A WELFARE ANALYSIS OF GENTRIFICATION IN WORCESTER, MASSACHUSETTS

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Abstract

Gentrification has the potential to reverse patterns of decline seen throughout postindustrial cities in the United States. However, gentrification is a controversial process because of the perceived negative impacts for original neighborhood residents. In this paper, I use tract-level longitudinal data compiled from the United States Census and the American Community Survey to study how postwar urban development in Worcester, Massachusetts has impacted neighborhood outcomes and resident welfare. I use neighborhood-level increases in the percentage of college-educated residents as my primary measure of gentrification.

Using a regression analysis, I determine that gentrification has a statistically significant and differential impact on a broad set of outcomes for neighborhoods throughout Worcester. I find that gentrification caused large and statistically significant increases in income and reductions in poverty and find evidence suggestive of rent increases in gentrified neighborhoods. Moreover, I find evidence suggesting that Black and Hispanic people were displaced from gentrified neighborhoods and thus had worse outcomes, while Black and Hispanic residents of gentrified neighborhoods experienced large positive increases in income.

Previous economic studies of gentrification focus on its driving forces, rather than the consequences and their significance for residents. Moreover, little gentrification research has been conducted in smaller cities. A case study of gentrification dynamics in Worcester may help to fill this gap for many smaller, postindustrial cities across America.

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Finally, to Worcester—never change.

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1. Introduction

Gentrification is prevalent in cities across the United States, yet smaller cities are rarely included in analyses of gentrification. Most studies focus on America's largest metropolitan areas, despite the vast number of small to medium sized cities across America at risk of gentrification. One such city is Worcester, Massachusetts.

Located in the Heart of the Commonwealth, the City of Worcester is less than fifty miles west of Boston. Recently, Worcester has seen huge resurgences in commerce, industry, and population. Worcester County's population grew 14.8% from 2000 to 2020, 38% more than Massachusetts as a whole (Manson, Steven et al. 2021). Champions of Worcester flaunt its "revitalization" and "redevelopment," but others express concerns of "displacement" and mourn a loss of "character."

In other words, Worcester residents—myself included—are concerned about gentrification, an investment of capital into an urban center designed to create a space for a more affluent population.[1] As the municipal government partners with firms who undertake massive construction projects, residents worry that their neighborhoods will fall victim to a growing creative class pushing them further away from the downtown neighborhoods built for them (Shaner 2018).

The current economic literature on gentrification focuses primarily on the forces driving the process and does not always address the welfare implications nor the significance of gentrification for residents. In this paper, I seek to analyze gentrification in the City of Worcester, Massachusetts. Specifically, I aim to identify the outcomes and welfare implications of gentrification for neighborhoods across the city and determine if the benefits are shared equally.

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[1] Given the robust academic discourse over the term "gentrification," I elaborate on my definition in Section 2.

Since gentrification is a dynamic process and looks different everywhere, I tailor my model specifically for Worcester by using large neighborhood-level increases in the percentage of college-educated residents as my primary measure of gentrification. I use two multiple regression analyses to model the relationship between gentrification, neighborhood level outcomes, and resident welfare, controlling for a detailed set of baseline neighborhood characteristics.

In my first analysis, I find that gentrification has an overall positive impact on neighborhood outcomes; gentrified neighborhoods experienced large and statistically significant increases in income and reductions in poverty and vacancies. However, when I disaggregate various outcome variables by race, I find that gentrification disproportionately benefits White people and harms some Black and Hispanic groups. I find evidence suggesting that Black and Hispanic people were displaced from gentrified neighborhoods and had worse outcomes as a result, but Black and Hispanic residents of gentrified neighborhoods who were not displaced experienced large increases in education and income.

The paper proceeds as follows. Section 2 defines gentrification and establishes the framework I use in my analysis. I outline existing models, the literature, and gentrification theory in Section 3. Section 4 provides context for the City of Worcester. Sections 5 and 6 describe my data and methodology respectively. I present my results and analyses in section 7, and I conclude and provide the implications of my findings in Section 8.

2. What is gentrification?

2.1 Definitions

Taken literally, gentrification— or "gentry-fication"—means the replacement of an existing population by a gentry. Sociologist Ruth Glass (1964) coined the term "gentrification" to

describe the process by which inner-city neighborhoods are upgraded for middle-class homebuyers, and the indigenous working-class residents are displaced. Glass uses the word to describe urban changes that were beginning to affect inner London:

> One by one, many of the working class quarters of London have been invaded by the middle classes—upper and lower. Shabby, modest mews and cottages—two rooms up and two down—have been taken over, their leases have expired, and have become elegant, expensive residences. Larger Victorian houses, downgraded in an earlier or recent period—which were used as lodging houses or were otherwise in multiple occupation—have been upgraded once again. Nowadays, many of these houses are being subdivided into costly flats or "house lets" (in terms of the new real estate snob jargon). The current social status and value of such dwellings are frequently in inverse relation to their status, and in any case enormously inflated by comparison with previous levels in their neighborhoods. Once this process of 'gentrification' starts in a district it goes on rapidly until all or most of the original working class occupiers are displaced and the social character of the district is changed. (Glass 1964, xviii–xix)

Glass's definition describes a commonly held perception of the process known as classical or first-wave gentrification (Lees, Slater, and Wyly 2008). As the term first-wave implies, there are several types of gentrification each of which is context and time specific. Since gentrification is a dynamic process and has mutated over time and space, scholars have since departed from Glass's original definition.

Gentrification has been hotly debated for decades—to the extent that researchers still cannot agree on a definition of the term (Ellen and O'Regan 2011a). Oftentimes, definitions will be positively or negatively biased, despite conflicting findings in the literature. At its core, gentrification relates to how activities and people sort themselves across space and how these locational choices matter for both individual and community outcomes. Perhaps the best definition of gentrification comes from geographer Neil Smith:

> The reinvestment of capital at the urban center, which is designed to produce space for a more affluent class of people than currently occupies that space. The term, coined by Ruth Glass in 1964, has mostly been used to describe the residential aspects of this process but this is changing, as gentrification itself evolves. (2000, 294)

Smith's definition has a relatively neutral tone and does not state the specific processes or outcomes of gentrification, as they can vary by location. His definition provides the necessary structure to reconcile conflicting views of gentrification without being overly restrictive and limiting our understanding of the process. Furthermore, it allows for flexibility in various contexts. Thus, I use Smith's definition of gentrification in this paper.

Terms such as urban restructuring, urban renewal, neighborhood revitalization, or redevelopment are sometimes used synonymously with gentrification but are each slightly different processes with different connotations (Smith 1982, 139). Thus, I will use only gentrification and neighborhood change interchangeably.

Smith's definition implies that "successful" gentrification will result in a relatively more affluent class of people occupying gentrified spaces. Based on prior studies of gentrification and the history of racism in the United States, I do not restrict affluence to actual financial capital, but I include cultural capital as well. I characterize the more affluent class of people—the typical in-movers—as wealthy, White, native-born, college-educated young people. Thus, the less affluent class of people—the original residents—are the opposite: poor, non-college-educated, older people of color. People need not possess all these attributes to be considered in-movers or original residents because these characteristics are context specific. However, these are the margins of heterogeneity that are typically studied.

2.2 Framework

Definitions of gentrification as used in research generally vary in three key ways:

1. whether neighborhood economic change is driven by the in-movement of higher-income households or the economic growth of the original residents

2. the change in the racial or ethnic character of the community as White households move into mostly minority communities

3. the extent to which lower-income residents are displaced in the process

These three points are all concerned with a more affluent class of people—whether they possess more cultural capital or actual financial capital—changing the sociocultural and socioeconomic character of a neighborhood. However, none are inherent to the gentrification process.

Using Smith's definition of gentrification, I propose a framework consisting of process, outcome, and welfare, rather than having each of these components subsumed as inherent parts of gentrification. The process of gentrification produces outcomes, and I conduct a welfare analysis of those outcomes.[2]

1. *Process*. The dynamic means by which space is visibly transformed. The economic, social, and political forces driving gentrification. It involves different actors and institutions, including the state, landlords, realtors, developers, corporations, and individuals.

2. *Outcomes*. The consequences resulting from the process of gentrification. The manner in which an area has been restructured, economically, socially, and spatially. How people have moved throughout changing neighborhoods.

3. *Welfare*. The significance of the outcomes of gentrification for residents of a given space. The extent to which original residents are affected by the gentrification status of their neighborhoods and larger communities. Who benefits from or is harmed by gentrification?

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[2] Despite the seemingly linear progression of this framework, gentrification is not a linear process. It is important to note that gentrification is dynamic and has no conclusion. Cities will continue to grow and evolve, regardless of gentrification status.

2.3 Applying this Framework

To clarify the framework, I have included questions that may be categorized as follows:

1. *Process*: What contributes to gentrification? Why does gentrification occur? Who gentrifies? When and where does gentrification occur?

2. *Outcomes*: What neighborhoods have been affected? Who lives there? Who used to live there? What are the characteristics of these neighborhoods and how have they changed?

3. *Welfare*: Who is negatively or positively affected by gentrification? How has gentrification influenced equality and diversity? Does gentrification improve overall city growth?

This framework allows me to clarify and focus the analysis, while separating complex dynamics and questions into manageable parts. Additionally, the gentrification literature and theory are quite vast. The framework I have laid out allows me to survey the literature and outline existing theories in a consistent and logical manner.

For example, take the three key variations given earlier: (1) drivers of neighborhood economic change, (2) demographic changes in the community, and (3) displacement. The first point—whether original resident economic growth or wealthy in-migration drive gentrification—is a question of process. The second point invokes all three parts of the framework. A change in the racial or ethnic composition of a neighborhood may drive gentrification (process), be a product of gentrification (outcomes), and may affect neighborhood diversity and equality (welfare).

A key concern of gentrification is that it either displaces original residents (outcome) or is driven by displacing the original residents (process), thereby preventing them from partaking in the potential benefits (welfare). While this third point is a valid concern that I address in the paper, displacement should not be conflated with the definition of gentrification. Rather, it is a potential

outcome of the gentrification process. Whether or not this displacement is harmful for the original residents or economically efficient is part of the welfare analysis.

The three parts are difficult to discern, but it is especially challenging to differentiate between outcomes and welfare. For example, Vigor (2002) asks if gentrification harms the poor (welfare). To answer his welfare question, he asks if revitalization increases housing costs beyond what poor households are willing to pay (outcome). Similarly, I seek to separate outcomes from welfare by interpreting the outcomes of gentrification before assigning normative value because outcomes themselves are not explicitly positive or negative.

Additionally, much of the economics literature focuses on the process portion of gentrification, thereby distracting from outcomes and welfare. Estimating complex neoclassical models of locational preference can draw attention away from the resulting inequalities (Lees, Slater, and Wyly 2008, 49). Consequently, any existing models of welfare often incorporate outcomes and vice versa. Dividing the framework into three parts allows me to place emphasis where it is necessary.

3. Models in the Literature

3.1 Process

Academic debates about the process behind gentrification are divided along disciplinary lines with differential emphasis placed on production (supply) and consumption (demand) forces. In particular, economic models tend to focus more on market forces and individual choices—thereby drawing attention away from the welfare effects—while urban planning and geography models are more likely to emphasize class and politics (Ellen and O'Regan 2011a). Debates about production versus consumption were most intense in the late 1980s and early 1990s. While most

gentrification researchers would now agree that supply and demand both play a role in neighborhood change, there are still debates over the exact factors and processes driving gentrification.

2.1.1 Demand Side Explanations

One of the formative works in land-use economics is William Alonso's bid-rent theory (1964). Later, Moth (1969), and Mills (1967) would offer unique augmentations of Alonso's theory. Together, the works of Alonso, Moth, and Mills form the crux of bid-rent theory—also called the monocentric model. Economists often embed their research on gentrification within existing monocentric models of urban land use.

The bid-rent theory describes the tradeoff between land and location in home buying. The theory relies on the assumption that employment is located in a central business district (CBD). Thus, housing and population density are higher near the center and land is more expensive. Households deciding how much to "bid" for housing face a tradeoff between the cost of commuting to the CBD and the price of housing. Assuming that housing is a normal good, households may prefer to increase their consumption of housing over living centrally. If this is the case, then the bid-rent model results in patterns of suburbanization common among many American cities. The wealthy would reside further from the CBD where they can consume more housing at a cheaper price per square foot, while lower-income households live near the CBD. Essentially, commuting cost differences within an urban area must be compensated by differences in the price of living space.

Gentrification is posed as a change in the housing patterns that Alonso, Moth, and Mills originally described. For example, the 1970s "back-to-the-city movement" (essentially a synonym for gentrification) initially challenged neo-classical economics as wealthy White households

migrated to the city center. This particular phenomenon was proposed as a shift in locational preferences, with some wealthy households now valuing low commuting times over greater space needs (Schill and Nathan 1983). Upper-income households that value low commuting costs outbid lower-income households for housing in the CBD and those that value living space more outbid lower-income households for suburban homes. Lower-income households would reside somewhere between wealthy households in the suburbs and wealthy households in the CBD.

Demand-side models of gentrification and land-use must describe how consumers rationally choose amongst available housing options in order to maximize satisfaction or utility, subject to the constraints of their available incomes. The monocentric model can be adapted in a variety of ways to account for consumer preferences, but it always accounts for the tradeoff between distance from employment and housing costs.

Every city is different and therefore each city's residents will face different tradeoffs. Consumable goods often incorporated in economic models of the city include endogenous amenities—such as restaurants, bars, and hotels—exogenous amenities—such as parks and lakes—local public goods, and transportation (Glaeser, Kolko, and Saiz 2001; Brueckner, Thisse, and Zenou 1999). The model can also be extended to modern polycentric cities with more than one center (1960).

3.1.2 Supply Side Explanations

One of the most influential production explanations of gentrification is Neil Smith's 1979 rent gap thesis. The original role of the rent gap paper was to critique the consumer sovereignty assumption underlying neoclassical land-use models (Slater 2018). Rent gaps are the shortfall between actual economic returns from a land parcel given its current use and the potential returns if it were put to its optimal use. More specifically, it is the difference between capitalized ground

rent and potential ground rent. Capitalized ground rent is the actual economic return from the rights to use the land that is captured by the owner given the present land value. Potential ground rent is the maximum economic return from the rights to use the land that can be captured if the land is put to its "highest and best" use. The rent gap theory states that gentrification occurs when this gap is sufficiently large (Smith 1979).

Although Smith is a geographer, his approach is a purely economic one. As a rent gap grows, it creates lucrative opportunities to arrange a shift in land use. Investment will only be made if the gap is wide enough such that a developer can purchase the land easily, fund their rehabilitation project, and sell the property for a profit. Economic agents—including landlords, developers, bankers—can produce and exploit rent gaps. "Extra-economic force" from the state can also help to produce these gaps (Slater 2018).

There is considerable literature relying on and critiquing the rent gap theory. One component of the debate is whether or not the rent gap can be meaningfully employed (E. Clark 1995). It is not clear how one would measure capitalized ground rent and potential ground rent, and there are only a handful of detailed empirical studies attempting to measure or proxy these values (Badcock 1989; E. Clark 1988; Engels 2009; Hackworth 2002; Ley 1986; Smith 1996). Additionally, rent gaps cannot necessarily be used to predict the timing or location of development or gentrification because they need to be considered in the local context. It remains unclear at what point a rent gap would trigger gentrification.

Other models of production-based gentrification incorporate the neo-classical economic perspective discussed earlier. Bruckner and Rosenthal's 2009 paper identifies the age of housing stock as a factor that affects where high- and low-income neighborhoods are located in U.S. cities. Driven by a high demand for housing, high-income households tend to locate in areas of the city

where the housing stock is relatively young. Because cities develop and redevelop from the center outward over time, the location of these neighborhoods varies throughout the city's history. The model assumes that housing deteriorates with age, thereby providing the impetus for rehabilitation.

3.1.3 Government Policies

Housing finance in the United States formerly perpetuated the processes of redlining, white flight,[3] and suburbanization (Wyly and Hammel 1999). Gentrification attracted attention for its potential to reverse this outcome of the housing finance system. Now, housing finance no longer hinders gentrification and can even expedite the process. Lending institutions—which were once instrumental in the creation of rent gaps—see significant profit potential in formerly redlined areas. By facilitating the "highest and best use" of the land, these institutions are exploiting the rent gaps which they created and are fueling gentrification (Wyly and Hammel 2004).

Furthermore, policies geared towards urban renewal facilitate private market operations designed to attract and retain wealthier households and investments in the city. Investments in a city are place-based, these investments may be benefitting the place more than the people in that place. Changes as a result of these policies often do not align with community development goals (Newman and Ashton 2004) and can result in heightened discrimination and exclusion (Wyly and Hammel 2004).

Changes in low-income housing policies have also served as a tool for gentrification. Wyly and Hammel (1999) point to Hope VI, a public housing redevelopment program in the United States. Hope VI destroyed large-scale public housing projects and dispersed previous tenants with housing vouchers. Coupled with redevelopment efforts and private sector partners, Hope VI played a large role in gentrification across American cities.

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[3] White flight is a large-scale migration of white people out of an area that is becoming more socioeconomically diverse. It was most commonly seen in urban areas during the postwar period and reinforced segregation.

3.1.4 Demographic, Social, and Cultural Factors

Urban areas experiences major population loss in the postwar era as many White households moved to the suburbs (Boustan 2007). The reasons why people fled the city are unclear. Early studies of urban population loss suggest that this was because of mounting urban problems and an increase in the concentration of minorities and the poor (Bradford and Kelejian 1973; Frey 1979). More recent studies emphasize transportation improvements, such as automobiles and highways (Baum-Snow 2007; Kopecky and Suen 2010). Since then, the pattern has reversed, and wealthy White households are moving back to the city center.

While economics explains the flow of capital to gentrifying urban areas, there are broader cultural, social, and demographic factors that can facilitate gentrification. Over the past several decades, demographic changes have occurred that make central city living and the demand for urban locations more desirable. Cities with lively or trendy downtowns may be particularly appealing to childless educated workers in their twenties or early thirties—a population that has grown in size due to the later onset of marriage and childbearing. Moreover, the aging baby boomer population might be more comfortable in cities with mild winters, thereby leaving northern cities open to demographic changes.

Moreover, many American cities have shifted away from manufacturing economies and are transitioning towards a service-based economy. These shifts may make downtown areas more appealing by removing manufacturing sites, creating more centralized professional employment opportunities, and increasing the demand for housing, thereby attracting more highly educated individuals (Vigdor 2002; Schill and Nathan 1983).

Additionally, a change in attitudes or beliefs may impact a consumer's desire to live in the city. The emergence of a "new middle-class" of professionals with "left-liberal politics" (Lees,

Slater, and Wyly 2008, 97) have an altered view of urban living and may gain greater utility from central city living.

3.2 Outcomes

Outcomes comprise how an area is restructured by the process of gentrification and how people have moved as a result. The debate over the outcomes of gentrification is even more heated than the debate over the process. Although one outcome of gentrification seems to remain the same regardless of definition: a more affluent class of people will occupy the gentrified space.

Moreover, it is important to note that investments in a city are place-based. Outcomes or improvements of a place does not necessarily imply that people experience these outcomes. I will attempt to distinguish between the two throughout this paper.

Much of neoclassical economics focuses on the process portion of gentrification, thereby distracting from outcomes and welfare. As a result, existing models of welfare also incorporate outcomes and vice versa. Though it is difficult to separate the two from one another, I attempt to do so in the following sections using a standard economist positive and normative distinction. I will discuss measurable outcomes in this section, then move towards a welfare analysis in the next.

3.2.1 Quality of life

When gentrification is framed as "revitalization" or "renewal," it implies that life in the city is improving. It is possible for gentrification to lead to improvements in quality of life for everyone. For example, there are commercial aspects to gentrification that result in a changed commercial and retail space meant for a wealthier clientele. More restaurants, bars, and shopping centers create more activity in an area and more jobs opportunities. Whether or not this comes at the expense of the original residents is a question of welfare. Moreover, if more affluent people move into a neighborhood, this creates a higher tax base for the city. Local public goods may

improve, such as schools and parks. Such investment into the city may also lead to a reduction in crime rates. Finally, referring back to the rent gap, if conditions in the older homes are bad, gentrification may improve the quality of a neighborhood's housing stock.

3.2.2 Displacement

If a neighborhood is "successfully" gentrified, there should be a more affluent class of people residing in a neighborhood than the original residents. This does not necessarily imply displacement.

The popular narrative of gentrification proceeds as follows: wealthy, White, college-educated young people move into a neighborhood,[4] rents increase, and the original residents are involuntarily displaced as a result. Investments in a city are place-based: if people are mobile within a city, improvements in one area may lead to higher rental rates, thereby pushing out the poor (Balboni et al. 2021). However, there are various viewpoints on whether gentrification actually displaces the original residents. The definition of involuntary displacement I use comes from Jacob Vigor:

> involuntary displacement… includes both forced and cost-driven moves, under the presumption that most individuals forced from their housing unit would have been able to stay if they had offered a large enough sum of money (2002, 148)

Essentially, residents of a gentrifying neighborhood are involuntarily displaced when they can no longer afford to live in a gentrifying neighborhood.

Gentrification might make central-city neighborhoods more attractive to low-income households for several reasons (Vigdor 2002). Employment opportunities near the CBD might improve, an increase in the city's tax base may lead to better public services and local public goods, and there may be improved housing or amenities. However, the neighborhood may decrease in

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[4] Developers "upgrading" the neighborhood can be a catalyst for gentrification, but this is often ignored in the popular narrative. The debate over whether individual gentrifiers or developers drive gentrification is discussed in section 3.1.

"character" and make the neighborhood less appealing to the original residents. Utility from living in a gentrifying neighborhood varies by household, and it remains unclear whether a low-income household's willingness to pay for housing increases or decreases as a result of gentrification. Regardless, low-income household's *willingness* to pay is severely restricted by their *ability* to pay.

If neighborhood improvements are insufficient to compensate low-income households for the associated cost increases, there are two potential results (Vigdor 2002). If the relocation costs are low enough, residents will move. This does not necessarily cause harm if the residents were unhappy with the way their neighborhood has changed. If the costs are sufficiently high, residents are forced to stay in the neighborhood and suffer a diminished standard of living. However, these decreases may be reduced or reversed if gentrification brings increases in the quality of neighborhoods, public services, and employment opportunities. Neither case has distinctly positive or negative net welfare effects.

There is inconclusive evidence on whether or not gentrification displaces people from their homes. Findings vary by city and time, thereby supporting the idea that gentrification is both temporal and spatial. For example, several studies have been conducted on New York City. Freeman and Braconid (2004) found that low-income renters were less likely to be displaced in gentrifying neighborhoods than in non-gentrifying neighborhoods in the 1990s. However, Newman and Wyly (2006) critiqued the paper's methods and quantified displacement for all of New York City. They found few displacements but explained the harmful consequences of even these few displacements. When Clark (2021) revisited New York in the 2000s, he found that living in a gentrifying neighborhood is associated with a higher likelihood of displacement compared to living in a persistently low-income neighborhood.

McInnis, Walsh, and White (2010) study urban neighborhoods across the United States using 1990 and 2000 Census data and find no evidence of displacement of low-income non-White households in gentrifying neighborhoods. Moreover, they find that the bulk of increase in average family income is attributed to Black high school graduates and White college graduates.

Ding, Hwang, and Diving (2016) study mobility patterns of residents in gentrifying Philadelphia neighborhoods from 2002 to 2014. They find that residents of gentrifying neighborhoods have slightly higher mobility rates than those in non-gentrifying neighborhoods, but this is largely driven by more advantaged residents. Additionally, if residents are not able to stay in the neighborhood, they face a higher risk of moving to a lower-income neighborhood.

Brummet and Reed (2019) find that gentrification modestly increases out-migration rates. They note that gentrifying neighborhoods had much lower initial populations, which may suggest that they had the capacity to meet new demand.

3.2.4 Segregation

Gentrification had the potential to reverse both economic and racial segregation. Reversing white flight seems positive, as long as the original residents can live side-by-side with the more affluent in-movers.

Wealthy White families move into predominantly non-White neighborhoods. Implying that at some point in the transition process, there must be a more socioeconomically diverse community. However, if later in the process, people of color are driven out from the neighborhood, creating a predominantly White neighborhood, then the effects of segregation may have actually been worsened. Wealthy White families would have displaced poorer people of color and created their wealthy Whites-only gentrified neighborhoods.

3.3 Welfare

Most existing literature on the outcomes of gentrification have focused on residential displacement. Without understanding why residents were displaced, this provides little guidance as to whether or not original residents are harmed by gentrification. Limited studies on welfare may be due to the fact that confidential census data, is typically required to distinguish between in-movers and original residents precisely and accurately.

Studies explore welfare by looking at income mobility by race (Connor et al. 2018), quality of life and racial transition (Ellen and O'Regan 2011b), or intergenerational mobility based on in-migration and out-migration (Brummet and Reed 2019).

The most important distinction between these papers and other welfare studies is that they delve deeper than just researching place-based investments and changes. Rather than just studying how a place is affected as a result of gentrification, they attempt to track the people who were affected or perhaps displaced. Essentially, they focus on how gentrification affects residents and people, or perhaps particular racial groups, and go beyond the neighborhood as a whole.

4. History of Worcester

Formerly a farming community, Worcester became a major manufacturing city by the mid-nineteenth century as well as a healthcare and education cluster. The manufacturing industry began to decline after World War II, but the city was resurrected in the 1980s with the emergence of the biotechnology industry.

Figure 1 – Population Change by Geographic Level
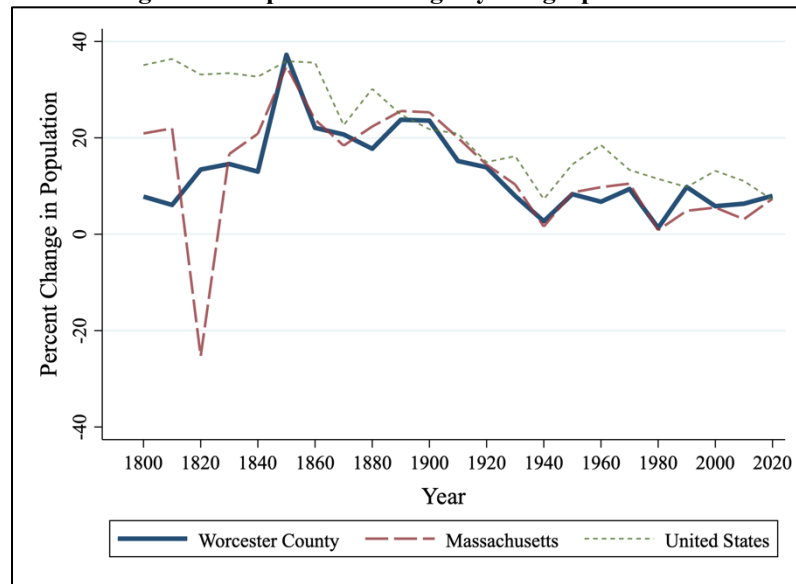
Notes: Data sourced from NGHIS IPUMS.

4.1 Industrial Rise (1800s to 1950s)

Worcester's economy first moved into manufacturing during the turn of the nineteenth century. New transportation systems in the mid-1800s decreased shipping costs considerably, and manufacturing firms began to collocate in Worcester. Manufacturing and factory growth led to an increase in population, as people moved into Worcester from both the countryside and overseas to obtain higher paying jobs.

Urbanization and population growth did not only lead to an increase in demand for goods, but also services, namely, education and healthcare. Many hospitals and institutions of higher education were founded in Worcester to serve the growing population.

Worcester reached its height as a manufacturing center in the early twentieth century. The Great Depression caused a massive crisis for industry in Worcester, but World War II quickly helped the city recover. Wartime spending and production helped grow the post-Depression economy, as Worcester's metalworks were in great demand.

4.2 Industrial Decline (1960s to Early 1980s)

Beginning in the 1960s, Worcester's aging industrial base eroded. Most firms closed or moved away as a result of now obsolete equipment and foreign competition from globalization. Worcester's population fell over 20% between 1950 and 1980 as residents moved to areas with greater opportunities and higher paying jobs (Thompson 2019). By the 1980s, the manufacturing industry was practically gone or had consolidated into a few small firms. In the absence of a booming industry, the city went into economic decline.

Nevertheless, Massachusetts placed its public medical school in the city in the 1960s (Davidson, 2016). The UMass Medical School was likely chartered due to the postwar global baby boom, which increased the need for healthcare as well as healthcare education. The state seems to have chosen Worcester due to the preexisting healthcare infrastructure. UMass continued to grow and bring high-paying medical jobs and a fair number of lower-paying support positions.

4.3 Biotechnology, Healthcare, & Education (Late 1980s to Present Day)

Worcester's existing healthcare infrastructure provided a basis for the biotechnology industry that emerged in the late 1980s. Biotechnology firms chose to locate in Worcester because of its pooled, highly educated workforce. There are nine colleges and universities in the city and six in surrounding towns—several offering degrees specialized for biotechnology ("Colleges & Universities" n.d.). Moretti (2004) observes that firms in cities with higher concentrations of college graduates are more productive than similar firms in cities with a smaller stock of human capital. Thus, firms view a higher concentration of college graduates in a workforce as an amenity. Biotechnology firms also receive the additional benefit of collaboration with local hospitals and universities.

Worcester's proximity to Boston's biotechnology industry cannot be ignored. Highways completed in the mid-twentieth century connected Worcester and Boston by the time the biotechnology industry emerged. Biotechnology growth in Worcester was partially due to a spillover effect from Cambridge and Boston. Biotechnology real estate became more expensive as larger firms monopolized the space along Boston's Route 128. Smaller firms and start-ups were attracted to Worcester for the more affordable space and because of the existing healthcare and education institutions (Mullin and Lacey 2003). So how has their growing presence impacted Worcester's affordability?

Industry growth in Worcester has led to a population resurgence. The city's population has increased by 14% between 1980 and 2016, compared to 8% for similar cities across the state and 9% for comparable cities throughout New England (Thompson 2019). Much of this population growth can be attributed to immigration; foreign-born residents make up 21% of the city's total population (University of Massachusetts Dartmouth Public Policy Center and Donahue Institute 2015). The majority of Worcester's foreign-born residents entered the country between 1990 and 2010, aligning with the time of industry and job growth in the city. Thus, there has been greater urbanization in Worcester since the 1990s, as people moved for higher paying job opportunities. Could people flocking to Worcester for high paying jobs exacerbate gentrification?

5. Data

In my final dataset, I combine data from the United States Census and the American Community Survey (ACS) from 1970 to 2019. Data from these surveys are divided by boundaries that are changed every ten years. Gentrification researchers often have access to confidential census data which allows them to directly map people to the exact location of their home, thereby

allowing them to adjust for these boundary changes. Given that I am studying a relatively small area, it is important that my data is as disaggregated as possible. In the absence of confidential individual-level data, I use publicly available data aggregated to the 2010 census tract level retrieved from Social Explorer (Social Explorer, n.d.). I define census tracts as neighborhoods[5] and conduct the majority of my analysis on 79 census tracts within ten miles of Worcester's CBD.

5.1 Boundaries and Harmonization

Census tracts are "small, relatively permanent statistical subdivisions of a county or equivalent entity that are updated by local participants prior to each decennial census" and have a population size between 1200 and 8000 people with an optimum size of 4000 people. When tracts are updated, their boundaries change. This means each census tract may capture a different area every period and therefore a different set of people. In order to conduct my analysis, I need disaggregated data that captures the same area during every period. In other words, the data must be consistent across both years and boundaries.

I use census crosswalks from the from the Longitudinal Tract Database (LTDB) to standardize the data for Worcester County. A crosswalk is a geographic correspondence tool that allows one to harmonize data to the same set of boundaries. I use LTDB crosswalks because they use more accurate methodology than other tools and their crosswalks are available for more time periods (Connor et al. 2018, 20; Logan, Xu, and Stults 2014; Logan et al. 2021).

The LTDB crosswalks weight census tracts from 1970 to 2000 censuses to match 2010 census tracts. For the years from 1970 to 1990, the LTDB census crosswalk uses areal interpolation to reallocate people into different census tracts. Suppose we have census tracts A and B with the exact same land area in 1980, each with a population of 4000 and 1000 housing units. Suppose we

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[5] Although there is no exact definition of a neighborhood, census tracts are regarded as sufficient for studying neighborhood-level processes (Freeman 2009; Sharkey and Faber 2014)

also have an unchanged census tract C. Now, suppose that in 2010, the boundary between census tract A and B have been redrawn so that the land area of census tract A decreased by 20% and the land area of census tract B increased by 20%. The census crosswalk might look like Figure 2.

Figure 2 – Sample Census Crosswalk

Tract 1980	Tract 2010	Weight
A	A	0.8
A	B	0.2
B	A	0.8
B	B	0.2
C	C	1

These weights would redistribute this data within the 2010 tract boundaries so that census tract A has 3200 people and 800 housing units. The remaining data is redistributed to census tract B so that it has 4800 people and 1200 housing units.

The 2000 census crosswalk uses both areal and population interpolation to create the weighted distributions. This means the crosswalk uses both the change in land area and the change in population to relocate people within census tracts.

I downloaded all my data from Social Explorer, a website that repackages census data using publicly available relationship files from the LTDB. Thus, all the census data that I use is consistent with 2010 census tract boundaries.

5.2 United States Census

The United States census counts each resident of the U.S. and records their place of residence every 10 years. The Constitution mandates that the enumeration take place to determine how to apportion the House of Representatives among the states (US Census Bureau n.d.).

From 1980 to 2000, the census was distributed in two forms. The full count survey was distributed to every household in the country, while only one in six Americans received a more detailed series of questions called the sample count survey. Exact questions vary by census period.

In 2000, the full count survey asked about sex, age, race, Hispanic or Latino origin, household relationship, and home ownership. The sample count survey asked questions about some of the following: educational attainment, employment status, income, and home value.

Only one census survey was distributed to all American households in 1970 and 2010. In 1970, this survey included both general and detailed questions. In 2010, the census only asked general questions due to the simultaneous distribution of the ACS. Thus, I substitute 2010 census data with ACS data.

5.3 American Community Survey

The American Community Survey (ACS) is an ongoing monthly survey that provides population and housing information annually (US Census Bureau n.d.). The survey began in 2005 and is distributed to a sample of about 3.5 million addresses annually. The ACS asks more detailed questions than the census, including questions about disability status, and internet usage.

I use ACS 5-year estimates from 2010 to 2019, each of which includes 60 months of data. 5-year estimates have the largest sample size compared to the ACS 1-year and 3-year estimates, which is necessary when working with small geographies such as census tracts.[6]

5.4 Selected Area

Worcester City Hall functions as the CBD because the surrounding tracts are the most concentrated in terms of population and commerce. Since gentrification revolves around a city's urban core, I restrict my analysis to those tracts within ten miles of the city hall.[7] This eliminates most rural areas and potential secondary business districts. Additionally, it removes tracts to the east that are more affected by their proximity to Boston.

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[6] ACS data for the 2010 to 2019 period is already mapped to 2010 census tracts, and thus requires no harmonization.
[7] Tracts whose centroids lie within ten miles of city hall are included in my analysis.

I also remove two tracts from the dataset because they are missing several important values. It appears as if these tracts were under sampled, resulting in extreme outlier values. The tracts are already small, and each contains a university, which may be causing the misestimation.

5.5 Justification & Potential Issues

A recent study comparing 2000 LTDB data estimates to the actual[8] census data has revealed issues with LTDB estimation methods (Logan et al. 2021). Their interpolation procedure assumes that all population subgroups are evenly distributed within their 2000 tract, but this assumption creates issues when people are reallocated to different tracts. In reality, residents are segregated by income, race, and a variety of other factors. Thus, when boundaries change, the process may result in large groups being incorrectly allocated into census tracts.

Tracts that are smaller, more heterogeneous, newly created, or fast growing have larger estimation error. Given the data limitations, I am restricted to using LTDB data. However, I proceed with caution by checking for outliers and noting significant tract boundary changes.

5.6 Summary Statistics

5.6.1 Education

As shown in Figure 3, nationwide college education rates have been increasing for decades. Massachusetts has consistently had a higher concentration of people with a bachelor's degree.[9][10] Worcester County had educational attainment rates below the national average until 1990 when Worcester County surpassed the national average. The increase in educational attainment during this period is consistent with the emergence of the biotechnology industry in Worcester.

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[8] The paper uses true census data with random noise injected to protect confidentiality of the raw data. The error in these estimates is random and relatively small.

[9] The Census Bureau used to record education based on years. I assume a person is college educated if they are recorded as having "4 or more years of college" before 1990 or have "a bachelor's degree or higher" after 1990.

[10] Throughout this paper, college education rates are calculated as the number of college-educated individuals aged 25 and older over all individuals aged 25 and over.

Figure 3 – Educational Attainment Over Time
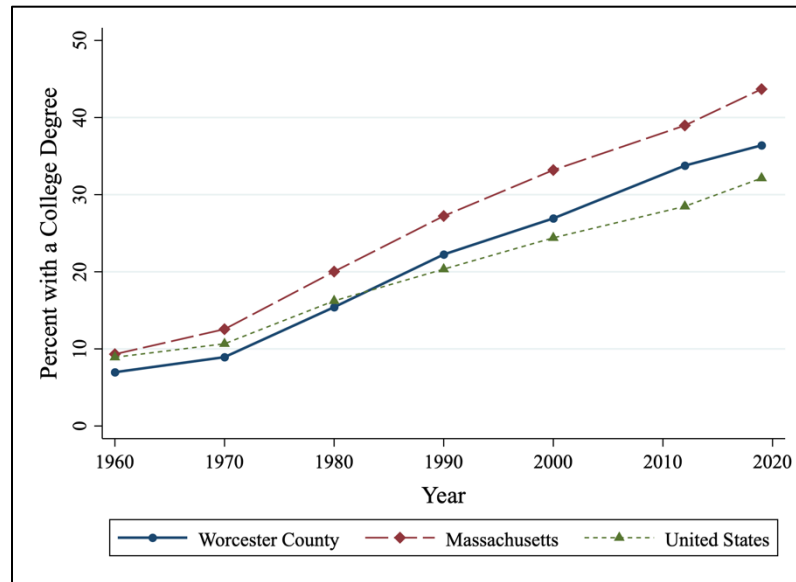
Notes: Percent college educated calculated among the population age 25 or older. Data pulled from IPUMS NGHIS.

Figure 4 compares percent college educated in a given year to 1970 education levels for all tracts in Worcester County. The circle size corresponds to each tract's relative share of non-White people in 1970. In 1970, the majority of census tracts had a population with less than 10% college graduates. College attainment rates have since increased amongst all census tracts. Many tracts with less than 10% of the population having a degree in 1970 rise well above that by 2010; several such tracts have a large minority share of the population in 1970. Tracts outlined in red are identified as gentrified later on in this paper.

5.6.2 Income

Figure 5 shows the distribution of median incomes across Worcester County by year. The peaks shift right, representing an increase in median income over time. Median income decreases slightly in 1980, likely due to further industrial decline around that time. There is a larger increase between 2010 and 2019 despite the period of time being one year shorter. I predict that this is the period where gentrification has the greatest effect. Additionally, the distribution flattens and spreads over time. This may indicate greater income inequality and a widening wealth gap.

Figure 4 – Neighborhood Educational Attainment Over Time, Worcester County

(a) 1980 versus 1970
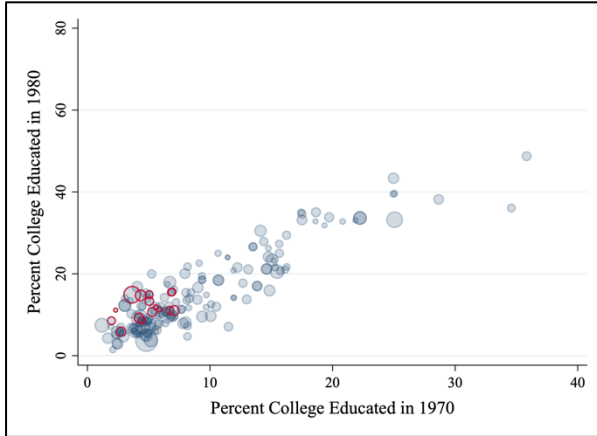
(b) 1990 versus 1970
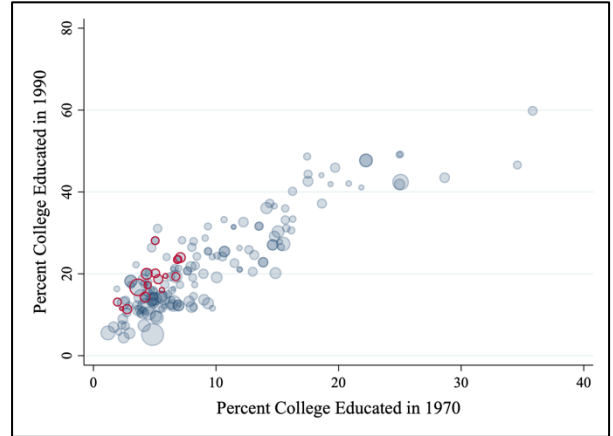
(c) 2000 versus 1970
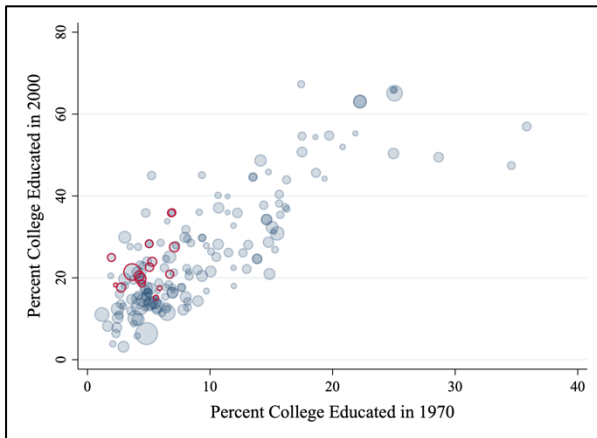
(d) 2010 versus 1970
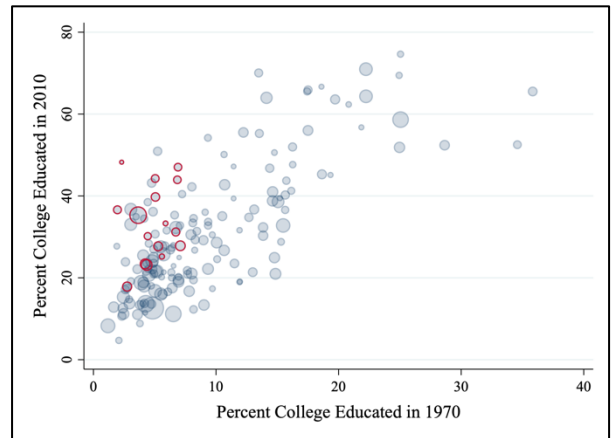
(e) 2019 versus 1970
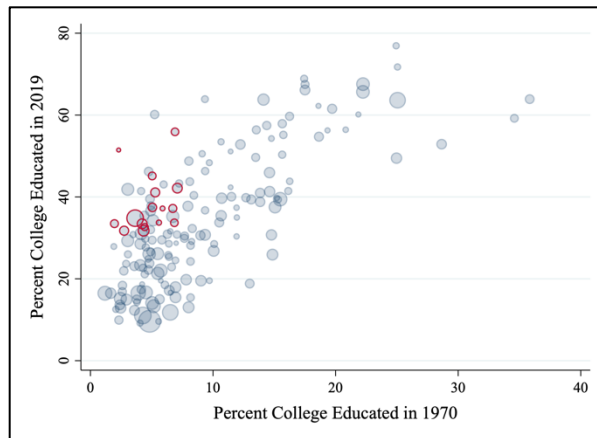
Notes: Percent college educated calculated among the population age 25 or older. Each marker represents a particular tract in Worcester County. Markers outlined in red are treated as gentrified in 2019. The size of each marker represents the tract's relative proportion of non-White people in 1970. A larger circle represents a larger share of non-White people in 1970. Marker sizes are consistent across years.

Figure 5 – Median Income Distribution by Year, Worcester County
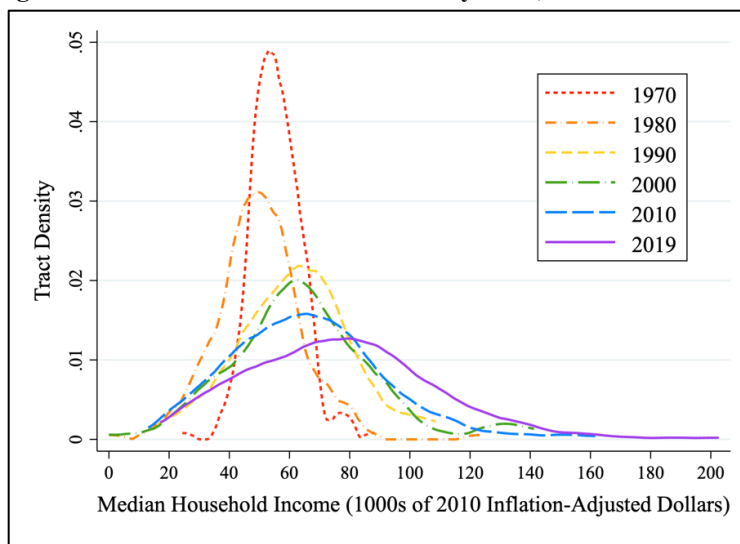
Notes: Each line is a year providing the kernel density of all tracts in Worcester County by their median income.

5.6.3 Race

Figure 6 depicts the percentage of White people in Worcester County. Worcester's share of White people has actually decreased significantly since its extremely high starting levels in 1960. While Worcester County is still Whiter than Massachusetts and the United States as a whole, in the last decade, the county's share of White people decreased at a faster rate than Massachusetts.

Figure 6 – Racial Composition Over Time
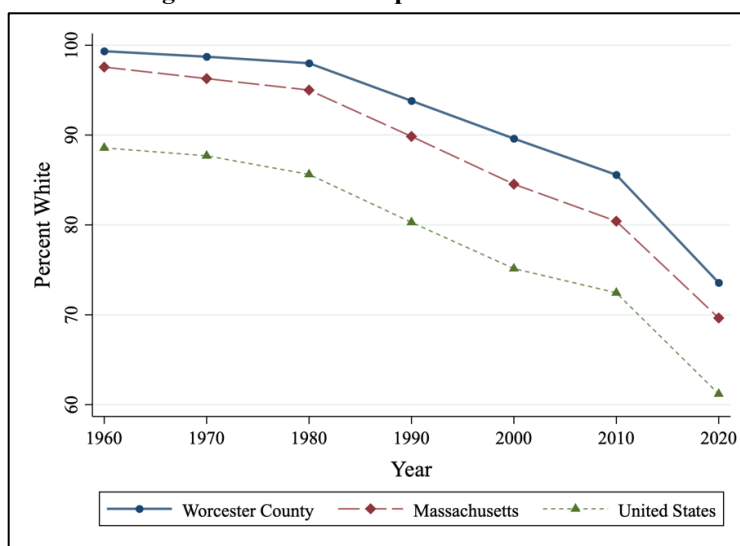
Notes: White includes Hispanic and non-Hispanic populations. Data pulled from IPUMS NGHIS.

Figure 7 – Age Distribution Over Time, Worcester County
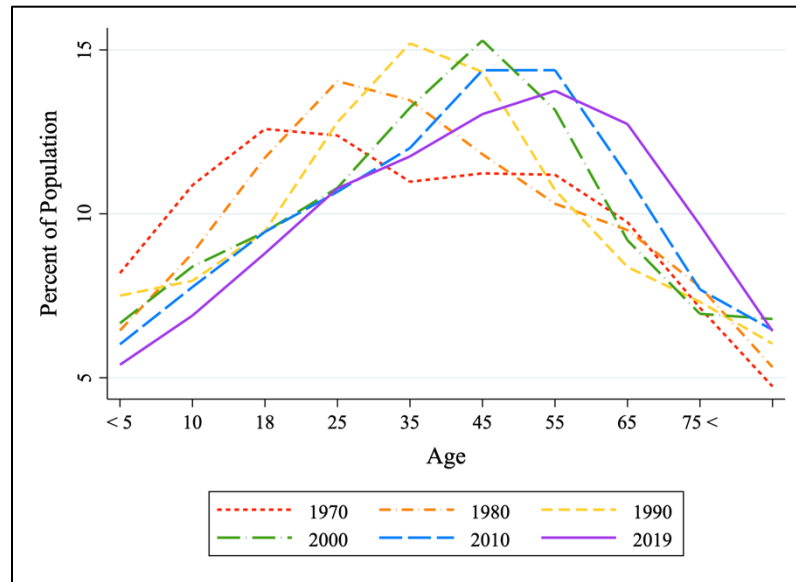
Notes: Each line is a year providing age distribution across Worcester County. The lines are smoothed using a bandwidth of 0.45. The x-axis uses age brackets and is not labeled to scale.

5.6.4 Age

Figure 7 depicts the age distribution of Worcester County residents by year. In 1970, there were more people under the age of 35 than over. Additionally, the percentage of adults between ages 25 and 55 was relatively consistent. In the following decades, a peak develops in that age group and shifts further right, indicating an increase in the median age, which may be due to the aging baby boomer population. Notably, the percentage of 25-year-olds is nearly the same in 2000 to 2019. It is possible that a younger population is moving into Worcester as baby boomers age.

6. Methodology

6.1 Process

The existing literature quantifies gentrification in varying ways. Other studies include data such as race, rent, age, and income, but I seek to study these variables as a part of outcomes or

welfare.[11] Furthermore, I want to use as few variables as possible to avoid constraining our understanding of this developing process.

Neighborhoods must initially have a less affluent population in order to gentrify. Following the most recent research, college education appears to be the most appropriate and robust measure of both gentrification and affluence. Education and income are highly correlated, and both have changed drastically over the past several decades in Worcester, thereby providing ample variation for my model. Therefore, I use college education as my primary measure of gentrification.

First, I establish which neighborhoods could potentially gentrify using each tract's baseline percentage of college-educated individuals. I categorize tracts with an education rate below the fiftieth percentile in 1970 as gentrification eligible or "gentrifiable." Tracts above the fiftieth percentile are considered "non-gentrifiable."

Next, I determine which of the gentrifiable tracts have actually gentrified. Using methods similar to Brummet and Reed (2019), I measure gentrification itself as a percentage point change from 1970 to 2019 in the share of college educated individuals aged 25 and older living in tract i:

$$(1) \; \Delta \, \% \, college_i = \%college2019_i - \%college1970_i$$

Neighborhoods experiencing large, positive changes in their share of college educated individuals are said to gentrify more than those experiencing smaller or negative changes.

Finally, I model gentrification using binary variable $gent_i$. If a neighborhood is gentrifiable and in the top half of all neighborhoods in change percent college-educated, then $gent_i$ is equal to one and the tract has gentrified. Otherwise, $gent_i$ is zero. Figure 8 provides the numerical categorization thresholds.

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[11] Additionally, neither race nor age follow the typical pattern of gentrification in Worcester. Worcester has gotten less White faster than Massachusetts and the country as a whole (Figure 6), and the population does not appear to be getting much younger (Figure 7).

Figure 8 – Gentrification Categorization Method

		(1) Percent College Educated 1970 (%)	
		Gentrifiable $\%college1970_i < 7.7\%$	Cannot be Gentrified $\%college1970_i \geq 7.7\%$
(2) Change in Percent College Educated 1970 to 2019 (pp)	$\Delta\% college_i > 26.8$	**Gentrified** $Obs: 15$	**Not Gentrified** $Obs: 40$
	$\Delta\% college_i \leq 26.8$	**Not Gentrified** $Obs: 24$	

Notes: Columns and rows are split by the median value of all 79 tracts. Units in parenthesis: percent (%) and percentage points (pp). Obs is observations or the number of tracts. First, the tracts are split into gentrifiable and non-gentrifiable. By definition, non-gentrifiable tracts cannot gentrify. Next, gentrifiable tracts are divided into gentrified and not gentrified.

6.2 Outcomes

I conduct a comparative analysis of gentrifying and non-gentrified neighborhoods, exploring how the two neighborhood types developed over time. I examine changes in observable outcomes of the neighborhood and population.

To determine the outcomes of gentrification, I estimate the following regression model:

$$(2) \; \Delta Y_{i,t} = \beta_0 + \beta_1 gent_i + \beta_2 gelig_i + \beta_3 X_{i,1970} + \beta_4 Y_{i,1970} + \epsilon_i$$

$\Delta Y_{i,t}$ measures change in an individual observable outcome variable from 1970 to year t, such as percent change in income. See Table 4 for the full list of outcome variables. Variables $gent_i$ and $gelig_i$ are the binary variables for gentrified and gentrifiable respectively. To be explicit, β_1 reflects the difference in outcomes of gentrified tracts relative to gentrifiable tracts, while β_2 reflects the difference in outcomes of gentrifiable tracts relative to non-gentrifiable tracts.[12] $X_{i,1970}$ is a vector of neighborhood characteristics in 1970, including variables such as distance from the CBD and percent renters. The full set of neighborhood characteristics is included in Table 1. $Y_{i,1970}$

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[12] The overall effect for gentrified tracts is $\beta_1 + \beta_2$.

controls for the baseline level of the outcome variable if it is not already included in the neighborhood characteristics vector.

All regressions in this paper use robust standard errors to account for heteroskedasticity. Although gentrification and other shocks are likely to be correlated across tracts and over time, I do not cluster standard errors due to the small sample size of only 79 census tracts.

6.3 Welfare

To determine gentrification's effect on welfare, I must determine who experiences the positive and negative outcomes of gentrification. I estimate a multiple regression model similar to the model I used to estimate outcomes:

$$(3)\ \Delta Ydemo_{i,2019} = \beta_0 + \beta_1 gent_i + \beta_2 gelig_i + \beta_3 X_{i,1990} + \beta_4 Ydemo_{i,1990} + \epsilon_i$$

$\Delta Ydemo_{i,2019}$ is an individual observable welfare variable. It is an outcome variable but for a particular demographic. For example, change in income for Black people from 1990 to 2019. Separating outcomes by demographic characteristics will help reveal how the outcomes of gentrification are distributed amongst the population. See Table 6 for the full demographic breakdown and Table 7 for all welfare variables. Regressors $gelig_i$ and $gent_i$ are the same. $Ydemo_{i,1990}$ is the 1990 level of the outcome variable in if it is not already in the vector $X_{i,1990}$.

I use change from 1990 to 2019 because there were so few non-White people in 1970[13] and 1980 that any estimates would be subject to bias due to the initially small sample size. Moreover, the 1970 census used race and ethnicity categories that are broader and almost discordant with today's census. Additionally, neither immigration nor the biotechnology industry began to pick up in Worcester until the early 1990s, so it is likely that change from 1990 to 2019 would still capture any significant variation in welfare.

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[13] The tract average of White people was nearly 97% in 1970.

Table 1 – Average Neighborhood Characteristics by College Attainment, 1970

Variable 1970	Gentrifiable			Not Gentrifiable	
	(1) First Quartile	(2) Second Quartile	(3) All Tracts	(4) Third Quartile	(5) Fourth Quartile
Population					
Population	4343.27	3379.58	3776.94	3720.21	3658.80
	(345.55)	(283.15)	(155.93)	(316.71)	(275.58)
Population Density	7673.95	4818.01	4694.69	3660.24	2517.71
	(1558.31)	(1285.71)	(635.26)	(1176.24)	(594.22)
Demographic					
College (%)	3.59	6.18	10.50	11.60	21.15
	(0.24)	(0.20)	(0.84)	(0.58)	(1.45)
White (%)	94.60	96.97	96.74	97.42	98.06
	(0.98)	(0.37)	(0.31)	(0.26)	(0.21)
Young Adult (%)	21.23	20.92	21.67	21.36	23.25
	(0.38)	(0.47)	(0.32)	(0.65)	(0.87)
Non-Citizen (%)	2.74	1.21	1.73	1.75	1.19
	(0.77)	(0.34)	(0.28)	(0.64)	(0.31)
Income & Poverty					
Median Income ($)	47478.39	54357.78	57486.86	59659.37	69029.02
	(1835.65)	(1320.76)	(1165.2)	(1194.48)	(1756.99)
Poverty (%)	9.25	4.78	5.38	3.82	3.60
	(1.70)	(0.67)	(0.54)	(0.41)	(0.26)
Low/High Ratio	0.05	0.02	0.03	0.01	0.01
	(0.02)	(0.00)	(0.01)	(0.00)	(0.00)
Housing					
Median Rent ($)	494.14	521.97	572.24	594.42	684.03
	(11.67)	(17.49)	(11.61)	(19.08)	(17.41)
Median Home Value ($)	74642.67	82651.17	91054.32	92623.68	1.2e+05
	(3176.40)	(2214.58)	(2218.35)	(2146.39)	(3687.80)
Vacancies (%)	54.57	37.51	35.04	29.40	17.83
	(5.29)	(4.71)	(2.63)	(4.41)	(2.58)
Renters (%)	57.57	38.75	36.43	30.27	18.20
	(5.68)	(4.95)	(2.80)	(4.62)	(2.66)
Median Year Built	1941.80	1943.85	1945.25	1944.55	1951.11
	(1.21)	(1.46)	(0.83)	(1.50)	(1.82)
Transportation					
Public Transport (%)	12.45	9.87	8.31	6.25	4.46
	(1.45)	(1.23)	(0.68)	(1.03)	(1.00)
Walking (%)	14.88	8.04	8.96	7.82	4.88
	(2.84)	(1.17)	(0.95)	(1.38)	(0.71)
Distance					
CBD (mi)	3.08	3.91	4.16	4.67	5.02
	(0.69)	(0.62)	(0.32)	(0.58)	(0.62)
Hospital (mi)	2.95	3.86	3.68	3.74	4.21
	(0.70)	(0.65)	(0.30)	(0.50)	(0.49)
College (mi)	1.52	2.22	1.74	1.45	1.78
	(0.35)	(0.45)	(0.17)	(0.25)	(0.25)
Observations	20	20	79	20	19

Notes: Means are shown with standard errors in parenthesis and standard deviations in brackets. Variables are recorded with units in parenthesis: percent (%), 2010 inflation-adjusted dollars ($), and miles (mi).

7. Results & Analysis

7.1 Process

To assess gentrification potential, I divide the census tracts into quartiles based on their 1970 share college educated such that 41 of Worcester's 79 neighborhoods could potentially be gentrified. Only tracts in the lower two quartiles of college education are considered "gentrifiable." A summary of 1970 neighborhood characteristics is provided in Table 2. For a complete set of pairwise t-tests between gentrifiable and non-gentrifiable neighborhoods, see Appendix Table 1.

Gentrifiable neighborhoods have lower median incomes than those that are not gentrifiable. The bottom quartile has a 10% poverty rate—7 percentage points higher than the top quartile. Furthermore, there is a huge gap in college attainment between gentrifiable and non-gentrifiable neighborhoods: the college education rate in the third quartile is almost double that of the second quartile.

Gentrifiable tracts are more densely populated, lending credence to the assumption that housing is a normal good. Gentrifiable tracts are closer to CBD on average, and more people walked or used public transportation to commute. However, the fourth quartile is slightly closer to the CBD than the third quartile, which may explain why its population density and share of walkers is greater. This may indicate a preference for short commutes among high-income households.

Gentrifiable neighborhoods have a lower share of White people, but all quartiles possess similar shares of young people. Median gross monthly rent prices are lower in gentrifiable tracts, with the difference ranging from about $90 to $180, which is consistent with their large vacancy rates and the older age of housing structures. Given the large percentile of vacancies, the lower rent, and the older buildings, these communities were ripe for development in 1970. However, there is a high concentration of vulnerable groups in these tracts, such as renters, non-citizens, and

non-White and low-income peoples. Gentrification could potentially put these groups at risk of displacement or other negative consequences of gentrification.

Tract characteristics in 1970 Worcester are not necessarily indicative of white flight. While tracts near the CBD have slightly lower shares of White people, and the difference is statistically significant, the average share of White people remains very high in all quartiles. Although this is inconsistent with the standard narrative of gentrification, it is not irreconcilable. It may be the result of researching gentrification in an atypical area.

To determine gentrification status, I divide tracts based on their percent change in college education rates. Tracts that are gentrifiable and have a change in their college education rate above the fiftieth percentile are considered gentrified. These tracts are mapped out in Figure 9 and summary statistics are provided in Table 2, which I will interpret in the next section.

Figure 9 – Maps of Worcester Neighborhoods by Gentrification Status
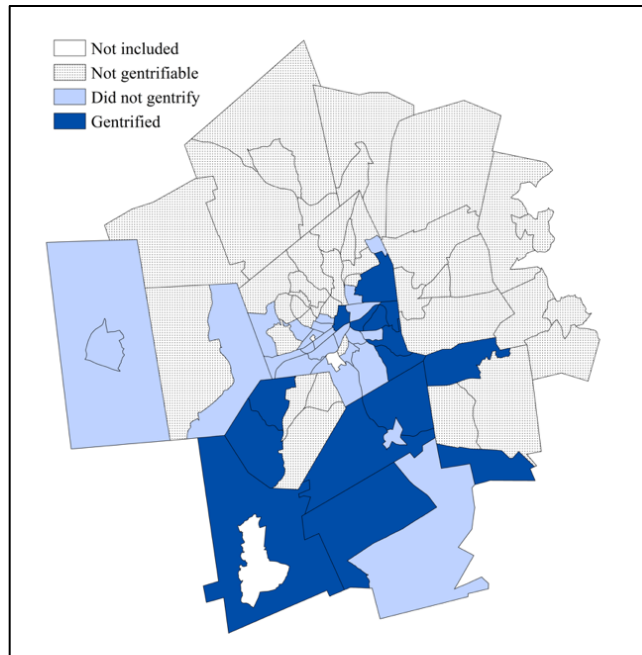
Notes: Gentrifiable tracts (light blue) are in the bottom half of college-educated tracts in 1970. Gentrified tracts (dark blue) are also gentrifiable and in the top half of my continuous gentrification measure.

Table 2 – Neighborhood Characteristics by Gentrification Status, 1970 to 2019

			Not Gentrified			
	Gentrified		Gentrifiable		Not Gentrifiable	
	(1)	(2)	(3)	(4)	(5)	(6)
	mean	% change	mean	% change	mean	% change
Population						
Population	4262.4	27.00	4317.3	12.10	4999.8	45.05
Population Density	2716.7	26.85	8060.9	12.13	3242.5	45.10
Demographic						
College (%)	38.62	828.2	19.60	358.2	48.28	228.2
White (%)	79.24	-18.40	70.20	-26.12	80.80	-17.34
Young Adult (%)	28.25	31.41	28.74	40.88	24.83	15.42
Non-Citizen (%)	7.664	6109.5	9.356	46477.2	6.864	30408.7
Income & Poverty						
Median Income	76624.1	38.07	48377.7	-2.435	90079.4	38.81
Poverty (%)	9.229	101.0	23.18	190.0	8.867	158.2
Low/High Ratio	0.104	961.8	0.459	1026.8	0.0971	625.4
Housing						
Median Rent ($)	1150.2	130.8	1065.5	113.5	1232.2	97.31
Median Home Value ($)	265440	212.3	214729.2	193.3	314225	203.6
Vacancies (%)	6.531	-79.29	9.919	-76.26	5.706	-69.42
Renters (%)	35.87	1.887	61.68	7.498	30.87	35.60
Median Year Built	1966.9		1962		1967.6	
Transportation						
Public Transport (%)	2.740	-17.32	4.616	-48.21	2.880	28.49
Walking (%)	4.211	-46.67	5.639	-60.12	2.838	-61.99
Distance						
CBD (mi)	4.346		3.005		4.784	
Hospital (mi)	4.000		3.057		3.936	
College (mi)	2.543		1.477		1.596	
Observations	15		24		41	

Notes: Gentrifiable tracts have below median shares of college-educated residents. Gentrified tracts have above median changes in the percentage of college-educated residents. Means are shown in columns 1, 3, and 5. Columns 2, 4, and 6 show average percent change from 1970 to 2019. See Table 1 for units.

7.2 Outcomes

Before beginning my regression analysis, it is worthwhile to take a preliminary look at how neighborhoods are affected by gentrification. Table 2 provides various neighborhood

characteristics in each of the three neighborhood types. For clarity, I will refer to each set of neighborhoods as gentrified (columns 1 and 2), non-gentrified (columns 3 and 4), and non-gentrifiable (columns 5 and 6). The former two are gentrifiable, and the latter two did not gentrify.

The table shows several outcomes I expect of gentrification; gentrified neighborhoods had the largest increases in college education, rent, and home value and had the largest decrease in vacancies. These neighborhoods also experienced a smaller decrease in their White population relative to non-gentrified neighborhoods. Interestingly, non-gentrified tracts are closer to the CBD and have the largest population density among the three groups. However, gentrified tracts experienced greater growth in population and population density.

Table 3 shows the full regression for percent change in median income from 1970 to 2019 for all 79 census tracts in my research area. The coefficient on gentrification is statistically significant across all the models at the 0.05 level or higher, indicating robustness. In the base specification, the coefficient is 0.17, which corresponds to a 17% increase in median income for gentrified tracts relative to all other gentrifiable tracts, all else equal. This is consistent with my hypothesis about gentrification attracting a more affluent population. Similarly, the coefficients on percent young adults and percent White are right-signed and statistically significant at the 0.10 and 0.05 levels respectively, indicating that both are positively associated with income growth.

The model predicts a 5.4% increase in income for every one-mile increase in distance from the CBD, *ceteris paribus*. While these findings do not rule out my hypothesis that tracts closer to the CBD would gentrify, Table 2 shows that gentrified tracts are about 1.3 miles further from the CBD than gentrifiable tracts on average. Moreover, the map in Figure 9 shows that tracts to the east and south of the CBD have gentrified. Although these tracts are further away than I expected, most of them are still within five miles of the CBD.

Table 3 – Effect of Gentrification on Percent Change in Income, 1970 to 2019

	(1)	(2)	(3)	(4)	(5)	(6)
				Distance +		
	Baseline 1	Baseline 2	Demographic	Transport	Housing	All
Gentrified	0.173***	0.165***	0.153***	0.158**	0.177***	0.142**
	(0.059)	(0.059)	(0.058)	(0.060)	(0.061)	(0.058)
Gentrifiable	-0.068	-0.073	-0.051	-0.034	-0.081	-0.044
	(0.059)	(0.059)	(0.059)	(0.074)	(0.059)	(0.070)
Population Density	-0.007	-0.007	-0.009	-0.005	-0.006	-0.009
	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.006)
Log income ($)	-0.452*	-0.754*	-0.675**	-0.434*	-0.404*	-0.724*
	(0.234)	(0.390)	(0.295)	(0.250)	(0.238)	(0.390)
Median Home Value ($)	0.003	0.004*	0.003*	0.003	0.003*	0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Renters (%)	-0.718***	-0.726***	-0.809***	-0.946***	0.383	-2.733
	(0.209)	(0.208)	(0.259)	(0.274)	(1.118)	(1.908)
Distance to CBD (mi)	0.054***	0.052***	0.040***	0.091***	0.051***	0.058**
	(0.009)	(0.009)	(0.009)	(0.024)	(0.010)	(0.023)
Poverty (%)		-0.988				-0.487
		(0.878)				(1.108)
White (%)			1.500**			1.602**
			(0.678)			(0.767)
Young Adult (%)			2.494*			2.344*
			(1.253)			(1.363)
Non-Citizen (%)			2.472***			2.859***
			(0.846)			(0.776)
Public Transport (%)				0.522		0.924
				(0.809)		(0.812)
Walking (%)				0.498		0.624
				(0.369)		(0.550)
Distance to Hospital (mi)				-0.034		-0.008
				(0.025)		(0.026)
Distance to College (mi)				0.004		0.002
				(0.024)		(0.024)
Median Rent ($)					-0.000	
					(0.000)	
Vacancies (%)					-1.199	1.843
					(1.182)	(1.924)
Constant	4.935*	8.191*	5.579*	4.671*	4.548*	5.792
	(2.549)	(4.209)	(3.162)	(2.769)	(2.573)	(4.437)
Observations	79	79	79	79	79	79
R-Square	0.793	0.796	0.836	0.801	0.796	0.844
Adjusted	0.772	0.773	0.806	0.768	0.769	0.797

Notes: Regression on the 79 census tracts within 10 miles of the CBD. Binary gentrification measure. All tract characteristics are included in their 1970 value. Percent change in income is calculated using natural logs. Column 1 provides the base specification. Column 2 includes the poverty rate. Columns 3 to 5 include varying sets of tract characteristics. Column 6 is the fully specified model. Columns 3 and 6 contain additional controls for the percent of children and people 18 to 24 that are not shown. See Table 1 for units. Robust standard errors in parenthesis. Significance indicated by: *** p<0.01, ** p<0.05, * p<0.10

The coefficient on the gentrifiable variable is not statistically significant for any model, but it is always negative and about half the size of the coefficient on gentrified. This may indicate that gentrifiabity has an overall suppressive effect on income growth relative to non-gentrifiable tracts, but gentrification results in larger, positive growth such that gentrifiable neighborhoods experience only a net 10.5% (0.173 – 0.068 = 0.105) increase in median income.

Table 4 – Effect of Gentrification on Outcomes, 1970 to 2019

	(1)	(2)	(3)	(4)	(5)	(6)
				Distance +		
	Baseline 1	Baseline 2	Demographic	Transport	Housing	All
Percent Change Income (%)						
Gentrified	0.173***	0.165***	0.153***	0.158**	0.177***	0.142**
	(0.059)	(0.059)	(0.058)	(0.060)	(0.061)	(0.058)
Gentrifiable	-0.068	-0.073	-0.051	-0.034	-0.081	-0.044
	(0.059)	(0.059)	(0.059)	(0.074)	(0.059)	(0.070)
Change in Employment Rate (pp)						
Gentrified	0.009	0.008	0.006	0.009	0.013	0.010
	(0.009)	(0.009)	(0.008)	(0.009)	(0.008)	(0.009)
Gentrifiable	-0.012	-0.012	-0.009	-0.009	-0.012	-0.014
	(0.008)	(0.008)	(0.008)	(0.010)	(0.009)	(0.009)
Percent Change in Rent (%)						
Gentrified	0.083	0.074	0.034	-0.015	0.109	0.042
	(0.148)	(0.157)	(0.149)	(0.153)	(0.145)	(0.159)
Gentrifiable	-0.050	-0.054	-0.013	0.166	-0.049	0.080
	(0.127)	(0.128)	(0.139)	(0.151)	(0.123)	(0.183)
Percent Change in Population (%)						
Gentrified	-0.116	-0.110	-0.160	-0.189	-0.114	-0.182
	(0.125)	(0.126)	(0.139)	(0.143)	(0.128)	(0.167)
Gentrifiable	0.016	0.020	-0.028	0.095	-0.025	0.017
	(0.146)	(0.150)	(0.149)	(0.173)	(0.153)	(0.198)
Change in Poverty Rate (pp)						
Gentrified	-0.058***	-0.058***	-0.060***	-0.049**	-0.055***	-0.041**
	(0.018)	(0.018)	(0.019)	(0.021)	(0.018)	(0.020)
Gentrifiable	0.016	0.016	0.018	0.011	0.018	0.002
	(0.015)	(0.015)	(0.015)	(0.018)	(0.015)	(0.016)
Change in Vacancy Rate (pp)						
Gentrified	-0.026**	-0.027**	-0.030**	-0.025*	-0.025**	-0.030**
	(0.012)	(0.013)	(0.013)	(0.013)	(0.012)	(0.014)
Gentrifiable	0.028**	0.027**	0.032**	0.029*	0.032**	0.032**
	(0.013)	(0.013)	(0.013)	(0.016)	(0.014)	(0.016)

Notes: Coefficients for gentrifiable and gentrified shown. Regressions run on multiple outcome variables. See Table 3 for regression details and Table 1 for units. Robust SEs in parenthesis. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 4 shows the effect of gentrification and gentrifiabity on a series of outcome variables calculated as percentage point or percent change from 1970 to 2019. The coefficients for change in poverty are as expected. According to the base specification, gentrification is associated with a 5.8 percentage point decrease in the poverty rate compared to all gentrifiable tracts. Including the demographic characteristics in column 3 causes the gentrification coefficient to grow in magnitude while the p-value remains highly significant (0.002). Even accounting for the positive gentrifiable coefficient, leaves a net 4.2 percentage point reduction in the poverty rate, *ceteris paribus*.

None of the coefficients for change in employment, rent, or population are statistically significant. The coefficients suggest anywhere from a 2% to 15% net increase in rent and predict that non-gentrified tracts have lower rents relative to all other tracts, but this is not enough information to conclude that gentrification causes rents to increase. Employment rate has one marginally significant coefficient in column 6 that implies gentrification is associated with a 1 percentage point increase in employment, all else equal. However, these results appear negligible when accounting for the negative gentrifiable coefficient of similar magnitude. The gentrification coefficient for change in population in column 4 is also marginally significant and negative. Though the results vary slightly between models, it appears that gentrified tracts experienced a net loss in population from 1970 to 2019.

The coefficients of interest for change in the vacancy rate are all statistically significant at some level and imply an almost 3 percentage point decrease in vacancies amongst gentrified tracts and relative to gentrifiable tracts. Gentrifiable tracts are associated with an almost 3% percentage point increase in the vacancy rate of non-gentrified neighborhoods relative to non-gentrifiable neighborhoods. Thus, gentrified neighborhoods do not experience any net change in their vacancy rates relative to non-gentrifiable neighborhoods.

Table 5 shows the baseline regression run over several years. Detailed tables for each year can be found in the Appendix. Measures of gentrification and gentrifiable are consistent across years such that tracts treated as gentrified in 2019 are treated as gentrified in 1980, 1990, and so forth. I calculate outcomes as a change from 1970 to a given year.

As expected, the effect of gentrification diminishes as we approach 1970. The effect on income remains positive and statistically significant in 2010; gentrification is associated with a 11% increase in income relative to gentrifiable tracts, all else equal. Though there may have been some fluctuation between decades, it appears that the majority of income growth in 2019 may have occurred before 2010.

The gentrification coefficient for change in poverty rate and employment fluctuates over time with both being right-sided and statistically significant at the 0.1 level in 2000. Employment was 1.5 percentage points higher, and the poverty rate was 3.8 percentage points lower relative to all gentrifiable tracts. Similarly, the gentrifiable coefficient was right-sided and statistically significant at the 0.05 level in 2000. These results indicate that gentrification may have begun to have a significant effect on neighborhood outcomes as early as 2000.

Interestingly, the regression suggests that rents were increasing in all gentrifiable neighborhoods relative to non-gentrifiable neighborhoods before 2019. Though these results are not statistically significant, it could indicate a change in supply or demand, such as deterioration of the housing stock. This seems plausible given that decreases in the vacancy rate of gentrified neighborhoods relative to all other gentrifiable neighborhoods only appear in 2019 as well. It could be possible that Worcester has only recently begun to reach a tipping point for gentrification, such as a sufficiently large rent gap.

Table 5 – Effect of Gentrification on Outcomes Over Time

	(1) 2019	(1) 2010	(1) 2000	(1) 1990	(1) 1980
Percent Change Income (%)					
Gentrified	0.173***	0.110*	0.074	0.034	0.018
	(0.059)	(0.064)	(0.056)	(0.047)	(0.036)
Gentrifiable	-0.068	-0.091	-0.026	-0.036	-0.009
	(0.059)	(0.075)	(0.051)	(0.048)	(0.040)
Change in Employment Rate (pp)					
Gentrified	0.009	-0.011	0.015*	0.001	0.001
	(0.009)	(0.010)	(0.009)	(0.009)	(0.007)
Gentrifiable	-0.012	0.000	-0.005	0.004	-0.003
	(0.008)	(0.011)	(0.008)	(0.008)	(0.005)
Percent Change in Rent (%)					
Gentrified	0.083	0.163	0.035	0.042	0.037
	(0.148)	(0.142)	(0.056)	(0.079)	(0.056)
Gentrifiable	-0.050	0.015	0.012	0.016	0.040
	(0.127)	(0.109)	(0.067)	(0.071)	(0.056)
Percent Change in Population (%)					
Gentrified	-0.116	-0.149	-0.110	-0.112	-0.084*
	(0.125)	(0.121)	(0.099)	(0.074)	(0.046)
Gentrifiable	0.016	-0.004	0.011	0.022	-0.013
	(0.146)	(0.139)	(0.109)	(0.077)	(0.053)
Change in Poverty Rate (pp)					
Gentrified	-0.058***	-0.002	-0.038*	-0.019	-0.007
	(0.018)	(0.023)	(0.021)	(0.019)	(0.016)
Gentrifiable	0.016	-0.007	0.021	0.013	0.007
	(0.015)	(0.018)	(0.018)	(0.015)	(0.014)
Change in Vacancy Rate (pp)					
Gentrified	-0.026**	0.009	-0.002	0.018	0.008
	(0.012)	(0.015)	(0.004)	(0.013)	(0.008)
Gentrifiable	0.028**	0.003	0.008**	-0.004	-0.001
	(0.013)	(0.015)	(0.004)	(0.010)	(0.006)

Notes: Coefficients for gentrifiable and gentrified shown. Gentrifiable and gentrified values are consistent across years for each tract. All regressions run using the base specification. Outcomes are multiple variables over multiple years. Outcome variables are calculated relative to their 1970 value. See Table 3 for regression and model details. Robust SEs in parenthesis. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

7.3 Welfare

Table 6 shows the main coefficients of interest for my regression predicting change in various demographic variables from 1990 to 2019. Columns 2 through 6 specify race and ethnicity such that each person is only counted in one column. Few of the coefficients are statistically

Table 6 – Effect of Gentrification on Demographic Makeup, 1990 to 2019

| | (1) | Race & Ethnicity | | | | | (7) | (8) | (9) |
| | | (2) | (3) | (4) | (5) | (6) | | | |
	Total (%)	White (pp)	Black (pp)	AAPI (pp)	Other (pp)	Hispanic (pp)	Young (pp)	Non-Citizen (pp)	Renters (pp)
Gentrified	0.033	0.058	-0.026	0.013	0.002	-0.039*	-0.038	-0.042	-0.045
	(0.072)	(0.043)	(0.021)	(0.020)	(0.008)	(0.023)	(0.033)	(0.035)	(0.032)
Gentrifiable	0.031	-0.088**	0.031	0.009	-0.006	0.051**	0.003	0.006	0.008
	(0.059)	(0.039)	(0.021)	(0.022)	(0.010)	(0.022)	(0.027)	(0.029)	(0.027)
Observations	79	79	79	79	79	79	79	79	79

Notes: Only coefficients for gentrifiable and gentrified shown. All regressions run using the base specification. See Table 3 for model details. Regressions predict growth in demographic populations from 1990 to 2019. Columns 2 to 5 are non-Hispanic. Units are in parenthesis: percent (%) and percentage point (pp). Robust SEs in parenthesis. Significance: *** p<0.01, ** p<0.05, * p<0.10

significant, but I still interpret these outcomes to discuss the implications of population change. Additionally, the majority of this analysis is conducted on the White, Black, and Hispanic parts of the population, which each have marginally significant p-values of 0.20 or less for both regressors. It is also important to note that even in 1990, tracts were 90% White on average, so the initial sample size for minorities was still relatively small.[14]

All tracts experienced an increase in population size. The model associates gentrification with a 6.4% net increase in population, *ceteris paribus*—3.1% is for all gentrifiable tracts and 3.4% is for gentrified tracts specifically. Both gentrifiable and gentrified tracts saw small increases in their AAPI population, with the net increase in gentrifiable tracts being slightly larger.

The model predicts modest decreases in the percentage of young adults, renters, and non-citizens in gentrified tracts relative to all other tracts. These differences are not statistically significant at standard levels but have p-values below 0.25. For change in renters, the gentrified

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[14] In 2019, tracts were 68% White on average.

coefficient (p=0.17) implies that there is a 4.5 percentage point reduction in renters relative to gentrifiable communities.

Perhaps the most noteworthy results can be found amongst the White, Black, and Hispanic populations. Relative to non-gentrifiable neighborhoods, gentrifiable neighborhoods experience a statistically significant decrease in their White population (8.8 percentage points), an increase in the Black population (3.1 percentage points), and a statistically significant increase in their Hispanic population (5.1 percentage points).

The coefficients indicate that gentrified tracts experience an increase in the White population (5.8 percentage points) and a decrease in their Black (2.6 percentage points) and Hispanic (5.1 percentage points) populations, relative to gentrifiable tracts. Though the net effect in gentrified neighborhoods relative to non-gentrifiable tracts is signed the opposite way, these results are still interesting as they present evidence of Black and Hispanic displacement from gentrified neighborhoods into gentrifiable neighborhoods. The increase in the positive gentrified coefficient for the White population is practically offset by the negative coefficients from the Black and Hispanic populations ($0.058 - 0.026 - 0.039 \approx 0$). The population shifts are similarly offset in gentrifiable tracts ($-0.088 + 0.031 - 0.051 \approx 0$). It remains unclear whether this displacement is involuntary or not.

With these new findings in mind, I now explore Table 7 to determine who benefits and loses from gentrification in Worcester. Table 7 presents the results of the baseline regression on several outcomes separated by race and ethnicity. Unlike in Table 6, columns 2 through 5 include both Hispanic and non-Hispanic people of that particular race. The 1990 data was only disaggregated by both race and ethnicity for population counts. Outcome variables were not disaggregated by other demographic characteristics of interest such as citizenship status.

Table 7 – Effect of Gentrification on Welfare by Race and Ethnicity, 1990 to 2019

	(1) Total	(2) White	(3) Black	(4) AAPI	(5) Hispanic
A. College Attainment (pp)					
Gentrified	0.120***	0.091***	0.008	0.304**	0.117
	(0.02)	(0.02)	(0.09)	(0.13)	(0.07)
Gentrifiable	-0.081***	-0.065**	-0.155*	-0.150	-0.209***
	(0.03)	(0.03)	(0.08)	(0.12)	(0.06)
Observations	79	79	72	75	77
B. Log Median Income (%)					
Gentrified	0.152***	0.129**	0.556**	-0.073	0.375*
	(0.05)	(0.06)	(0.23)	(0.29)	(0.20)
Gentrifiable	-0.063	-0.078	0.016	0.135	-0.192
	(0.06)	(0.06)	(0.26)	(0.37)	(0.26)
Observations	79	79	35	32	53
C. Poverty Rate (pp)					
Gentrified	-0.049***	-0.059***	-0.103	0.038	-0.043
	(0.01)	(0.02)	(0.11)	(0.04)	(0.09)
Gentrifiable	-0.009	0.008	0.049	-0.124**	0.002
	(0.01)	(0.02)	(0.09)	(0.06)	(0.05)
Observations	79	79	74	76	78
D. Employment Rate (pp)					
Gentrified	0.011	0.008	0.039	-0.034	0.054**
	(0.01)	(0.01)	(0.03)	(0.03)	(0.02)
Gentrifiable	-0.022**	-0.017**	0.011	-0.018	-0.015
	(0.01)	(0.01)	(0.05)	(0.02)	(0.03)
Observations	79	79	73	74	77

Note: All regressions run using the base specification. See Table 3 for model details. Column 1 includes the whole population. Columns 2 to 4 are separated by race. Column 5 includes all Hispanic people in the tract regardless of race. The AAPI column for Log Median Income only includes Asians and does not include Pacific Islanders. Units are in parenthesis: percentage point change (pp) and percentage change (%). Robust SEs in parenthesis.
Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Part A of Table 7 shows which groups had the largest increases in education and therefore helped propel gentrification. Gentrified tracts are predicted to experience 12% growth in their college education rate compared to gentrifiable tracts. This change appears to be largely driven by the White and AAPI populations. These groups both have had an increased presence in gentrified tracts since 1990, indicating that changes in educational attainment can likely be attributed to gentrification by in-movers rather than improvements in educational outcomes of existing

residents and their children. The model only predicts a 0.8 percentage point increase in college education amongst the Black population but predicts a marginally significant 11.7 percentage point increase amongst the Hispanic population in gentrified tracts relative to gentrifiable tracts.

In non-gentrified tracts, the education rate is decreasing among all race groups, particularly amongst the Black (-15.5 percentage points) and Hispanic populations (-20.9 percentage points) who experience large and statistically significant decreases relative to non-gentrifiable tracts. These declines are large enough that the Black and Hispanic populations in gentrified neighborhoods actually experience a net decrease in their education rate relative to non-gentrifiable neighborhoods. However, the White and AAPI populations have a net increase in their education rate.

In terms of income, the model associates gentrification with large and statistically significant increases in median income for White, Black, and Hispanic people relative to other gentrifiable tracts. Though the Black and Hispanic populations in gentrified tracts decrease, those who remain are predicted to receive 55.6% and 37.5% increases in median income respectively. This increase remains large when accounting for the coefficients on the gentrifiable regressor.

Interestingly, the model does not predict increases in median income nor decreases in the poverty rate of the AAPI population to match their increase in education. Instead, the model predicts an increase in median income for Asian[15] people across all gentrified tracts, but a relative decrease if they gentrify. Similarly, the AAPI gentrifiable coefficient is associated with a 12.4 percentage point reduction in the poverty rate, but a relative increase if the tracts gentrify.

The poverty rate in gentrified tracts is predicted to be 4.9 percentage points lower compared to gentrifiable tracts. This decrease appears to be driven primarily by the White and Hispanic

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[15] Median income variable does not account for Pacific Islanders. However, Pacific Islanders made up only 1.5% in 2000 and 2.9% in 2019 of the overall AAPI population.

populations who experience 5.9 and 12.4 statistically significant percentage point reductions in their respective poverty rates. Hispanic people may be counted in any of the other race columns, most typically White and Black. Thus, it is possible that the negative coefficient predicting the White poverty rate is larger than it would have been if I could have separated the two groups. The model also predicts a 10.3 percentage point reduction in the poverty rate amongst Black people in gentrified neighborhoods, but this value is not statistically significant.

Finally, the employment rate in gentrifiable tracts is expected to decrease by 2.2 percentage points relative to non-gentrifiable tracts, all else constant. There is a predicted statistically significant decrease in employment amongst the White population in gentrifiable tracts, and a net decrease of about 1 percentage point in gentrified tracts. The model predicts a relative and net increase in the employment rate for both Black and Hispanic people in gentrified tracts, though only the Hispanic gentrified coefficient is statistically significant at the 0.05 level.

7.4 Interpretation

In my outcomes analysis, I find that gentrification makes neighborhoods in Worcester better off overall. Gentrified tracts experience large and statistically significant increases in income and decreases in poverty relative to all other census tracts. Additionally, there is insufficient evidence to conclude that gentrification causes rent prices to rise, and population appeared to be decreasing as a result of gentrification. Given this and the initially high vacancy rate, one might assume that the benefits of gentrification are shared equally and that nobody is displaced.

My welfare analysis shows that this is not that case. Disaggregating the outcome variables by race revealed modest evidence of White people displacing Black and Hispanic residents from gentrified tracts and into gentrifiable tracts where they experience worse outcomes, such as lower incomes, employment, and college-attainment. While I do not have information on geographic

mobility and hence cannot say for certain that White in-movers displaced the original Black and Hispanic residents, it seems highly plausible given the evidence and the overall population increases—especially since the demographic shifts offset each other nearly perfectly.

I cannot prove that this was, indeed, involuntary displacement. I do not have statistically significant evidence of increases in the cost of living typically associated with gentrification. Black and Hispanic residents may have chosen to move for a variety of reasons. However, there is statistically significant evidence of a decrease in the vacancy rate of gentrified tracts relative to non-gentrified tracts. Given the laws of supply and demand, it is likely that the cost of rent is increasing in places where the number of vacancies is decreasing. Table 2 also shows that rent levels are higher in gentrified neighborhoods than in the other gentrifiable neighborhoods. Since these tracts initially had high Black and Hispanic poverty rates, it is plausible that these residents were indeed involuntarily displaced due to a higher cost of living.

Involuntary displacement does not necessarily harm to out-movers if residents are unhappy with how their neighborhood has changed. While I cannot measure neighborhood satisfaction rates, it is worth noting that Black and Hispanic people gentrifiable tracts are better off in terms of income, poverty, and education relative to non-gentrifiable tracts.

My findings conflict with some of the literature that does not find evidence of displacement, but these results already vary greatly between cities and studies. My results do align with the those of Brummet and Reed (2019) who also find modest out migration and observe that original residents who stay benefit from declining poverty exposure.

8. Conclusion

This paper aims to identify the outcomes and welfare implications of gentrification in Worcester, Massachusetts. My results suggest that overall, gentrification does have a statistically

significant and differential impact on outcomes and welfare in Worcester. Gentrification is associated with large positive increases in income and reductions in poverty and neighborhood vacancy rates. However, these positive outcomes are not distributed equally. I find evidence that White people displace Black and Hispanic residents from gentrified tracts into gentrifiable tracts that did not gentrify. They experience worse outcomes in these tracts, such as lower incomes, employment, and college-attainment. It is plausible that they were displaced due to higher costs of living in gentrified neighborhoods. Black and Hispanic residents who remained in gentrified neighborhoods experienced large increases in education and income. Due to data limitations, I cannot conclude that these effects are due to in-movement of White people and out-movement of Black and Hispanic people. However, given the shifts in population, this is also a likely explanation.

My hypothesis was correct—gentrification improves an area overall, but the benefits are not shared equally. In fact, those harmed by gentrification in Worcester are already part of America's most vulnerable populations. If it is indeed the case that increased housing costs in gentrified neighborhoods caused people to be displaced, then the City of Worcester may benefit from increasing affordable housing options in these areas.

I find additional evidence that gentrification in Worcester may have begun as early as 2000, but the bulk of the changes in outcomes occurred between 2010 and 2019. Regardless, these results indicate that gentrification is a long-term process. As Worcester continues to gentrify and stakeholders look to the city in pursuit of economic growth, it is important for policy makers to account for the welfare of *all* Worcester residents.

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10. Appendix

Appendix Table 1 - Neighborhood Characteristics by Gentrification Potential, 1970

	(1)	(2)	(3)
	Not Gentrifiable	Gentrifiable	Difference
Population			
Population	3580.28	3861.43	-281.15
Population Density	3725.45	6245.98	-2520.52*
Demographic			
College (%)	17.41	4.89	12.52***
White (%)	97.49	95.79	1.70***
Young Adult (%)	21.41	21.07	0.34
Non-Citizen (%)	1.41	1.98	-0.57
Income & Poverty			
Median Income	63436.48	50918.08	12518.40***
Poverty (%)	4.17	8.18	-4.01***
Low/High Ratio	0.02	0.05	-0.03**
Housing			
Median Rent ($)	638.07	508.05	130.02***
Median Home Value ($)	98717.42	78646.92	20070.50***
Vacancies (%)	22.60	46.04	-23.44***
Renters (%)	23.78	48.16	-24.38***
Median Year Built	1947.55	1942.83	4.72***
Transportation			
Public Transport (%)	5.11	11.16	-6.05***
Walking (%)	8.69	11.46	-2.77
Distance			
CBD (mi)	4.68	3.49	1.19*
Hospital (mi)	3.86	3.40	0.46
College (mi)	1.53	1.87	-0.34
Observations	41	40	

Notes: See Table 1. Low/high ratio is the number of individuals whose income is 0.75 times the poverty level over those whose income is 2.00 times the level. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

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<div align="center">**Appendix Table 2 - Effect of Gentrification on Outcomes, 1980**</div>

	(1)	(2)	(3)	(4)	(5)	(6)
				Distance +		
	Baseline 1	Baseline 2	Demographic	Transport	Housing	All
Percent Change Income (%)						
Gentrified	0.018	0.016	0.018	0.026	0.012	0.023
	(0.036)	(0.036)	(0.033)	(0.037)	(0.037)	(0.036)
Gentrifiable	-0.009	-0.011	-0.009	-0.024	-0.022	-0.031
	(0.040)	(0.040)	(0.040)	(0.046)	(0.038)	(0.044)
Change in Employment Rate (pp)						
Gentrified	0.001	-0.000	-0.002	0.004	-0.001	-0.002
	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)
Gentrifiable	-0.003	-0.003	0.000	-0.006	-0.002	-0.002
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
Percent Change in Rent (%)						
Gentrified	0.037	0.025	-0.006	0.033	0.047	0.028
	(0.056)	(0.056)	(0.055)	(0.056)	(0.055)	(0.061)
Gentrifiable	0.040	0.032	0.078	0.095	0.040	0.073
	(0.056)	(0.054)	(0.055)	(0.059)	(0.054)	(0.064)
Percent Change in Population (%)						
Gentrified	-0.084*	-0.081*	-0.089*	-0.110**	-0.085*	-0.120**
	(0.046)	(0.045)	(0.047)	(0.050)	(0.047)	(0.052)
Gentrifiable	-0.013	-0.011	-0.021	-0.028	-0.002	-0.021
	(0.053)	(0.054)	(0.057)	(0.065)	(0.050)	(0.067)
Change in Poverty Rate (pp)						
Gentrified	-0.007	-0.007	-0.009	-0.007	-0.006	-0.010
	(0.016)	(0.016)	(0.015)	(0.017)	(0.016)	(0.015)
Gentrifiable	0.007	0.007	0.007	0.012	0.009	0.016
	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)	(0.013)

Notes: See Table 4. Robust SEs in parenthesis. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Appendix Table 3 - Effect of Gentrification on Outcomes, 1990

	(1)	(2)	(3)	(4)	(5)	(6)
				Distance +		
	Baseline 1	Baseline 2	Demographic	Transport	Housing	All
Percent Change Income (%)						
Gentrified	0.034	0.023	0.026	0.030	0.014	-0.017
	(0.047)	(0.047)	(0.046)	(0.048)	(0.046)	(0.044)
Gentrifiable	-0.036	-0.043	-0.031	-0.092	-0.048	-0.058
	(0.048)	(0.048)	(0.050)	(0.057)	(0.040)	(0.050)
Change in Employment Rate (pp)						
Gentrified	0.001	-0.001	-0.000	0.003	-0.004	-0.003
	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)
Gentrifiable	0.004	0.003	0.005	-0.006	0.002	-0.005
	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)
Percent Change in Rent (%)						
Gentrified	0.042	0.028	-0.003	0.021	0.055	0.016
	(0.079)	(0.079)	(0.072)	(0.085)	(0.082)	(0.084)
Gentrifiable	0.016	0.005	0.053	0.090	0.016	0.052
	(0.071)	(0.073)	(0.068)	(0.084)	(0.071)	(0.083)
Percent Change in Population (%)						
Gentrified	-0.112	-0.106	-0.120	-0.147*	-0.106	-0.145*
	(0.074)	(0.073)	(0.079)	(0.082)	(0.074)	(0.084)
Gentrifiable	0.022	0.025	-0.001	0.001	0.015	-0.018
	(0.077)	(0.079)	(0.082)	(0.093)	(0.079)	(0.103)
Change in Poverty Rate (pp)						
Gentrified	-0.019	-0.019	-0.019	-0.024	-0.011	-0.008
	(0.019)	(0.019)	(0.017)	(0.019)	(0.017)	(0.015)
Gentrifiable	0.013	0.013	0.010	0.031*	0.013	0.017
	(0.015)	(0.015)	(0.014)	(0.017)	(0.012)	(0.013)

Notes: See Table 4. Robust SEs in parenthesis. Significance: *** p<0.01, ** p<0.05, * p<0.10

Appendix Table 4 - Effect of Gentrification on Outcomes, 2000

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline 1	Baseline 2	Demographic	Distance + Transport	Housing	All
Percent Change Income (%)						
Gentrified	0.074	0.064	0.057	0.048	0.069	0.020
	(0.056)	(0.056)	(0.054)	(0.058)	(0.058)	(0.054)
Gentrifiable	-0.026	-0.032	-0.022	-0.040	-0.040	-0.043
	(0.051)	(0.051)	(0.051)	(0.056)	(0.048)	(0.051)
Change in Employment Rate (pp)						
Gentrified	0.015*	0.012	0.008	0.016*	0.015	0.011
	(0.009)	(0.009)	(0.008)	(0.010)	(0.009)	(0.008)
Gentrifiable	-0.005	-0.007	0.002	-0.009	-0.005	-0.007
	(0.008)	(0.007)	(0.007)	(0.009)	(0.008)	(0.008)
Percent Change in Rent (%)						
Gentrified	0.035	0.016	-0.005	-0.025	0.048	-0.012
	(0.056)	(0.055)	(0.048)	(0.061)	(0.057)	(0.063)
Gentrifiable	0.012	-0.002	0.044	0.086	0.012	0.035
	(0.067)	(0.067)	(0.061)	(0.075)	(0.068)	(0.071)
Percent Change in Population (%)						
Gentrified	-0.110	-0.103	-0.132	-0.180	-0.102	-0.167
	(0.099)	(0.099)	(0.107)	(0.113)	(0.100)	(0.120)
Gentrifiable	0.011	0.015	-0.028	0.030	-0.001	-0.027
	(0.109)	(0.111)	(0.111)	(0.131)	(0.113)	(0.140)
Change in Poverty Rate (pp)						
Gentrified	-0.038*	-0.038*	-0.042**	-0.046**	-0.032	-0.036*
	(0.021)	(0.021)	(0.021)	(0.022)	(0.021)	(0.019)
Gentrifiable	0.021	0.021	0.021	0.042**	0.017	0.035*
	(0.018)	(0.018)	(0.018)	(0.021)	(0.017)	(0.018)

Notes: See Table 4. Robust SEs in parenthesis. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Appendix Table 5 - Effect of Gentrification on Outcomes, 2010

	(1)	(2)	(3)	(4)	(5)	(6)
				Distance +		
	Baseline 1	Baseline 2	Demographic	Transport	Housing	All
Percent Change Income (%)						
Gentrified	0.110*	0.098	0.093	0.093	0.105	0.062
	(0.064)	(0.066)	(0.060)	(0.067)	(0.065)	(0.060)
Gentrifiable	-0.091	-0.098	-0.081	-0.136	-0.112	-0.125
	(0.075)	(0.076)	(0.077)	(0.093)	(0.076)	(0.091)
Change in Employment Rate (pp)						
Gentrified	-0.011	-0.013	-0.013	-0.013	-0.015	-0.020*
	(0.010)	(0.010)	(0.011)	(0.011)	(0.010)	(0.012)
Gentrifiable	0.000	-0.001	0.003	-0.005	0.001	0.002
	(0.011)	(0.011)	(0.011)	(0.012)	(0.010)	(0.013)
Percent Change in Rent (%)						
Gentrified	0.163	0.156	0.121	0.073	0.170	0.081
	(0.142)	(0.146)	(0.140)	(0.139)	(0.147)	(0.139)
Gentrifiable	0.015	0.009	0.058	0.226*	0.015	0.214
	(0.109)	(0.108)	(0.111)	(0.123)	(0.110)	(0.139)
Percent Change in Population (%)						
Gentrified	-0.149	-0.144	-0.177	-0.224*	-0.143	-0.219
	(0.121)	(0.122)	(0.136)	(0.131)	(0.124)	(0.152)
Gentrifiable	-0.004	-0.001	-0.033	0.019	-0.043	-0.026
	(0.139)	(0.142)	(0.147)	(0.157)	(0.145)	(0.185)
Change in Poverty Rate (pp)						
Gentrified	-0.002	-0.002	-0.005	-0.004	0.004	0.007
	(0.023)	(0.023)	(0.022)	(0.023)	(0.022)	(0.022)
Gentrifiable	-0.007	-0.007	-0.007	0.009	-0.007	0.002
	(0.018)	(0.018)	(0.019)	(0.022)	(0.016)	(0.021)

Notes: See Table 4. Robust SEs in parenthesis. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$