to City Center, Next 12 Cities



Notes: This figure plots the share of college-educated residents by distance to the city center across the 13th-24th largest cities, as ranked by 2000 CBSA population. Each line is a nonparametric kernel regression of Census tract-level demographic data from the largest 100 cities, defined as the Core-Based Statistical Areas (CBSAs) with the highest populations in 2000. Each kernel regression observation is weighted by tract population. Distance is measured as the share of the city residents that live at least as close to the city center, which is 0 at the center and 1 at the furthest point in the metropolitan area.
Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)

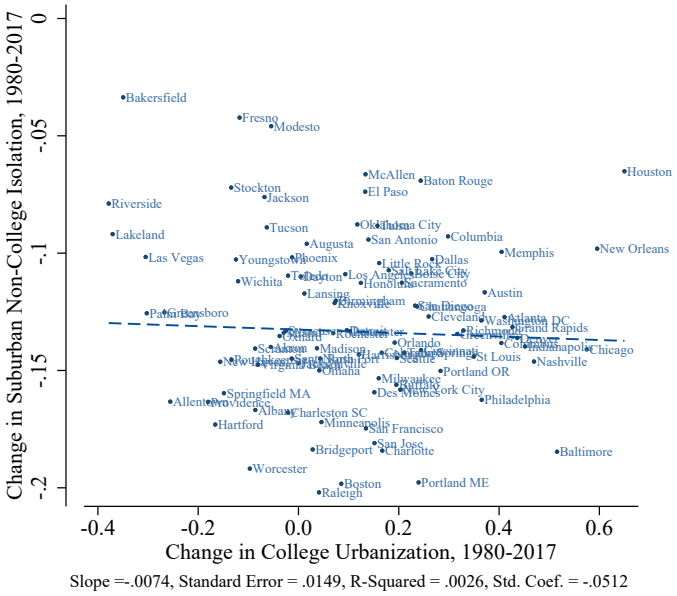
Figure A.5: Average Daily Trips Per Person, by Household Income



Notes: This figure displays the average daily number of work and non-tradable service trips taken per person, within each household income bracket, for individuals 25 to 65 year olds with non-missing income data living in urban areas with a population greater than 500,000. The figure shows the mid-point of each household income bracket, except for the highest bracket that includes all households earning above $100,000 per year. Work trips include trip purpose "work", "go to work", "return to work", "attend business meeting/trip", and "other work related" (NHTS codes 10, 11, 12, 13, and 14). Non-tradable service trips include trip purpose "buy services", "go to gym/exercise/play sports", "go out/hang out", "use personal services" (e.g., haircut), "meals", "get/eat meal", and "coffee/ice cream/snacks" (NHTS codes 42, 51, 54, 63, 80, 82, and 83).
Sources: National Household Transportation Survey 2009

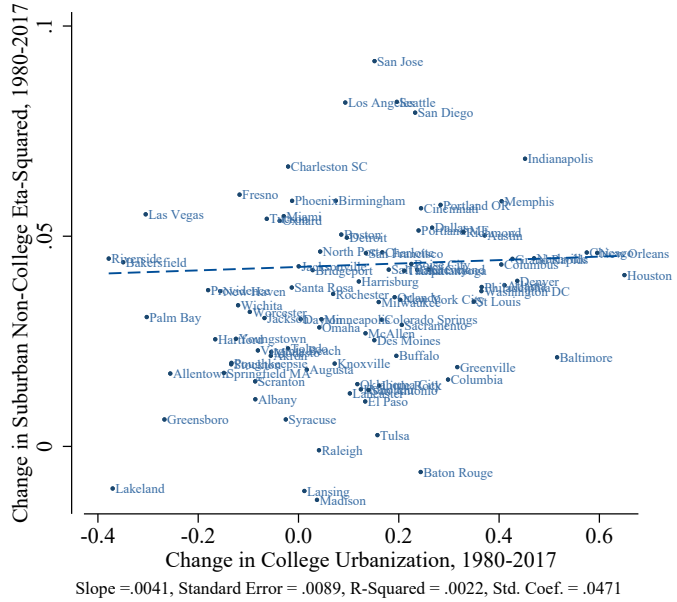
Figure A.6: Changes in College Urbanization and Suburban Segregation, 1980-2017

(a) Non-College Isolation



Slope =-.0074, Standard Error = .0149, R-Squared = .0026, Std. Coef. = -.0512

(b) Non-College η^2



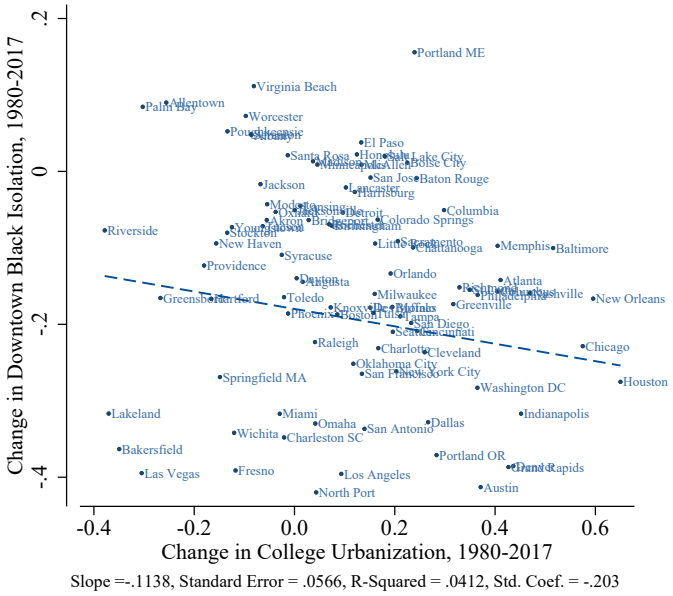
Slope =.0041, Standard Error = .0089, R-Squared = .0022, Std. Coef. = .0471

Notes: This figure plots changes in college urbanization and changes in segregation in the suburbs of the largest 100 cities, as ranked by CBSA total population in 2000. College urbanization is the share of the CBSA's college-educated population that lives downtown divided by the share of the CBSA's total population that lives downtown. Downtown is defined as the tracts closest to the center city that make up 10 percent of the CBSA population. The dashed line shows the results of a linear regression of change in the suburban non-college segregation index, either isolation or η^2, on the change in college urbanization, weighted by city population. The coefficient, standard error, R-squared, and standardized coefficient of the regression are reported beneath each panel.

Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)

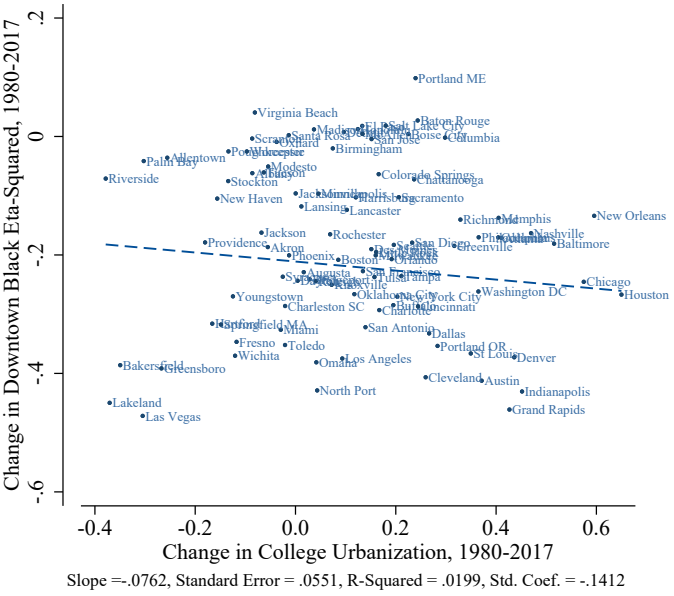
Figure A.7: Changes in College Urbanization and Downtown Racial Segregation, 1980-2017

(a) Black Isolation, Urban Areas



Slope =-.1138, Standard Error = .0566, R-Squared = .0412, Std. Coef. = -.203

(b) Black η^2, Urban Areas



Slope =-.0762, Standard Error = .0551, R-Squared = .0199, Std. Coef. = -.1412

Notes: This figure plots changes in college urbanization and changes in downtown racial segregation in the suburbs of the largest 100 cities, as ranked by CBSA total population in 2000. College urbanization is the share of the CBSA's college-educated population that lives downtown divided by the share of the CBSA's total population that lives downtown. Downtown is defined as the tracts closest to the center city that make up 10 percent of the CBSA population. The dashed line shows the results of a linear regression of change in the downtown black segregation index, either isolation or η^2, on the change in college urbanization, weighted by city population. The coefficient, standard error, R-squared, and standardized coefficient of the regression are reported beneath each panel.

Sources: NHGIS Census (1980, 1990, 2000) & American Community Survey (2008-2012, 2015-2019) (Manson et al., 2022); Longitudinal Tract Data Base (Logan et al., 2014); Holian (2019)