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Travel Behavior Change and Economic Transition in Gentrified Neighborhoods

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Abstract

Post-industrial cities in the US have experienced social and economic transitions, mostly in declining downtown neighborhoods. This process, known as gentrification, typically involves revitalization that reverses the decline and disinvestment in inner-city neighborhoods. The industrial shift increased the demand for housing near downtown. The employment of college-educated and high-skill workers has been centralized, while low-skilled jobs continue to decline downtown. While the impacts of gentrification on housing and residential displacement is frequently investigated, little attention has been given to its impact on travel behavior change and economic transition, which is the focus of this research. Change in travel behavior is shown to be primarily related to distance to the workplace, spatial context, and individual attitude. Gentrification inherently encompasses all three attributes: contextual change for in-movers and out-movers is associated with residential relocation and potential employment change. The upgrading neighborhoods tend to witness economic restructuring and higher growth rates in the knowledge-based economy, local retail establishments, and other services that did not previously capture those markets.

The purpose of this dissertation is to shed light on the change in job and commuting patterns in gentrified neighborhoods located within the 98 most populated U.S. MSAs between 2000 and 2019 by using a longitudinal quasi-experimental research design. This study adopts a quantitative definition to select the potentially gentrifying and gentrified tracts with minor changes. The study uses two sets of t-tests to compare first between changes in job and travel to work in gentrified and non-gentrified tracts. Second, to detect whether a gentrified tract

witnessed statistically significant differences regarding the travel and job variables at the start and end of the period. The data analysis continues with a series of two-way ANOVA to further explore the combined effect of gentrification and other control variables on job and travel behavior. This result shows that gentrification comes along with densification, racial turnover, less unemployment, more professionalism, and less service jobs. While residents of gentrified neighborhoods had higher average vehicle ownership, their overall auto trip decreased at a sharper rate. Nonetheless, the overall sustainable travel had risen in gentrified neighborhoods. This study is an important scholarly work because it adds to the field of research pertaining to housing demand and transportation. Densification can potentially bring jobs and daily destinations closer. Densification in a combination with TOD and/ or mixed-use development can strongly reduce driving and promote sustainable transportation.

Chapter I: Introduction

Post-industrial cities in the U.S. have experienced social and economic transitions, mostly in declining downtown neighborhoods. The process, known as gentrification, typically involves revitalization that reverses the decline and disinvestment in inner-city neighborhoods. Gentrification has had many definitions over time. Recent literature defines gentrification as a process of neighborhood change characterized by increased investment, a rise in housing values, and a change in neighborhood class composition [1] [2] [3]. In the US, inner-city gentrification has captured urban planning policymakers' and scholars' attention since the 1970s, when the federal urban renewal program displaced low-income communities [4]. During the 1990s, deindustrialization changed the urban labor market from factory work to retail services. Studies showed that gentrification in this era was associated with industrial restructuring and improved employment for downtown residents [5] [6] [7].

The industrial shift increased the demand for housing near downtown. Incumbent residents who previously worked in the goods-producing sector, experienced job losses even if the area gained more jobs overall. However, the new business establishments, which do not require technical skills or college-educated professionals, will be able to hire long-lasting community members [8]. This helps explain the complexity of this phenomenon and why, after fifty years of discussion, there is no universal method to predict and measure gentrification.

The gentrification trend has accelerated with an increase in millennial and baby boomer migration to downtown neighborhoods [4]. With the rise of the creative class in the 2000s, the

central cities had undergone even more drastic transformations. The employment of college-educated and high-skill workers has been centralized, while low-skilled jobs continue to decline downtown [9]. The creative class theory by Richard Florida suggests that creative workers are attracted by lifestyle elements those downtown areas offer, including public transit, job access, and availability of bars and restaurants. In this sense, gentrification is competition among classes to capture the locational advantages of urban resources. Individuals may be willing to undertake higher housing costs to gain additional benefits from the desired residential locations [10]. These first waves of gentrifies are usually portrayed as low-to middle class, non-Hispanic white, -educated, who frequently hold art and educational occupations. Researchers have identified a combination of cultural, political, and economic motivations for the new middle class to move into the central neighborhoods. Cultural capital and access to a job or recreational opportunities alongside low housing value make neighborhoods attractive to in-movers.

Neighborhoods are a source of inequality, and gentrification, as a distinct form of neighborhood upgrading, may lead to limiting opportunities for incumbent residents through producing less affordable housing and transforming the landscape of employment [11]. Displacement, a central concern of gentrification, takes place through a shift in racial makeup and prices poorer households out. Racial dynamics in the gentrification process have transitioned due to the arrival of white in-movers in the places that were historically occupied by people of color. Income dynamics are also critical in the investigation of gentrification due to their impact on housing affordability. Median household income is used as a predictor factor of mobility. Rental inflation and increased home values force low-status households to move away from their

place, therefore contributing to urban poverty regeneration. The inevitable and undesirable displacement of vulnerable groups goes beyond a physical dislocation to the destruction of the social meaning attached to their place.

Statement of the Problem

Many studies have investigated the impacts of gentrification on housing and residential displacement [2] [3] [12]. Still, little attention has been given to its impact on travel behavior change and economic transition, which is the focus of this research. Change in travel behavior is shown to be primarily related to the distance to the workplace, spatial context, and individual attitude [13] [14]. Gentrification inherently encompasses all three attributes: contextual change for in-movers and out-movers is associated with residential relocation and potential employment change. Numerous studies have described that the living place has an underlying role in determining people's travel behavior [15] [16]. A mixed-use development, transit-oriented development (TOD), proximity to the transit station, and active transportation facilities encourages walking, cycling, and use of public transit. However, the extent to which spatial context has a causal role in commute mode choice is still unclear. Some people simply move into the neighborhoods that would enable them to travel in their desired way [17] [18]. Travel behavior might also change due to the attitude of new residents who may have different values and pro-environmental beliefs and intend to switch from automobile travel. When residential location choice is based on broader considerations than just housing affordability, a modal shift may occur.

Other studies have observed employment growth and industrial restructuring in gentrifying

neighborhoods [8] [19] [20]. The upgrading neighborhoods tend to witness economic restructuring and higher growth rates in the knowledge-based economy, local retail establishments, and other services that did not previously capture those markets. There is also an increase in commercial investment, which is a byproduct of a change in the consumer population and demand for goods and services. Furthermore, newcomers follow well-paying jobs that require high-skilled, white-collar workers. On the other hand, gentrification in historically manufacturing neighborhoods forced former blue-collar workers to shift from factory employment into informal sectors such as retail services. Lower-income groups rely more on nearby employment opportunities but whether these poorer longstanding community members could still abide by rent hikes and escalating housing prices is questionable [8]. Therefore, gentrification might play a catalyst role in economic transition or a consequence of the industrial shift in the 1990s and rising creative occupations in the 2000s. Either way, economic changes generated in gentrified neighborhoods accelerate the polarization of the job market and, the resegregation of the housing market when incumbent residents move out of their neighborhood [5].

Purpose of Study

Neighborhood is a dynamic entity; a nexus of actors determines and perceives neighborhood change [2]. While affluent in-movers recognize the potential benefits of gentrification, such as improved accessibility and increased amenities; neighborhood change has an adverse effect on poor urban communities adversely. Displacement of people with low socioeconomic status is a main concern among academics who believe that population turnover in gentrified

neighborhoods is a threat to equitable and inclusive communities. Despite being well-studied, gentrification has remained a hot topic in urban economy and housing debates.

While some scholars such as Neil Smith attribute a causal role for local agents such as city planners and policy makers, broader gentrification literature views macro-level changes as the drivers of gentrification [5]. Expanding upon the previous studies, this study seeks to fill a literature gap by testing the association between neighborhood change and its two less-studied dimensions: travel behavior (commuting mode and time) and employment transition. This research uses a national sample for the period between 2000 and 2019, which also supports the external validity of the results.

There is significant amount of research on the economic impacts of gentrification, which heavily relied on case studies, yet comparatively little has been completed for a larger sample [8] [12]. Lester and Hartley (2012) examined the economic restructuring of gentrified neighborhoods in the 1990s across a sample of 20 large cities. In addition, most studies employed economic data, such as employment growth and increase in a professional occupation, to define and predict gentrification. Few studies have systematically examined the change in the economic landscape despite its importance. This study helps resolve the questions about how neighborhood change is associated with transition in major economic sectors between 2000 and 2019.

A recent national study explored the linkage between neighborhood change and travel behavior among urban residents between 2000 and 2015 [21]. The study examined urban core census tracts located within 2 km of city halls because gentrification is identified as an inner-city process. However, gentrification occurs for many reasons, including transit infrastructure

investment, proximity to charter schools, and tourism industry (citation?). Thus, urban cores may no longer be the only places undergoing gentrification, although gentrified neighborhoods are still higher in central cities. This study addresses this limitation by selecting neighborhoods located further away, within 3 miles from urban cores. Furthermore, it uses a long-time span between 2000 and 2019, and controls for additional independent variables such as car possession and access to sustainable transport facilities.

Gentrification, economic change, and travel behavior are inherently interrelated. Economic upgrading in gentrified neighborhoods can benefit longstanding communities by overall job growth, but it also can force them to move out through the transition of the local job sectors into professional services that demand highly educated workers. Residential relocation and the arrival of the middle-class into the once-declining neighborhood can potentially reverse the travel pattern in favor or against sustainable transport goals. Changing jobs and moving home relate to distance to work and eventually impacts commuting mode choice, travel duration, and average household car possession.

It should be noted that literature on the role of new transit infrastructure in spurring gentrification has received increased attention [4] [22] [23]. Transit investment can increase nearby property value because public transit, particularly a heavy rail system, is desirable and can improve access to work and other destinations. In such a case, incoming residents' different attitudes encourage them to choose residing neighborhoods that suit their travel mode preference [13]. While there is still an urgent need to extend the body of literature, no studies to date test the linkage between industry type and commuting mode choice in the recently

transformed neighborhood.

The purpose of this longitudinal quasi-experimental research is to shed light on the change in jobs and commuting patterns in gentrified neighborhoods located within the 98 most populated U.S. Metropolitan Statistical Areas (MSAs) between 2000 and 2019. This study adopts a quantitative definition developed by Freeman (2005) to select the potentially gentrifying and gentrified tracts with minor changes. Hereafter, neighborhoods that are susceptible to gentrification but that did not gentrify are referred to as non-gentrifying [2]. This methodology is well established in the literature because it captures the multifaceted nature of gentrification, including increased income, housing stock market, rising education, and escalating home value [5] [24].

The next part of the study uses two sets of t-tests to compare first changes in job and travel to work between gentrified tracts and non-gentrified tracts. Second, to detect whether a gentrified tract witnessed a statistically significant differences regarding the travel and job variables at the start and end of the intercensal period. Job variables are measured as employment growth and the number of workers over 16 years old in four industries (professionals, manufacturing, service, and retail); travel variables are commuting time, commuting mode, and automobile ownership. This study defines gentrification as a dichotomous variable, either gentrified or not gentrified. Data analysis continues with a series of Two-way ANOVA to further explore the combined effect of gentrification and other control variables on employment and travel behavior.

Research Questions

This study focuses on neighborhoods located in 98 mid-sized and large MSAs with over a half-million population. Census data from 2000 and 2019 are statistically analyzed to identify which neighborhoods have undergone gentrification. Comparing the commuting pattern and geography of jobs, this research aims to address the questions below:

- Has the economy resurged faster in gentrified neighborhoods than non-gentrified neighborhoods over the last two decades? Did the employment rate grow faster in gentrified neighborhoods? Has any significant shift occurred from one economic sector to another?
- How do residents' travel behavior in gentrified neighborhoods differ from that of non-gentrified ones? Have gentrified neighborhoods experienced improved access to jobs for residents? Do in-movers, so called as gentrifiers, demonstrate a higher share of sustainable transportation (walking, biking, transit) or less car ownership?

The remainder of this dissertation is organized as follows. Chapter 2 starts with a review of literature and academic work to date and situates this research within a theoretical framework. Chapter 3 describes the methodology for selecting sample areas, and data sources and introduces the statistical methods applied. Chapter 4 presents the results from the analysis, concludes, and discusses policy implications. This study is an important scholarly work because it adds to the field of research pertaining to housing and transportation.

The research presented here is helpful to inform planners, policymakers, and researchers about

the recent demographic dynamics of urban neighborhoods in order to mitigate the social costs of gentrification and displacement.

Chapter II: Review of the Literature

Gentrification Overview

The origin of the term “gentrification” in urban studies literature dates back to a document in the 1960s that describes the invasion of affluent households into a historically poor neighborhood in London [25]. In the U.S., inner-city gentrification has attracted attention since the 1970s, when the federal program for urban renewal widely resulted in the displacement of low-income groups and communities of color. During this period, gentrification was slow and limited to downtown [9]. After 2000, the trend accelerated with increasing millennial and baby boomer migration to downtown neighborhoods [4]. By 2010, more than one-half of all large cities and 15 percent of smaller metropolitan areas had undergone gentrification in at least one neighborhood [9]. Increased population displacement risk has captured researchers and policymakers' interests to identify, measure, and predict the phenomenon.

Three distinctive waves of gentrification, driven by political and economic forces, were discussed by Hackworth and Smith in 2001 [26]. The first wave in the 1960s and early 1970s involved government-led gentrification generated by reinvestment in small downtown neighborhoods to counteract urban decline. The second wave began in the late 1970s, primarily in global cities, expressing a broader global and national economic and cultural process. The nature of gentrification was in line with the ‘back to the city’ movement, often driven by individual action. These two waves have anti-suburban liberal values and ‘do it yourself’ ideology.

The third wave was common in the early 1990s in smaller, non-global cities and highly integrated into the economic and cultural trends. This wave was a social-class change characterized by the flow of large-scale capital, the prominent role of transnational developers, and the catalytic role of the local interventionist state [1]. The working class continued to be displaced; resistance to gentrification decreased, and a new middle class who migrated to the central city had art and cultural occupations; a new "creative class," as described by Richard Florida. In addition, local and national governments assisted the process more than they did in the second wave by using their regulatory and financial powers. Hackworth and Smith recognized a mutation period or degentrification between the second and third waves, leading to the constriction of capital flow into central neighborhoods [26].

Lees et. al (2008) proposed a subsequent gentrification wave featured by ‘financialization of home’ and pro-gentrification policies. This fourth wave is considered a continuation and intensification of the third wave. Aalbers (2019) recently developed the fifth wave of gentrification featured by the materialization of financialized capitalism. Financial capital refers to the concentration of capital controlled by financial institutions. Like the fourth wave, the state maintained its prominent role in sponsoring gentrification. However, the state does not work alone; the financial market supplements its role function. The role of the financial sector is not limited to pushing mortgages for homeownership but backing corporate landlords through international capital markets (e.g., Wall Street) and developing the sharing economy and platform capitalism (e.g., Airbnb). The purpose of this reinvestment is to increase the potential benefits of gentrification. However, they have extreme consequences such as diminishing housing affordability, loss of local job opportunities and a decreased sense of place [26].

In the gentrification process, a series of actors from government agencies to the developers to the builders make up a sizeable political economy that pushes the idea of a "growth machine." The process could stem from a nexus of actors or events such as individual action, market forces, or government intervention [4]. The supply and demand theory explains the dynamics among these actors and how the dynamics among these actors affect the process. Whereas the actors on the supply side (e.g., landowners, real estate agents, banks, and national policymakers) are well studied, the literature provides unclear descriptions for demand groups such as 'young urban professionals.

Blasius et al. (2015) suggest a new classification of the demand group, including pioneers, early gentrifiers, and super-gentrifiers. Each group is involved in different stages of gentrification regarding their attitude, profession, and socioeconomic characteristics. Pioneers are described as young, well-educated, and low-income persons in one- or two-person households. This first wave of gentrification is commonly employed by social and cultural professionals seeking inexpensive housing in socially diverse neighborhoods [4] [27]. This group accepts a relatively high investment risk because they move into a declining neighborhood faced with continuing disinvestment. The second wave is gentrifiers who move into the neighborhood when physical improvements have changed the image of the area. Eventually, the third wave is affluent professionals, so-called super-gentrifiers, entering the neighborhood, accepting lower risk than the two other groups.

Causes

A series of factors have been identified as causes of gentrification, including public policy,

access to jobs and amenities, housing supply and demand, public investments, etc. [28]. Public investments and proximity to an amenity (e.g., transit station, charter school, stadium, brownfield redevelopment, etc.) are built environment indicators frequently used to explore or predict gentrifying neighborhoods. However, such metrics are better applicable for micro-level studies but can hardly be utilized for a national-level study since it is challenging to track the origins of gentrification at the macro-level. Additionally, public investment and access to amenities may not be the cause of gentrification for many gentrified neighborhoods and, thus, are not sufficient to predict and understand future gentrifications.

Public sector intervention, whether direct actions (e.g., physical infrastructure, urban redevelopment, neighborhood revitalization) or indirect activities (e.g., tax abatements, zoning, land assembly), put the state at risk of not simply a sponsor and an agent of gentrification. Given the growth of TOD in recent years, many scholars have increased attention to the role of public transportation investment in gentrification and displacement [22] [28] [29] [30]. A study on 12 major cities with massive rail transit investment between 1970 and 2000 shows that communities nearby new stations experienced more significant gentrification than communities located farther away [22]. However, a recent study conducted by Baker and Lee (2016) across 14 U.S. urbanized areas demonstrates mixed results and did not find any evidence of spreading gentrification in station areas. The degree to which a TOD neighborhood changes is highly akin to the local and regional planning and policies.

Sport-led redevelopment can change the socioeconomics of nearby neighborhoods one decade later. Analyzing neighborhoods surrounding 24 minor league basketball stadiums shows that

the population movement, housing market, and the median rent price have not changed considerably, unlike many gentrified neighborhoods. Lack of turnover may accrue from a higher educational level and change in occupation profile, presumably due to the increased employment opportunities in the surrounding neighborhood after the stadium opens. The influx of service jobs and the retail industry may potentially decrease the unemployment rate and spatial mismatch [31].

Some scholars tied gentrification to a broader economic and cultural shift such as the global economy, the deindustrialization from factory work to the service/ knowledge-based economy, and recently to sharing economy [5] [32] [33]. Airbnb and other short-term rental services introduced capital flow into New York City's housing market. This generated a form of rent gap and, as a result, created Airbnb-induced gentrification. The rent-gap theory, developed by Neil Smith (1987), views gentrification as caused by the changes in flow of financial capital, long-term disinvestment, and reinvestment for developers and real estate interests. This Marxist perspective defines gentrification as a product of free market ideology and individual choice and preference [6] [24]. This theory was built on David Harvey's idea of urban redevelopment, that states over cumulation of capital in a given sector (e.g., investment in the built environment) results in reproduction and reinforcement of class structure [34]. The rent gap theory suggests that property upgrading, access to transit, or proximity to amenities may widen the gap between the actual and potential value of a property. This gap has attracted benefit-seeker capitals to invest in central city real estate, resulting in gentrification. Improved access to amenities and transit is capitalized in property values and leads to a higher real estate capital flow in the area, which is assumed to benefit the community, but ultimately, causes

displacement of minorities and disadvantaged populations [32].

Expansion of urban tourism in the historic downtown of Lisbon is reshaping the city center by generating significant revenue, demand for housing, and boosting rehabilitation jobs. Although 60 percent of properties were vacant before, the remaining local populations are subject to be dislocation. The socioeconomic transitions usually come along with new capital and investment, which is a path for prosperity, new businesses, and employment opportunities. The process thus can result in power struggles between different urban residents about the community decisions and the amount of power they have to control their neighborhood. This usually ends up in favor of upper-income groups and the free-market [35]. Selecting the location for a casino development in a Philadelphia neighborhood is an example of a class conflict between long-time residents and high-income gentrifiers [36].

Definitions

Gentrification has had many definitions and operationalizations which have evolved over the last fifty years. While there are some common attributes between connotations, there is still no consensual definition that can capture the multifaceted essence of the phenomenon. Zuk et. al (2015) reviewed the history of neighborhood change, gentrification, and displacement in the U.S. and defined gentrification as a transformation in a neighborhood historically occupied by a disadvantaged population into an upper-class residential area.

The upgraded physical environment of the neighborhood drives up the housing value and cost of living beyond the households' budget and consequently contributes to the dislocation pressure on low-income groups [6]. An increase in rent price is often pointed to as responsible

for the displacement. It can be included as a predictor factor for dislocation of households residing at their current residence. Rent values escalate more than home values since homeowners have some protection against an increase in home price [2]. The transition usually is characterized by public- or market-led investment in a neighborhood that has experienced long-term disinvestment.

Many investigations emphasized displacement and the dynamics of uneven development as a critical feature of gentrification [4] [28]. Displacement of long-term residents is widely recognized as a key characteristic and an inherent element of gentrification, not only an outcome [28]. Displacement is an involuntary movement of residents due to appreciation of home or rental price. This phenomenon is different from residential mobility, which includes voluntary movement [3]. Controversy continues regarding the occurrence of displacement in gentrifying neighborhoods. Some studies state that gentrification does not essentially induce displacement, and results show no evidence of significant differences in displacement for minority households between gentrifying and non-gentrifying neighborhoods [12] [31] [37].

Vigdor (2002) states that gentrification will not lead to demographic transition or displacement, especially when moving cost for incumbent residents is reasonably high. It is notable that improvement of the physical environment can encourage long-term residents to stay and gain the benefits of neighborhood upgrading, which can result in “upward social mobility.” This unique situation is called “positive gentrification.” For instance, new service-oriented businesses in gentrified neighborhoods can hire local laborers since their tasks do not require human capital. This can decrease the unemployment rate and spatial mismatch for current low-

skilled workers [8] [38]. Despite extensive studies in this area, whether gentrification results in displacement or not is still an open question. A few studies have shown that high-poverty neighborhoods hardly undergo gentrification. Cortright and Mahmoudi (2014) debated that poverty is persistent, and approximately 70 percent of tracts with a high poverty level in 1970 had been at the same or higher poverty level until 2010 [39].

Literature defines gentrification as a process of neighborhood change characterized by a combination of several factors such as increased investment, rise in rent values, land price appreciation, local retail upgrading, and change in neighborhood racial and class composition [2] [22] [28]. Gentrification occurs with the arrival of residents of higher socioeconomic status into a reinvested neighborhood that was historically populated by poor and minority populations [8] [9]. High-educated, wealthier, and white in-movers renovate declining neighborhoods that were previously defined by the concentration of poverty, deteriorated housing and infrastructure, and racial segregation. The motivations of in-movers consist of a spectrum of economic demands, cultural diversity, and political orientation [28]. This process of redevelopment and reinvestment takes place in deteriorated neighborhoods, underutilized industrial sites, or even former railyards. Gentrification has been viewed as a tool, goal, or unexpected consequence of revitalizing declining neighborhoods [4]. The gentrification process may take only a few years or even decades [27] [40].

Measuring Methods

Quantitatively measuring gentrification is a challenging task because different studies define gentrification differently. No universal method exists for measuring gentrification but there are

some standard measures that researchers constantly use to identify or predict gentrified neighborhoods. Two common indicators include changes in housing value and demographic transition in cases where displacement occurred. Some studies used single metrics such as family income growth or housing stock to simplify the quantification [37] [41]. In contrast, others used a combination of metrics (e.g., race, income, age, education, etc.) to better capture the multi-dimensional nature of gentrification [2] [42].

McKinnish (2010) used a very narrow definition of gentrification by looking at a $10,000 change in the average household income of census tracts between 1990 and 2000. This study did not find any displacement associated with gentrification; instead, predominantly black neighborhoods are still attractive to the black middle-class population [41]. Ellen and O'Regan (2011) used the change in average household income to measure the neighborhood change in 240 metropolitan areas. They described economically changed neighborhoods as those tracts that experienced a five percent increase in their relative income. Consistent with the previous study's findings, they concluded that neighborhoods gained a higher income over the time without experiencing racial transition [37].

Some scholarly works have been designed to identify already gentrified neighborhoods while others developed predictive models for where gentrification may occur. Bradway Laska et. al (1982) used property transaction data, such as age of structure, at census tract data to estimate the neighborhood renovation to measure gentrification in downtown New Orleans. They conducted a regression analysis to determine other critical variables predicting urban renovation and concluded that education, owner-occupied housing, and multi-family buildings

positively predict renovation [43]. Galster and Peacock (1986) analyzed the eligibility of tracts for gentrification in Philadelphia between 1970 and 1980 by measuring several indicators such as percentage of black population, college degree holders, household income, home value, and proximity to public investment (e.g., parks and universities). The eligible tracts were tested for thirteen predictive characteristics on each of the indictors mentioned to find the variability of the stringency of each indicator [44]. Melchert and Naroff (1987) construct a predictive model of gentrification based on forty-one variables that explain racial composition, economic status, housing conditions, and urban amenities ultimately ending up with six predictive variables [45].

Although gentrified neighborhoods are identified as low-income tracts that experienced an increase in median household income, this variable is not sufficient to measure gentrification. According to Lester & Hartley (2013), educational attainment can be a better indicator of gentrification than household income for two reasons; first educational attainment is more stable than income. Second, it can attract young professionals who may not still be well-paid but are the pioneers of gentrification to improve their quality of living. Likewise, Vigdor (2002) believes that educational attainment is a better proxy for measuring socioeconomic status than income since income can be a function of gentrification.

Exploring demographic change in a neighborhood requires a methodology to compare the potential difference between characteristics of newcomers and the displaced. According to Baker and Lee (2019), gentrification without any change in the social makeup should be considered as neighborhood upgrading, which involves the enhanced quality of the environment plus changes in occupational status from working-class to high-skilled workers. As

a result, they identify a neighborhood as a gentrified when both displacement and upgrading happens. Analyzing 14 urban areas in the U.S. between 1980 and 2010, this study employed race, education, income, and poverty in the beginning decade year before the first light rail transit opened, and the percentage they changed in 2010 [28]. Since there is a lack of ability to track out-movers, a combination of multiple demographic metrics such as income, race, family size, and educational attainment help to improve the accuracy of the measuring gentrification [4].

Others have used slightly different methodologies, but most studies use dimensions that regularly appear in the literature of gentrification. Analyzing average income, housing value, educational attainment, and occupational status, Owens (2012) documented different types of neighborhoods change since 1970. Her study was not limited to identifying gentrified areas. Still, beyond that, she examined a broader range of neighborhood socioeconomic ascent, including urban white influx, Hispanic immigrant neighborhoods, minority urban neighborhoods, booming suburbs, etc. [11]. Hwang and Lin (2016) computed socio-economic status (SES) indexes ranging between 0 and 1 for each census tract which shows the average neighborhood's percentile rank within the metropolitan area based upon two factors; the share of adults 25 years old and older with at least a college degree and the average household income [9].

Van Holm (2018) tested whether a neighborhood nearby a minor league basketball stadium is gentrified. He looked at four variables to capture different aspects of gentrification: percentage change in median rent, the percentage change in the median household income, population

turnover within the ten years before the stadium was built, racial makeup, and change in the population of minorities [31].

Freeman (2005) has attempted to suggest a robust methodological approach to quantify gentrification [2]. According to him, a neighborhood is eligible for gentrification if it is:

- Located downtown at the beginning of the intercensal period.
- Populated by lower household income relative to the respective MSA at the beginning of the intercensal period.
- Experiencing disinvestment relative to the MSA at the beginning of the intercensal period.

To be considered a gentrified neighborhood, a tract must meet two additional criteria:

- The percentage increase in educational attainment must be more significant than the educational attainment increases of the respective MSA.
- There must be an increase in median home value during the intercensal period.

In an investigation of rail-transit induced gentrification in three Canadian cities (Montreal, Toronto, and Vancouver) Grube-Cavers (2015) used a similar methodology which addresses two valid shortcomings of many earlier studies. First, gentrification should be defined by using multiple variables jointly, not only one variable at a time. A variety of indicators (e.g., education, income, housing value, etc.) at the neighborhood level have to experience an increase faster than in the metropolitan region. Second, gentrification should not be examined by continuous variables, but it is a 0 or 1 event which means a neighborhood is either gentrified

or non-gentrified. Like Freeman (2005), this research uses a two-stage approach to identify gentrified tracts; first, gentrifiable tracts are classified as those neighborhoods with household income and a number of degrees per capita lower than the metropolitan area. Second, eligible neighborhoods were tested for additional three indicators: housing rent, professional occupation, and homeownership. Tracts that had experienced improvement of all variables between 1961 and 2006 were recognized as gentrified neighborhoods.

Researchers have often relied on census data to evaluate gentrification occurrences because the 3,000-4,000 population of census tracts is a better proxy for neighborhood characteristics than other geographic boundaries such as block level or block-group level. The neighborhood transition is calculated by whether the change of factors at the census level exceeds either absolute thresholds or benchmark changes at the metropolitan or regional level. Table 1 summarizes metrics that various investigations applied to quantify gentrification.

Although gentrification is known as an urban phenomenon, some studies examined suburban and rural neighborhoods' gentrification. For example, Charles (2011) studied attributes of gentrification in over a hundred suburbs in Chicago and concluded that small houses and properties with lower value compared to their neighborhood are more likely to be redeveloped while neighborhoods with a non-white population are less likely to be redeveloped [46]. In Atlanta, Markley (2018) shows that gentrification is the outcome of New Urbanism policies in inner suburbs, resulting in redevelopment in low-income neighborhoods with a Hispanic population, older housing stock, and lower rent relative to home value [47].

Table 1. Summary of existing literature on Metrics of Gentrification

Author (year)	**Study area/Geographic unit /Year/**	**Operations of gentrification**	**Treatments/ All met?**	**Measuring methods**
Vigdor et al. (2002)	Boston/ American Housing Survey Zone/ 1970-1990	Educational attainment Owner-occupied housing value		- % increase in college-educated share relative to the average of - changes in mean owner-occupied housing values for AHS zones
Freeman (2005)	?study area/Individuals as head of household/ 1986-1999	central city tract, low-income, experienced disinvestment, educational attainment, increased housing prices	No / Yes	- Tract located in the central city - Median income less than the median for that MSA at the beginning of the intercensal period - Proportion of housing built within the past 20 years is lower than the proportion found at the median for the MSA - % increase in educational attainment greater than the MSA - Increase in real housing prices during the intercensal period
Kahn (2007)	14 cities/ census tract/ 1970-2000	Home price Demographic data	TOD/ No	- Average HH income - Average home price - Population per sq. mi - % of adults with a college degree - % of the population in poverty - % of black and % of Hispanic - % of commuters using transit
McKinnish et al. (2010)	64 MSA / Census tract/ 1990-2000	Baseline income and income change	No/Yes	Increase of average household income in Low-income neighborhoods of at least $10,000

Grube-Cavers (2015)	Toronto, Montreal, Vancouver/Census tract/1961-2006	Housing rent Occupation Homeownership Household income Educational attainment	Rapid rail transit/ Yes	- Average housing rent - Proportion of professional workers - % of owner-occupied homes - Average HH income - # of a degree per capita
Baker & Lee (2017)	14 urbanized areas/ Census tract/ from the beginning decade year when the first light rail transit opened in each UA-2010	Neighborhood change index Race Education Income Poverty	UA with light rail operation by 2000/ No	- Principal Component Analysis of socioeconomic variables - % of the white population -% of +25 years old with a college degree - Log median household income - the % poverty rate
Van Holms (2018)	32 cities/ Census tract/ 2000-2010	Housing rent Income Turn over Racial makeup	Baseball stadium/ No	- % change in the median rent - % change in median income - change in the percentage of the household that has living in the neighborhood in the last decade - % in the percentage of minorities
Bereitschaft (2020)	101 urban cores/ Census tract/ 2000-2015	Household income Educational attainment Racial makeup Household structure	No/ No, but most indicators changed significantly	- % of homeowners - Average household size - % of Age 18-39 - % of BA degree or higher - % White - Household income

Transition in Occupation Sectors

Studies linked gentrification to economic restructuring and deindustrialization of factory jobs that occurred in the late 20th century [5]. Globalizing the economy and the shift from manufacturing toward a knowledge-based economy and service sector works have strengthened the economic role of downtown areas. Gentrification, particularly during the 1990s, was accompanied the influx of affluent households who were seeking higher-paying jobs and professional occupations. Since 2000, low-skilled jobs have declined in the downtown while the number of jobs that require high-skilled professionals remained steady or even increased. Improving access to high-status occupations for in-movers and decreasing low-wage jobs within the urban cores accompanied by rising property values can potentially price out incumbent residents [9]. Hartley et al. (2016) found that inner cities experienced job growth at the same rate of suburbs, gaining over 1.8 million jobs between 2002 and 2011. They concluded that neighborhoods with proximity to downtown, access to public transit, and adjacency to other highly populated neighborhoods grew at a faster rate [48]. Such changes in the urban economic landscape result from private market-driven development or economic development policies (e.g., tax credits) created by urban policymakers.

Neighborhoods are social contexts that influence the life opportunities of residents, a source of social inequality or upward mobility. Individuals may benefit from living in or moving into a particular neighborhood over others [11]. Employment opportunities are an utmost motivator of residential mobility for those who want a secured job. Neighborhood upgrading can result in local economic growth and create a new job geography. While it is repeatedly argued that

gentrification is linked to the improved labor market in the central city, there is little empirical and micro-level evidence on how gentrification affects urban employment.

During the first decade of this century, manufacturing had been a diminishing but still viable economy sector in the Williamsburg neighborhood in Brooklyn, New York. Curran (2004) showed that small-scale manufacturing was at the risk of conversion to residential use, and the degradation of blue-collar jobs led to an increased informal sector [20]. Lester and Hartley (2013) conducted a similar analysis to determine the nature of economic shifts in gentrifying neighborhoods during the 1990s across 20 large central cities. Employment grew slightly faster in gentrifying neighborhoods, replacing retail services with goods-producing industries. The results showed the favorable positive impact of gentrification on employment opportunities. These two studies came to a similar conclusion: gentrification contributes to the labor market shift from traditional blue-collar jobs to local service positions such as restaurants and entertainment. Gentrification can increase the number of local jobs; however, it may harm businesses that serve low-income households and displace industries that provide jobs to long-lasting residents [5].

Economic transition in upgrading neighborhoods appears to be accrued from either the consumption or production side. The consumption side implies that changing consumer population and rising new demands for services increase commercial activity in gentrifying neighborhoods. Literature on gentrification has focused chiefly on its impacts on the housing market. However, urban settings are also determined by businesses and retail services that serve residents living nearby. Preferences for services in a gentrified neighborhood are highly

correlated with the changing of the consumer population and characteristics of middle-class segments that engage in gentrification, such as their higher income and educational attainment. Having a great capital resource to achieve their preferences, middle-class gentrifiers are keen to reside in central neighborhoods with access to urban amenities and services.

The link between income and retail growth is well demonstrated in a study undertaken by Schuetz et al. (2012) by looking at 58 large U.S. metropolitan areas. Unlike the conventional retail location model, which suggests that costumers are uniformly distributed and have identical preferences, this study assume that consumer preferences and retail patterns are not uniformly distributed through space but highly varied based upon income distribution. Results indicate that employment density for retail decreases with poverty, and retail establishment size increases with median household income. Low-income neighborhoods have lower employment densities for pharmacies, food stores, supermarkets, and laundry. In contrast, neighborhoods experiencing income upgrading are more likely to see an increase in retail employment [49].

Retail turnover in the city of New York is shown to be associated with three sets of factors: type of business, commercial infrastructure, and consumer profile. Consumer-related characteristics are a stronger predictor; a higher share of the white population and larger household size negatively explain the business turnover, while population growth is positively associated with it [19]. Using microdata on businesses in New York, Meltzer (2016) showed that gentrification could be associated with both retention and disruption of local businesses. Since businesses are

tied to the surrounding communities, any meaningful demographic change such as gentrification can influence them. Meltzer found that most businesses stayed in gentrifying neighborhoods. Still, when businesses left the area, the gentrifying neighborhood are more likely to attract service industries than the non-gentrifying neighborhoods [50].

The other perspective is the production side, suggesting gentrification as a byproduct of deindustrialization and the global economic change in American urban cores during the 21st century. Behrens et al. (2018) studied the gentrification of businesses in New York between 1990 and 2010 and tested the decision for business locations to understand pioneer economic sectors in gentrifying neighborhoods. These pioneer industries are primarily cultural, recreational, and creative jobs that foster gentrification by revitalization and investment in new amenities. Because gentrification is considered a multi-stage process, identifying pioneers can help predict the future gentrifying spots in the early stages. By the final stages, gentrification may end with urban segregation and residential displacement, so it is essential to see where gentrification happens in the early stages [51].

Harlem and Williamsburg in New York are two examples of state-led and market-led commercial gentrifications that experienced identical processes. The economic transactions started with boutiques owned by local residents, which was the agent of neighborhood change in the city. Once population density increased, new boutiques arrived, and rental value rose beyond the level that pioneers could afford. Ultimately, rent value determines who will stay and reside in the neighborhoods. Invasion of the affluent population signals to the private and public sectors that the neighborhood is ready for a wide range of investments [52].

Spatial Mismatch

Households and job clusters relocate until they have the best in the urban economic landscape. Firms aim to improve their productivity by locating near their customers, and households aim to maintain shorter distances to work, activities, and amenities. Accessibility is a primary metric to assess an urban environment's efficiency in performing its primary role. Accessibility alludes to the capability of residents to reach out to other people, work, or daily destinations [53]. Limited access to urban amenities and job centers restricts residents' participation in social activities, creates disparities across low- and high-income jobs, and eventually can lead to more profound social exclusion.

Distance to employment is a critical factor in explaining the socio-economic status of residents, especially for low-income workers. Incumbent residents in gentrified neighborhoods in New York lost low- and moderate-wage, nearby jobs in service and good producing sectors despite the overall job growth; however, they could gain low-wage jobs farther away. While the entry of money into a neighborhood can price out the low-income residents, increased economic activity can also bring in nearby employment opportunities for local hires- a reversal of the spatial mismatch phenomenon. Information about job opportunities of new local business establishments that do not require higher-skilled workers is accessible and transparent. Furthermore, government policies may encourage local hiring for new businesses through subsidies [8].

Kolko (2009) assessed the relationship between employment location and neighborhood change between 1990 and 2000 and found the most vital relationship in tracts closer to the

urban core. High-income jobs explain gentrification within two miles of downtown because high-income households prefer to live near higher-paying industries [54]. Kneebone and Holmes (2015) used multiple demographic and economical sources to construct a database to assess how distance to work changed between 2000 and 2012 and whether patterns of change vary for different types of residents based on their racial and socioeconomic status. They concluded that in 67 out of 96 of the largest metro areas in the US, the number of jobs within a certain home-workplace distance had decreased for the US. With the suburbanization of jobs, jobs within a typical commute distance (between 4.7 to 12.8 miles) from residents dropped for both city and suburban residents by three and seven percent, respectively.

Mass displacement of high-poverty and minority households to the suburbs in the 2000s decreased their access to jobs much more steeply than high-income households. Understanding these dynamics is critical for policymakers who seek to promote access to employment and upward mobility for disadvantaged neighborhoods. Baum-Snow et al. (2019) examined the long-run impact of neighborhood attributes on incumbent residents' children. Their results indicate that growth in accessible employment opportunity would enhance the quality of neighborhood and family income, which eventually allows children experience improvement in their credit outcomes decade later [55].

In the 2000s, two economic recessions and the subsequent weak recoveries resulted in fewer jobs in 2010 compared to 2000, which caused an economic shift within regions in the largest U.S. metro areas. While jobs declined, surprisingly, job locations were also pushed outward and shifted away from the urban core. The suburbanization of jobs produced the suburbanization of

minorities and low-income households. The outward demographic and economic shifts redrew the map of job opportunities in large metro areas [56].

As discussed earlier, a major economic transformation happened from industrial and agricultural economies to cultural occupation, services, and knowledge economies within the last few decades. Stage theory hypothesizes that the gentrification occurs in multiple stages, and cultural works are frontier industries that invade the gentrifying neighborhoods with high contribution to the values that cities generate. The economic restructuring of downtowns continues with the rise of managerial occupations, finance, insurance, and legal service to revive the urban economy. The vitality of knowledge-based jobs is highly place-based, determined by locational characteristics such as compactness, industry clustering, transit service, walkability, distance to amenities, and street network connectivity. Studies show that innovative firms are located in less dense areas but closer to other related business sectors. Regional compactness is shown to be an effective predictor in the number of these firms because high density supports public transit and human capital [57].

Attributes of occupations regarding their costumer and labor substantially differ in the service economy from the knowledge-based economy. The knowledge-based economy provides immaterial services usually transferred via online networks and do not need to be at a close distance from their customers. Instead, spatial clustering is a key principle in determining the location of knowledge-economy firms because it improves the knowledge exchange between relevant industries with more frequent face-to-face encounters and lower access costs to the workforce. The new urban economy strongly depends on young and skillful human capital. This

population group actively desires to live in neighborhoods with amenity richness and within walkable distance to restaurants, retail, and cultural centers. Clusters of creative industries in professional services such as engineering, computer science, and data processing favor active transportation and transit, following the preferences of professionals and workers of the creative class. However, aerospace and biopharmaceutical industries are located in urban peripheries. Low and medium order services such as convenience stores, or banks, … locate homogenously within the cities while high order services such as travel agents, car dealers, or jewelers…like to agglomerate in urban cores to cover a broad market [57].

Travel Behavior

Suburbanization

Before 1900, U.S. cities grew steadily. With the advancement of railroad transportation technologies at the turn of the 20th century, wealthy and middle-class people could live in the suburb and commute to work downtown, and later, roads were built to accommodate private vehicles as an efficient mode for the urban trips. In addition to affordable transportation, the low price of land encouraged people to move beyond the urban jurisdictions [58]. After WWII, the United States became an auto-dependent country and build interstate highways that accommodated the growing level of travel.

Commuting is the link between labor and housing markets. Between 1950 and 1990, the population of central cities in the U.S. declined and moved outward to the suburbs of metropolitan areas. Proximity to the job clusters in the suburbs and faster commuting time can explain the higher housing demand in the suburbs relative to the city centers. According to

Gordon (1997), labor forces benefited from the movement of industries to the suburb because they traveled away from the congested urban centers and, thus, shorter travel times [59]. However, Ewing (1997) challenged this argument by referring to the data from the 1980s, which showed the average commute times in suburbs were significantly greater than in central cities [60]. Transportation infrastructure and highway expansion have played a crucial role in changing the spatial landscape of population, accounting for about one-third of the overall population shift toward suburbs. One mechanism of how highways caused suburbanization was that highways allowed manufacturing firms to move to the suburbs. Highways give firms freedom of movement to ship their goods to port or rail hubs [61].

At that time of highway expansion, federal money for building industrial companies increased by twice as before. Lacking adequate space in city jurisdiction and the good access provided by a beltway road encouraged the relocation of industries to the suburbs. Access to the highways attracted more people and led to more residential developments in the suburbs. These movements resulted in racial division in that white communities migrated to the suburbs, and populations of colors stayed inside central cities. This segregation also formed a class division pattern in the suburbs [62]. The main issue with urban planning in the 20th century was urban sprawl, and the one in the 21st century is the opposite: gentrification of urban cores. While consumer preferences in the middle of the previous century were not to live in crime-prone and congested downtown, the new generation desires to live in walkable, mixed-use, dense neighborhoods in city centers.

In the suburbanization scenario, the job clusters were located mainly outside of city centers,

where the low-income portion of the society can hardly reach employment opportunities. They lived in neighborhoods with high crime rates and a low quality of life. The affluent and middle class, at the same time, enjoyed living in the safe, clean suburbs and commuted to their job places by their vehicles. Once the job market shifted from industrial to the service economy and professional occupations, the tendency to live downtown increased. Poor communities were pushed out of their neighborhood toward places with less access to the job centers. Instead, the new generation middle class moved to the revitalized neighborhood with great access to the various amenities and resources. Most of their destinations had been within walking distance, or at least they live close to the transit stops.

The modal shift in gentrified neighborhoods may result from investment in transportation infrastructure or the different preferences of new residents. The construction of rail transit or new bike paths can potentially cause new investment in the area because many people seek residential neighborhoods with alternative transportation modes. The tendency toward non-automobile transportation increases the demand for housing and, consequently, increases property and rent prices. The results are precise; current low-income tenants are being pushed out since the rent is no longer affordable. Here, gentrification is a socioeconomic by-product of TOD or new transport options. To mitigate the negative consequences of such public investments, decision-makers must consider that any forced displacement will not diminish access to basic facilities and resources such as jobs, parks, schools, healthcare, etc. [23].

On the other hand, the new middle-class generation may decide to live in central city neighborhoods, close to their workplace and daily destination, which can translate into their

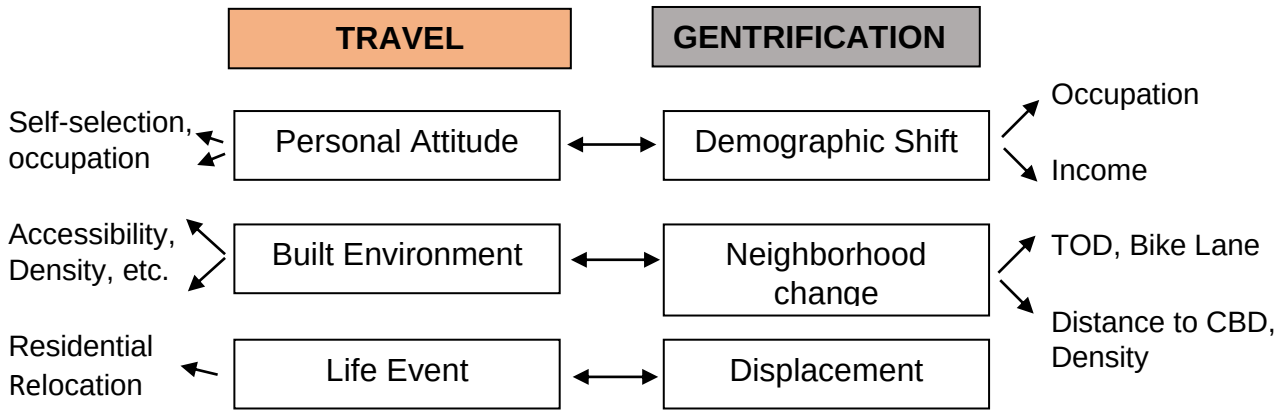
less willingness to drive. Alternative transportation such as transit, bicycle, and walking could be more attractive in gentrified neighborhoods. Either of these situations leaves underprivileged groups and minorities in less developed neighborhoods without having access to city resources and transportation options so they have less alternative for travel modes.

Built Environment and Social Context

Numerous studies have shown that travel behavior is a function of life events, neighborhood environment, and individual attitude [13] [63]. A gentrified neighborhood may be characterized by a combination of these changes through neighborhood upgrading and demographic shift (See Figure 1). In-movers experience a life event by residential relocation by moving into an urban neighborhood with new transportation supply and urban amenities. High density, job clusters, proximity to the urban amenities, and street network connectivity in such neighborhoods can generate less auto travel because mode choice in urban neighborhoods is significantly different from the suburbs, showing fewer auto trips in downtown areas. Neighborhood characteristics such as compactness, land-use, access to public transit, and active travel facilities can significantly impact how people choose to use non-automobile modes [14] [15].

Access to amenities such as rail transit and TOD is considered a fundamental cause of neighborhood gentrification in many North American cities [22] [23] [28] [30]. Upgraded transit can promote economic prosperity and increase nearby property value, leading to the displacement of low-income households. In such cases, it is difficult to know whether gentrifiers change their attitude once they arrive in the new neighborhood with better transit service or

Figure 1. Conceptual Framework of Relationship Between Gentrification and Travel Behavior Change



decide to relocate to the TODs due to their personal preferences and environmentally progressive attitude.

Chatman et al. (2019) analyzed the travel pattern of TOD-induced gentrification in California. They concluded that neighborhoods near the rail stations have shown higher population density and reduced their vehicle mile traveled (VMT). Also, high-income families reduce more VMT compared to low-income households. As a result of the new market forces generated by gentrification, poorer long-term residents may decide to leave the neighborhood or relocate further away or, at best, into the small number of inexpensive houses remaining there. Such homes provide weaker access to urban resources since they are generally placed at a greater distance from job hubs, amenities, and public transit services. Consequently, car dependency and higher transport costs are indirect outcomes of gentrification for low-income out-movers. Inversely, it is expected that in-movers experience shorter commuting time and are a higher share of public transit and active transportation users.

Travel behavior is also affected by an individual's attitude and preferences, which do not necessarily accrue from their residential relocation. Instead, people may select to reside in a certain neighborhood that enables them to travel in their desired way [64] [65]. Some studies controlled for the attitudes of travelers and concluded that the built environment variables are less significant than attitudinal variables [17] [66] [67]. These studies suggest that residents do not have a passive role but actively choose where to live based on travel preferences. They claim that the impact of residential location on transportation is overestimated, and individuals' attitude and their choices can better explain travel behavior. The modal shift from automobiles to walking, cycling, and public transit may occur when people choose to relocate from suburbs to urban-type neighborhoods. This concept, called residential self-selection, suggests that individuals select their home location in a way that meets their desired travel options [14]. However, the results are still mixed and unclear because other studies found evidence of the significance of built environment features on travel behavior even after controlling for residential self-selection [18].

One study in the UK examined the commuting behavior of dual-earner households. They concluded that mens' commuting time is more sensitive to the local market conditions such as employment rate than womens'. Mens' commute time increases by 25 seconds for each percent increase in the unemployment rate, while women experience 14-second increases in commuting duration. Economics has two different approaches to explain the linkage between home and job locations. First, people select where to live based on housing value and neighborhood amenities and then compensate for longer commuting time with a higher salary or other benefits. Second, the workplace is predetermined; people decide where to work based

on wages and then try to minimize their commuting time by considering their limited budget for housing prices [68].

The demographic change in gentrified neighborhoods can also reveal a broader value system and political identity of gentrifiers. Gentrifiers are typically portrayed as the educated population with a college degree and small family size. According to Danyluk (2007), there are three commonalities that shape the political orientation of gentrifiers. First, middle-class gentrifiers support left-liberal political values, government intervention, and social liberalism. Second, their occupational philosophy stands beyond their profits but focuses on helping marginalized and disadvantaged people to improve their quality of life.

Third, their higher education degrees and professional occupations are associated with progressive and democratic values. Such attributes strongly influence gentrifiers to be inclined against the North American car culture and support anti-suburban ideology. The tendency to use non-automotive transportation varies among different population groups; gentrifiers with environmentally progressive attitudes get the opportunity to adjust their travel behavior in line with their values [14]. Public transit, cycling, and walking, which are built in urban cores, offer the desired alternative to automobile travel for middle-class in-movers [27]. Examining 101 U.S. urbanized areas, Bereitschaft (2020) found a rise in walking and cycling trips and a reduction in transit commuting in gentrified neighborhoods between 2000 and 2015.

Gentrification and TOD

Investment in transit infrastructure has the potential to change the neighborhood landscape. Transit is a valuable amenity for communities since it improves access to jobs and services. The

studies on how transit proximity impacts property value have inconsistent findings. A reliable transit system and a strong housing market may critically escalate housing prices. The impact of transit on home sales price and rent value depends on the type of transit. For instance, a heavy rail system is more likely to increase home value. Gentrification scholars affirm that transit investment is a catalyst for urban renewal, and the improved accessibility provided by transit can price out incumbent residents. In an analysis of 14 U.S. cities with transit development between 1970 and 2000, Kahn (2007) concluded that home value and educational attainment were substantially changed in TOD-adjacent neighborhoods [4] [22]. The primary purpose of TOD policies is to reduce auto driving by offering an affordable and efficient alternative mode to residents who live nearby stations. But TOD investment usually contributes to gentrification and displacement. With the influx of new arrivals, travel factors such as transit ridership, car ownership, and vehicle mile travel might change.

Edlund et al. (2015) showed that a greater labor supply of full-time skilled workers resulting from reduced tolerance for commuting had increased the housing price in urban cores between 1980 and 2010. The study hypothesized that high-income families increasingly spend time on work; therefore, leisure time is the most prized commodity. The higher the value of leisure time is, the less willing to travel a longer distance to get a better job. Accordingly, the driving factor for gentrification is the “time-saving mechanism of modern life,” translated as high-income, low-leisure households who decided to relocate to neighborhoods where they can save their travel time [68]. Understanding the changes in the geography of jobs and amenities under the gentrification context helps understand the changes in commuting and travel behavior.

Few studies examined where the displaced population moved to or moved from during the gentrification process. This one focused on the characteristics of receiving tracts (tracts where out-movers resided) and sending tracts (tracts where gentrifiers lived there before movement) in Los Angeles between 2014 and 2015. The growth of rail transit stations in Los Angeles has reshaped the transportation geography of the city in the last 30 years. Rail stations played a catalyst tool in moving low-income populations away into less-resourced areas compared to where they lived previously. Such household residential mobility decreases transit-related job access and school quality for the displaced population [51]. Searching for a better job from a predefined home location is limited by distance. At some threshold, people decide to relocate to a residential area with less journey time [69].

Research Questions

While the impacts of gentrification on housing and residential displacement is frequently investigated, little attention has been given to its impact on travel behavior change and economic transition, which is the focus of this research. Change in travel behavior is shown to be primarily related to distance to the workplace, spatial context, and individual attitude. Gentrification inherently encompasses all three attributes: contextual change for in-movers and out-movers is associated with residential relocation and potential employment change. The upgrading neighborhoods tend to witness economic restructuring and higher growth rates in the knowledge-based economy, local retail establishments, and other services that did not previously capture those markets.

This national-level investigation does not aim to explore the cause of travel behavior change in gentrified neighborhoods due to the limitation of data. Either the personal attitude of in-migrants leads to different travel preferences or neighborhood context provides for better mode choices and access. Previous literature shows that gentrified neighborhoods usually experience a modal shift, lower commuting time, and less vehicle mile traveled. This study aims to first test for any potential change of travel preferences in gentrified neighborhoods, and, then to control for distance to CBD, density, and the presence of amenities such as transit and bikeshare, that are shown to be critical to travel preferences.

Chapter III: Research Method

Longitudinal quasi-experimental design

This study establishes a series of spatial and statistical analyses to understand several aspects of the changing landscape of employment and travel behavior in large and mid-size U.S. metro areas between 2000 and 2019. I use a longitudinal quasi-experimental design to compare gentrified and non-gentrified tracts regarding transportation and employment. Quasi-experimental research lacks randomized assignment for treated and control groups. As shown in Figure 2, I follow three steps to conduct this analysis. First, I use ArcGIS to identify the sample tracts by quantifying the long-term gentrification. The literature widely described gentrification as a dynamic process, thus, it is essential to track the changes throughout time. Second, I calculate the pretest-posttest shift in travel behavior and employment data of gentrified and non-gentrified neighborhoods. Two-group pretest-posttest design is also called a nonequivalent-group design and involves a comparison of observations from a treatment group and a control group before and after an intervention. Gentrified and non-gentrified neighborhoods are the treatment and control groups, respectively.

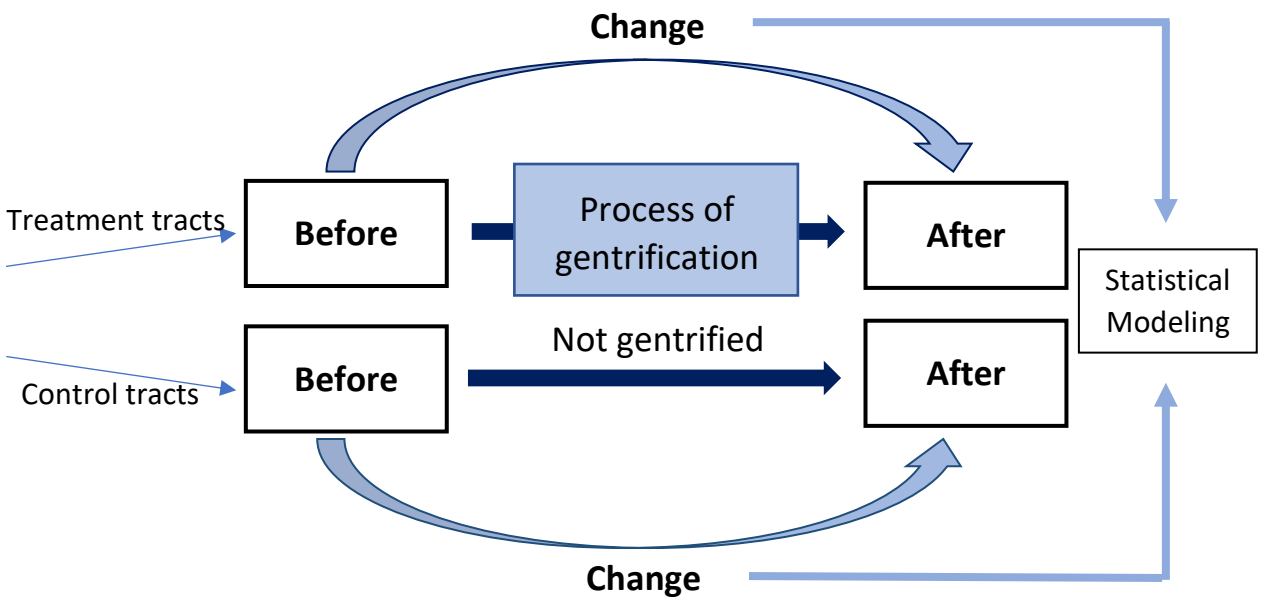
Since quasi-experiments are subject to internal validity, a design control (e.g., pretest-posttest design) can minimize the influence of threats. Internal validity refers to whether the intervention has a causal role in the outcome [70]. I test whether differences of variable changes between the gentrified (treatment) and non-gentrified (control groups) are statistically significant. Lastly, I use a series of two-way ANOVA to test the combined impact of

gentrification and control variables on dependent variables.

To understand changes in the economic landscape and travel behavior of gentrified tracts relative to neighborhoods that did not experience gentrification, I use the national census data to answer the questions below:

- First, have gentrified neighborhoods experienced any economic shift and occupational changes between 2002 and 2019?
- Second, have the residents of gentrified neighborhoods changed their travel behavior compared to those who resided in non-gentrified areas?

Figure 2. Longitudinal quasi-experimental research design



Study Area

This research focuses on census tracts that fall within 98 U.S. MSAs with a population of over half-million in 2019. According to Freeman (2005), the MSA is the best geographic unit for the labor market and housing studies. Owens (2012) states that there are some advantages in measuring neighborhood upgrading relative to their respective MSA. First, a neighborhood that experiences drastic socio-economic improvement relative to the other neighborhoods in their MSA would hardly see a substantial position change in its national ranking. Second, households are more likely to search within a particular MSA when looking for available residential opportunities, not across the country. Finally, considering tract changes relative to the MSA effectively controls MSA-wide improvement in the socio-economic condition and limits the bias of changes beyond the neighborhood.

I use the MSA boundary developed by the Federal Office of Management and Budget, which defines MSA as a region consisting of an urban core and neighboring communities with high social and economic integration levels. MSAs are categorized into 4 levels based on their population. In this study, I selected all MSA of category A (those with one million or more people) and a number of category B, (those with a population between 500,000 to one million)[1]. In 2019, 109 metros had over 500,000 inhabitants, not all of them existed as MSA in 2000. After matching and creating a pair of metros, 11 MSAs were eventually removed from the

[1] https://obamawhitehouse.archives.gov/omb/bulletins_b99-04/

analysis, leaving 98 MSAs in the sample. Likewise, the number of census tracts has increased since 2000 because many tracts have developed and populated or declined, so they divided into multiple tracts or merged as one in 2010. For longitudinal studies, tracts have to be normalized to a base year definition (2010) to make a consistent analysis.

Many scholars exclude suburban neighborhoods in their analyses because gentrification is described as an inner-city process. Couture et al. (2018) formalized the notion of downtown in MSA as the closest tracts to the urban core accounting for 10 percent of the MSA population [71]. Bereitschaft (2020) and Dong (2017) suggested city hall as the political and economic epicenter of the city and defined urban core neighborhoods as those located within a 2 km radius of the city hall [21] [23]. While initially there was a general agreement that gentrification is downtown-specific, recent gentrification caused by TOD, tourism or Airbnb may occur somewhere outside the urban core boundaries.

Owens (2012) believes that urban and suburban neighborhoods can experience ascent. She further explained that neighborhood ascent could happen through suburbanization and urban sprawl. There might be undeveloped suburban tracts at the beginning of the period. This process is different from gentrification because such suburban communities see dramatic population growth, from no population to having some residents (mostly high-income white), so experience socio-economic improvements. Even qualification of brownfield redevelopment in downtowns as gentrification is questionable because the process does not involve any population displacement [27]. Gentrification is more about displacement and population turnover. Compared to the previous literature, this study looks at a larger sample of tracts,

including inner suburban neighborhoods, by buffering three miles from the nearest city hall.

Data Sources

Data for this study are derived from various sources at the census tract level. Census tracts are a proper geographical unit for measuring demographic change across the neighborhood. The average 3,000-4,000 population of census tracts is close to what we perceive as a neighborhood. Additionally, the census tract is the smallest unit for which most required sociodemographic data can be collected. Census data is the primary data source for variables associated with gentrification, including median household income, educational attainment, investment, racial composition, housing price, and rent value. Data required for this study is 2000 decennial census data 2015-2019 five-year estimates (hereafter referred to as 2017 ACS). The five-year aggregated data cannot clearly show the changing characteristics of neighborhoods over 60 months, especially when a neighborhood changes rapidly. Still, it represents a composite image of the area during this period. Additionally, the five-year estimate has a sampling frame of 1 in 15 households compared to 1 in 6 of the decennial data. Despite these issues, I use 2015-2019 non-decennial data because it is the only publicly available source that provides the latest socioeconomic data for neighborhoods at the national level [11].

The primary measure of urban gentrification is from 2000 census, and the 2015-2019 American Community Survey (ACS). Since census boundaries may slightly change from one census year to another, it is essential to reconfigure those changes over the time period to make data comparable. To have a consistent geographic unit, some studies either interpolate data from

census year X to census year Y tract boundaries through splitting and recombining tracts or use normalized data from available data sources. I collected tract-level data from Longitudinal Tract Database2 (LTDB) [28] [31], built and maintained by researchers in Brown University. This database provides demographic and socioeconomic data normalized to the tract boundaries as defined in the 2010 census. Census boundaries are redefined from a decade to a decade.

As discussed earlier, literature has measured gentrification based on one or more demographic and socio-economic factors. In this research, I use four variables to identify gentrification: household income, housing stock, and share of residents with at least a bachelor's degree from LTDB. All dollar values in this database were already adjusted to the 2017 dollar. When measuring Core Based Statistical Area, I aggregate tract-level variables from LTDB. Shapefiles for Core Based Statistical Area and Census Tracts are obtained through the U.S. Census Bureau TIGER data.

Travel behavior data is obtained through National Historical Geographic Information System (NHGIS) for 2000 decennial census and 2015-2019 five-year estimates with the same approach. The independent variables of travel behavior include percentage change in commuting mode (walking, biking, transit, automobile, work at home, active travel, sustainable modes), change in average travel time to work (<10 min, 10-30 min, 30-60 min, over an hour), and an average number of vehicles per household. Other variables, selected based on previous literature, will be used as control variables in the statistical model. These are population density, median

[2] https://s4.ad.brown.edu/Projects/Diversity/researcher/bridging.htm

household income (to control the automobile possession), distance to CBD, access to transit, and access to a bikeshare station. Bikeshare data from the Bureau of Transportation Statistics (BTS) does not show any facility installed before 2015. Bikeshare systems have been launched since 2015, which is not early enough to capture the impact of the amenities on neighborhood change in 2019. This research does not intend to detect the causality but rather the association between variables. Thus, the number of bikeshare stations within the tracts is included regardless of being a cause or an outcome of gentrification.

I have another control variable that represents the geographic location of a neighborhood. Distance from each neighborhood to the city hall is calculated to estimate if proximity to downtown makes a neighborhood prone to change. Furthermore, distance to downtown is a metric to represent employment accessibility. City hall can represent the political and economic center in most metro areas as a single point location. Distance to city hall is calculated by measuring the direct distance between the tracts and city hall by ArcGIS. Data on the latitude and longitude of city halls for each metro area is collected through a web search on Google maps.

Employment data is also obtained from the NHGIS. The employment data includes the type of industries and employment status for workers over 16 years old. Industry sectors included here are four occupations that have been frequently cited as economic sectors sensitive to gentrification: professionals, manufacturing, service, and retail. Since professional occupation data come from LTDB, it is worth mentioning that the codebook defines professionals as management, business, science, and arts occupations. For travel behavior variables, retail, and

service, which LTDB does not offer in the normalized data, I use the Model Builder tool of ArcMap to address this shortcoming and maintain the consistency of tract boundaries between 2000 and 2019. A model of Intersect and Dissolve tools is created to recalculate the variables based on the change in tract area between 2000 and 2010. The model reconfigures 19 factors, including 13 independent variables, from 2000 decennial data into 2010 definitions of the tract.

Dependent Variable

The first step in this empirical analysis is to develop a consistent, quantitative definition of gentrification to construct the main dependent variable of the study: gentrification. Due to the multi-dimensional nature of gentrification, an investigation of whether a neighborhood is gentrified requires a combination of demographic indicators. Although there is no universal measuring method, the present study conceptualizes gentrification along socioeconomic lines that existing literature mostly alluded to. This study defines gentrification as a dichotomous variable, having either occurred or not, and adopts the definition developed by Freeman (2005), with minor changes, because it is well-established and highly cited in the literature. Neighborhoods must meet three criteria below to be included in the analysis as potentially gentrifying:

- Be located three miles from the city hall.
- Have a median income less than the median income of the respective metro area in 2000.
- Have a percentage of housing structures built over the past 30 years higher than the proportion found in the metro area in 2000.

To identify which eligible neighborhood in 2000 has undergone gentrification before 2019, two additional criteria are required:

- Experience an increase in the percentage of college degree holders greater than the increase in the respective metro area.
- Have an increase in property value during the study period.

For a census tract to be identified as gentrified, both -not just one- of these indicators must be improved faster than the rate of the respective MSA during the same period. In summary, neighborhood change is calculated by whether the change of factors at the census level exceeds threshold changes at the metropolitan level. Hereafter, tracts that meet the first three conditions but not the additional two are considered non- gentrifying.

Table 2. The Key Measures of Gentrification

Measures	Description	Source
Location	3 miles from downtown	Computation using Google maps and ArcGIS
Structure year built	Percentage of structures built over 30 years	LTDB
Income	Median household income	LTDB
Education	Population age over 25 and more with at least 4-year college degree	LTDB
Home value	Median home value	LTDB

Housing price is a key measure to track residential investment and flow of financial capital to the neighborhood real estate; family income is used as a proxy variable for high-SES population and opportunity for reinvestment, housing structure age over 30 years is a concept for disinvestment, and a college degree is a measure of human capital and professional workers. This calculation generates the dummy, dependent variable showing whether a tract is gentrified.

Independent variables

Dependent variables for travel behavior included commuting mean, auto ownership, and commuting time broken down into four categories of less than 15 minutes, 15-30 minutes, 30-60 minutes, and over an hour. Means of transportation specify automobile, transit, cycling, walking, and work from home for civilian workers 16 years and over. Auto ownership represents the number of cars per occupied housing unit and is classified as: no automobile, one automobile, and more than one automobile. Dependent variables constructed by employment data are employment growth and industry sectors as a percentage of employed persons 16 years and over in professionals, good producing, service, and retail industries. Control variables are median rent value, percentage of household heads moved into a unit less than 10 years ago, distance to CBD, bikeshare stations and TOD stations (e.g., heavy rail, light rail, BRT), and the number of stations located within each tract.

Statistical Analysis

Using a series of spatial analysis and statistical tools, the analysis consists of three main

Table 3. Variables' description and data sources

Variable	Description	Source
Commuting mode	Percentage of means of transportation to work breaks down to walking, biking, transit, automobile, active travel, sustainable trips, work from home, taxi & motors	NHGIS, ArcGIS modeling
Travel time to work	Percentage of average commuting time (<15, 15-30, 30-60, >60)	NHGIS, ArcGIS modeling
Car ownership	Percentage of car possession per occupied household (0,1, +1)	NHGIS, ArcGIS modeling
Average car ownership	The average number of cars per occupied household	
Occupation	Change in overall job growth Change in number of jobs in four economic sectors (professional jobs, manufacturing, service sector, and retail)	LTDB
Unemployment	Change in percentage of unemployed	LTDB
Distance to CBD	Distance between the centroid of each tract to the city hall	Computation using ArcGIS
TOD stations	Number of rail/bus stations within each tract (dummy & continuous)	UNOTI Archive
Bikeshare docks	Bikeshare docks within each tract built since 2015 (dummy)	BTS
Duration of residency **Socio-economics**	Percentage of household moved into unit less than 10 yrs., Non-Hispanic whites, median rent, population, density	LTDB NHGIS

sections: measuring gentrification, testing whether gentrified neighborhoods experienced a change in travel behavior and employment, and finally, the association between gentrification, travel behavior, and job transition.

Second, I use a t-test to make two forms of comparative analysis to explore first: a potential distinction in characteristics of the gentrified neighborhood over the time (before and after groups), and second, any meaningful changes in all variables between gentrified and non-gentrified tracts (experimental/control groups). A T-test or difference of mean test is a powerful tool to validate the assumption about the effect of a given phenomenon. The central question here is which aspects of life are substantially affected by neighborhood change between 2000 and 2019. I hypothesize that there is no significant difference between the two sample mean for each variable if the p-value is less than 0.05. Otherwise, the null hypothesis is rejected, and I conclude that the differences between the means of samples are statistically different.

To test differences in features of the gentrified neighborhood between 2000 and 2019, I employ a dependent sample t-test (pairs t-test) because two sample data are matched somehow and represent the before and after observations for the same group of census tracts. Conversely, testing differences between gentrified and non-gentrified tracts demand independent samples t-test since there is no overlap between the two groups [70]. Being considered low-income neighborhoods in 2000 helps to create a robust comparison of how a change in income and education in some tracts could potentially alter the job locations and travel patterns. Displacement, population turnover, and the arrival of educated in-movers with new ideologies that are primarily anti- suburban in sentiment and support sustainability can

potentially change the dominant commuting mode and decrease commuting duration.

In addition, gentrification can occur along with new transit investment or active travel facilities, which may favor a sustainable form of travel. Increased urban density and new TOD spots can help the growth of certain forms of occupations. However, transit ridership, particularly bus transit, is more desirable for poorer households than higher-income households. As TOD policies result in gentrification and displacement, poorer families lose access to the newly built transit system. Thus, net transit ridership might fall significantly among TOD neighborhoods since the most underprivileged groups are not living in walking distance of transit stations [29].

Finally, the relationship between gentrification, travel behavior, and transition in job geography and the relationship between gentrification and travel behavior changes will be evaluated by using a series of two-way ANOVA tests. The test will also include bikeshare stations, access to the different types of transit, and proximity to the CBD as control variables. Bikeshare dock data is obtained from the Bureau of Transportation Statistics indexing the list of dock locations nationwide and the year built. Bikeshare system may have an immediate effect on the area, improve livability and increase housing prices. The earliest bikeshare system was launched in 2015 and rapidly developed in other areas until today. Since bikeshare facilities are nearly recent investments, it might be controversial because a longer time horizon is required to find a meaningful relationship between installing bikeshare and gentrification. The research presented here is not designed to explore the causal relationship between transit proximity or bikeshare dock stations and gentrification. Regardless of being a cause or an outcome, I will test the relationship between public investment and neighborhood change.

Chapter IV: Analyses and Results

I first assess the socioeconomic characteristics of tracts to identify the gentrifiable (but non-gentrified) and gentrified neighborhoods, respectively representing the control and treatment groups. The following discussion focuses on the difference between travel behavior and job transition; (i) between gentrified and non-gentrified neighborhoods, and (ii) between gentrified neighborhoods in 2000 and 2019. Then, I use a combination of two independent dummy variables (gentrification status and a fixed factor) to assess how their combined impact can affect a dependent variable (commuting/ job change).

Neighborhood Change

As discussed earlier, a combination of five criteria measures whether a neighborhood has undergone gentrification. The study samples are tracts with lower income and a higher proportion of old housing structures in 2000 than the respective MSA median. The sample has all eligible tracts for gentrification, including all gentrified or did not gentrify by 2019. Tracts that fall within MSAs could be urban, suburban, and rural areas. I discussed that despite gentrification's urban nature, and studies show that neighborhoods in suburbs or rural areas experienced gentrification.

For this reason, I selected a larger study area from the MSAs and did not limit the analysis to the immediate urban core as previous studies did. But in the case of brownfield redevelopment or newly developed areas that mainly occur in exurban neighborhoods, a significant socioeconomic change can happen due to fast population growth. These sites were not

formerly residential, and no gentrification and displacement occurred as a result. Therefore, to exclude the recent development or an immediate neighborhood decline that are not essentially related to the gentrification [27], I removed tracts that had a population growth rate of less than 60% as well as neighborhoods with less than 1200 residents in 2000. Census Bureau of U.S. defined census tract as small subdivision of a county with a population size between 1200 and 8,000 people but generally with a size of 4,000 people [72]. This definition helps to exclude the nonresidential tracts (parks, industrial areas, etc.) and rural neighborhoods where have small size of population or tracts that have undergone a recent urban development where experienced a substantial population growth.

Neighborhoods within 3 miles from CBS with at least 1,200 population and experienced less than 60% population growth were examined for income and housing structure age in 2000. Suppose the neighborhood's median income was less than the median income of the MSA and the portion of housing built more than 30 years was higher than the respective MSA. In that case, the tract was considered to be susceptible to gentrification. Eventually, the spatial analysis demonstrates that 4,686 neighborhoods were qualified for gentrification in 2000. In the next step, looking further at changes in educational attainment and median home value shows that 2,200 were ultimately gentrified by 2019. Figures 3 and 4 show the number of gentrified tracts per state and MSA, respectively.

Exploring the transition in residents' occupations and travel patterns in gentrified tracts as a treatment group requires a control group. The control group in this study is the eligible neighborhoods for gentrification in 2000 that were not gentrified by 2019. The following

section compares the commuting behavior and job transition between changes in these two groups.

Figure 5 displays gentrified and non-gentrified neighborhoods in four metro areas that experienced an extensive neighborhood change. Figure 6 demonstrates the gentrification occurrence in New Orleans between 2000 and 2019.

Descriptive Statistics

Table 4 summarizes the descriptive statistics of the socioeconomics, transportation, and occupation variables for 2000 versus 2019. To this data, I added distance to CBD, number of transit and bikeshare stations per tract. Duration of Residence reveals a potential displacement of population in a neighborhood. The decline in the percentage of households who moved into neighborhoods less than 10 years ago indicates that overall neighborhoods experienced less turnover between 2010 and 2019 compared to 1991-2000. Surprisingly, the population of non-Hispanic whites decreased in central cities despite the concern that the urban core is losing its minority population. Reduction in the rate of unemployment, the share of industrial occupation, and the rise of the service industry are consistent with the results of previous studies. The percentage of households owning both at least one automobile and over one vehicle increased during the last two decades. Travel duration less than 30 minutes has decreased slightly while travel time between 30 and 60 minutes has grown. In neighborhoods close to the urban core, auto trip and transit use had a downward trend falling from 75 to 73.1, respectively. Inversely, a higher portion of residents commuted by bicycle, taxicab, or worked from home.

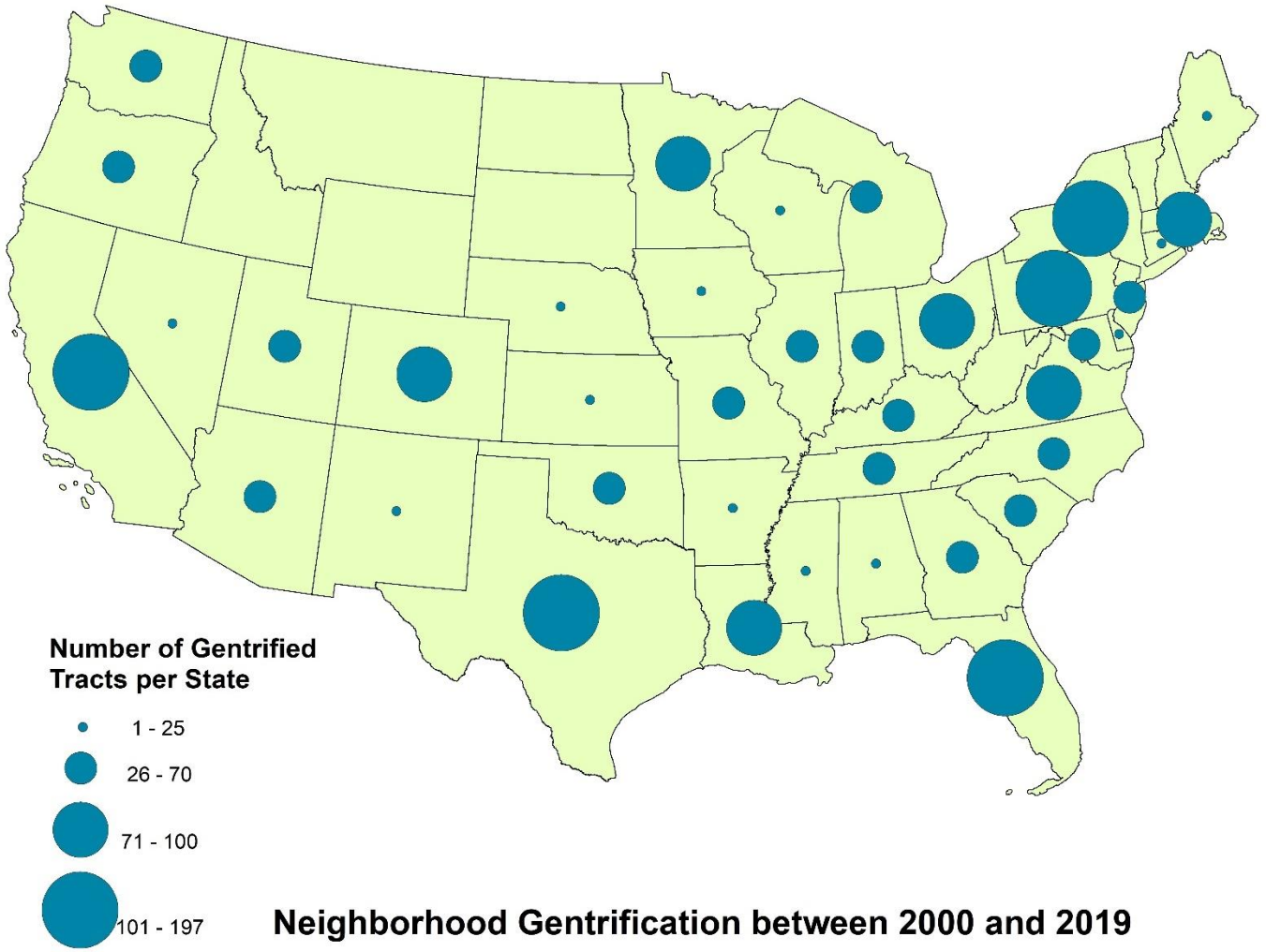


Figure 3. Neighborhood Gentrification Between 2000 and 2019: Tracts per State

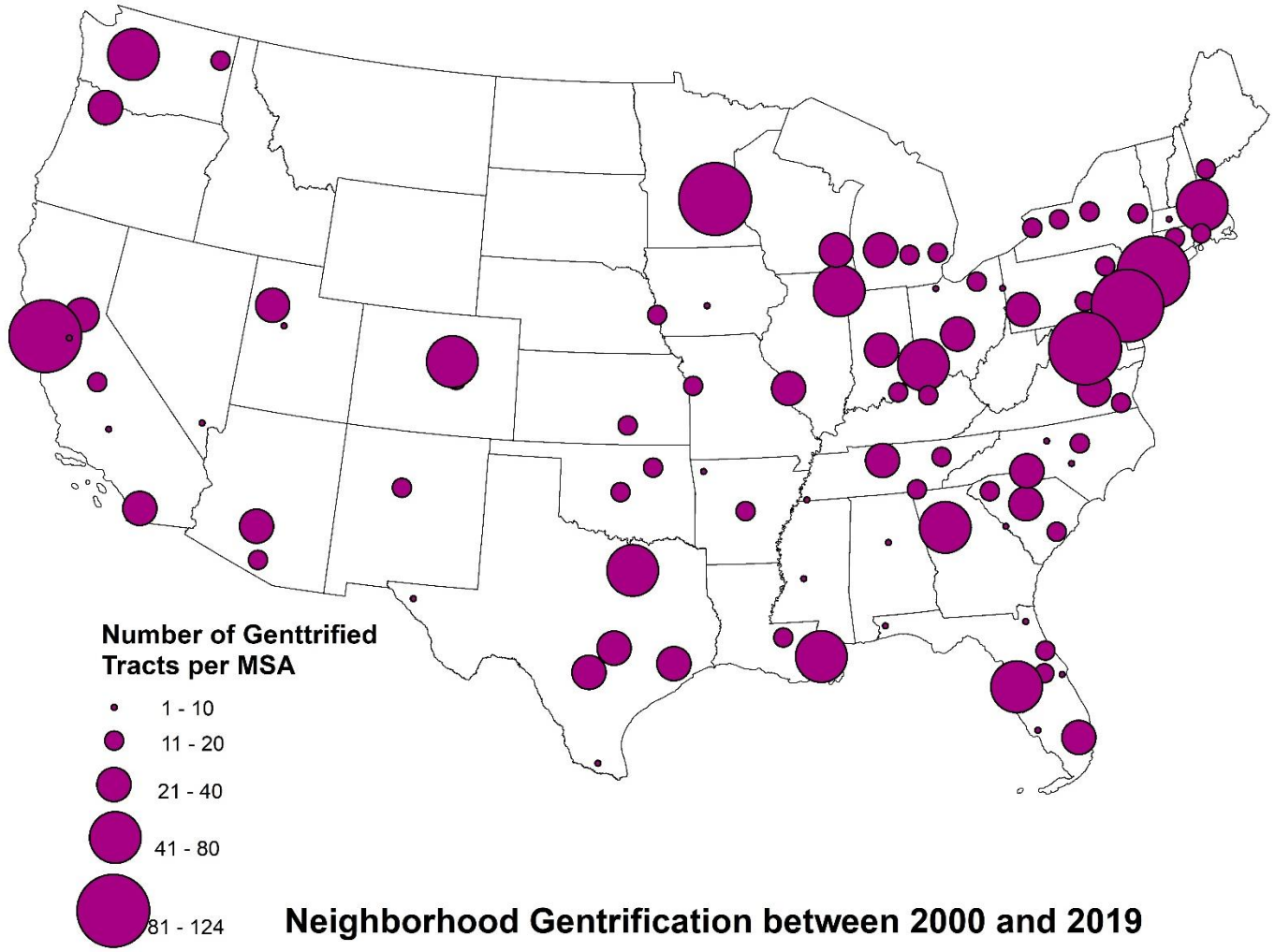


Figure 4. Neighborhood Gentrification Between 2000 and 2019: Tracts per MSA

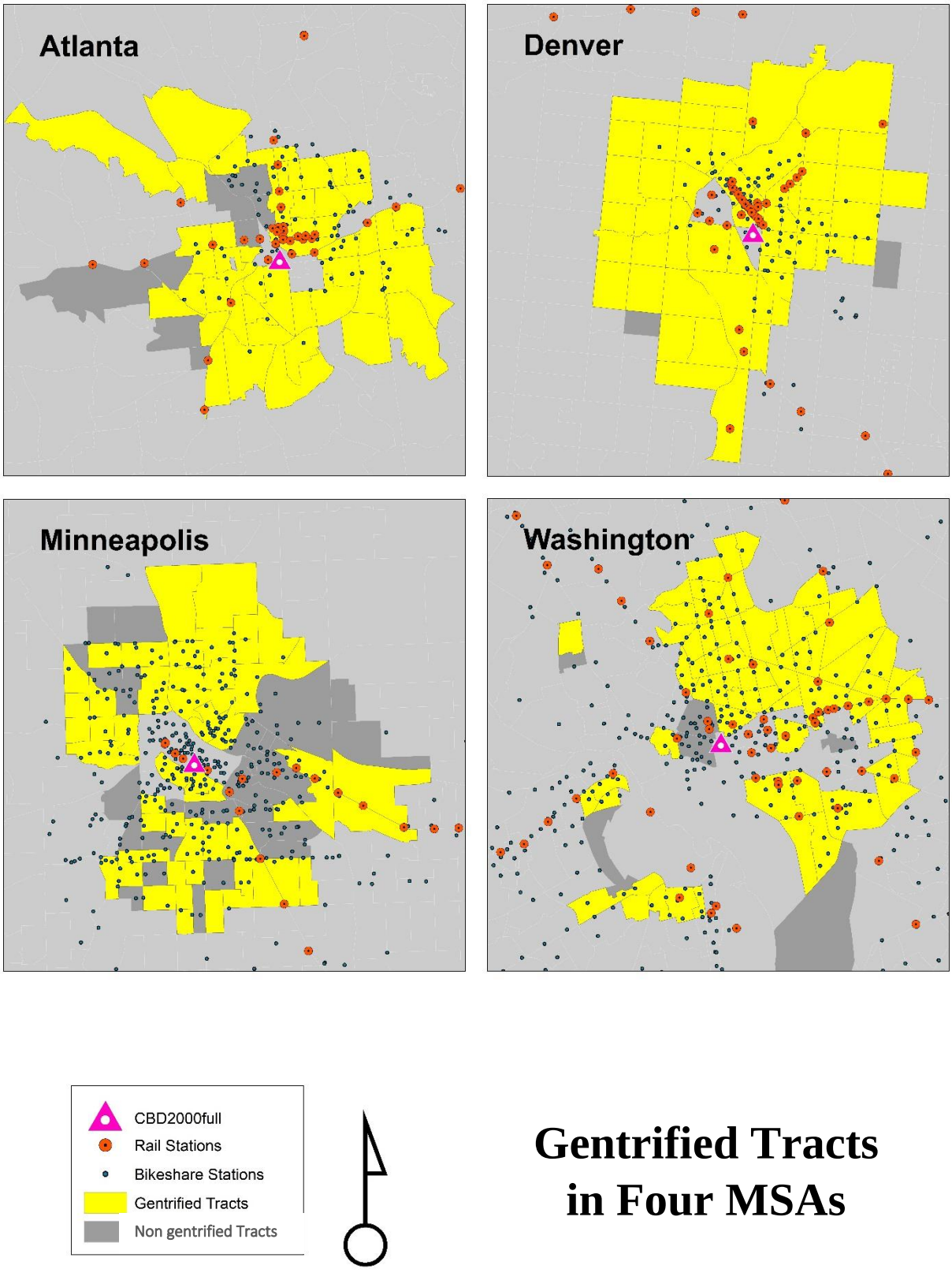


Figure 5. Gentrified Tracts in Four Major MSAs

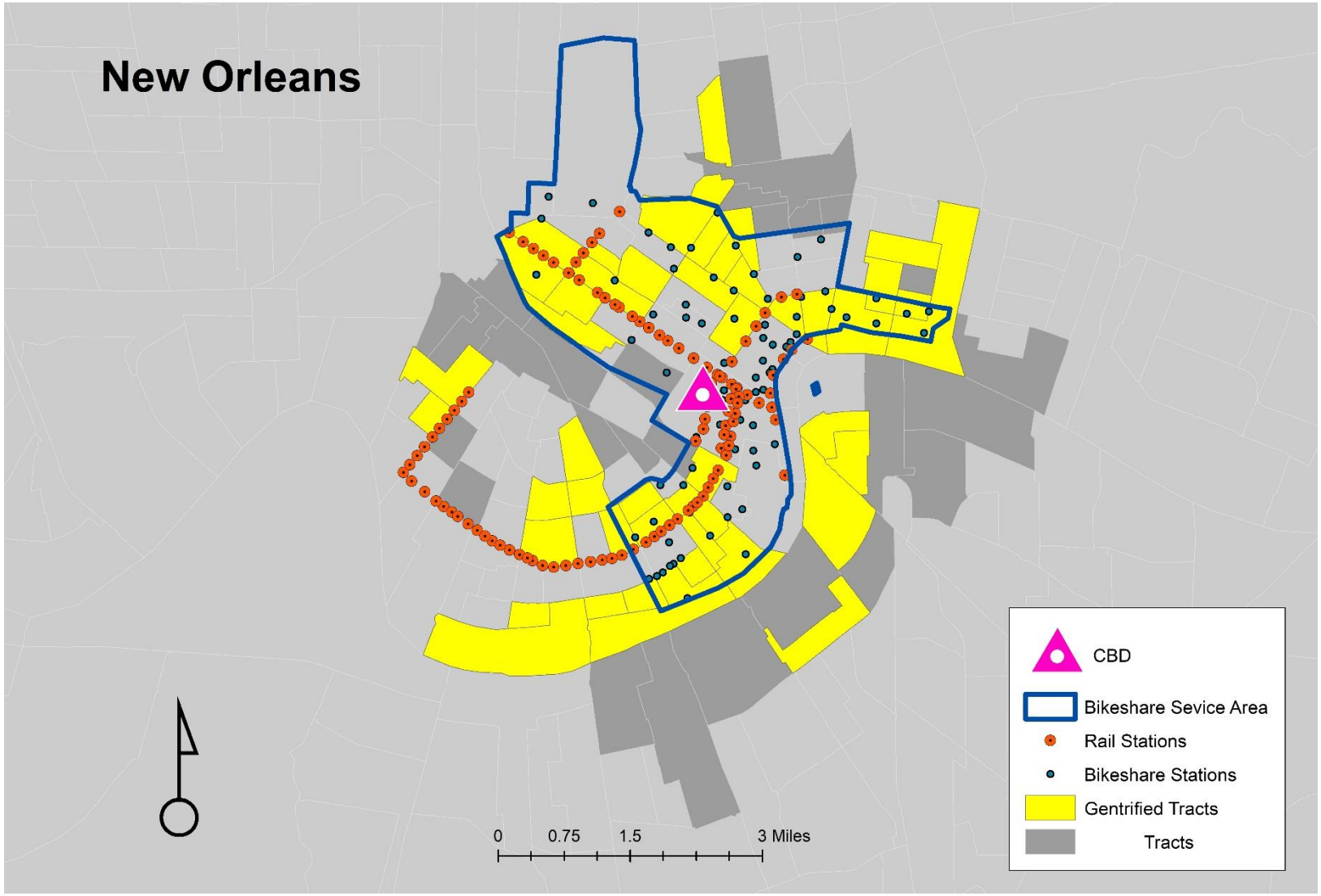


Figure 6. Gentrified Neighborhoods in New Orleans

Table 4. Descriptive Statistics

Measures	**2000**		**2019**		
	Mean	SD	Mean	SD	change
10 years of residency	68.41	12.95	61.27	13.68	-7.14
Non-Hispanic white	43.48	31.22	41.09	27.69	-2.39
Median rent	455	147	883	401.32	428
population	3425	1451	3491	1668	66
Density sq mile	10079	12997	10221	13283	142
unemployment	10.73	7.96	8.20	6.02	-2.53
professional	26.55	14.16	34.75	18.81	8.2
manufacturing	11.44	7.10	8.14	5.71	-3.3
Retail	9.77	3.40	10.74	4.91	0.97
Service	18.8	6.13	22.90	9.52	4.1
No vehicle	25.90	17.49	21.40	16.17	-4.5
One vehicle	42.33	8.62	42.59	9.71	0.26
Over 1 vehicle	31.76	14.86	36.22	16.70	4.46
Aver. vehicle	1.17	0.37	1.28	0.39	0.11
< 10 min	12.88	7.32	11.53	7.61	-1.35
10-30 min	56.79	10.86	56.51	12.53	-0.28
30-60 min	23.50	10.60	25.09	12.01	1.59
Over 60 min	6.81	5.04	7.10	7.53	0.29
Auto trip	75.03	19.41	73.17	21.17	-1.86
Transit trip	13.31	13.75	11.89	14.22	-1.42
Bike trip	0.99	1.62	1.76	2.87	0.77
Walk trip	7.18	9.53	6.76	9.78	-0.42
Active travel	8.17	10.04	8.51	10.82	0.34
Work home	2.31	2.06	4.45	3.84	2.14
Sustainable trip	23.80	19.42	24.82	20.96	1.02

Taxi & motor	1.15	1.40	2.19	5.54	1.04
TOD station per tract			0.21	0.97	
Heavy rail per tract			0.04	0.25	
BRT per tract			0.02	0.30	
Distance to CBD (meter)			2484	1359	
Bikeshare per tract			3.53	9.96	

Findings

This research has three-stages of data analysis. First, I applied a paired sample t-test to compare the mean value of factors in gentrified neighborhoods between 2000 and 2019. This sample represents before and after observations from neighborhoods that experienced gentrification. To assess the validity of this analysis, I then conducted a pretest-posttest comparison between the treatment and control groups to explore whether gentrified tracts have significantly changed compared to the non-gentrified group. This operation removes a potential bias source: bias from a wider-area improvements which means job transition and change in commuting behavior are not limited to the gentrified tracts. Finally, I employed a set of two-way ANOVA to further explore the combined effect of gentrification and other control variables on job and travel behavior.

Pretest-Posttest

While analyzing gentrified neighborhoods in the first stage, three socioeconomic factors, including income, education, and housing have been examined. The concept of duration residency states that the probability of moving out of a neighborhood is conversely related to

the duration of residence. The longer residents live in the neighborhood, the more commitment they have to the area [24]. Few households moved into gentrified neighborhoods within the last ten years compared to the same neighborhoods in 1990-2000. Fewer in-movement in gentrified tracts during the previous decade is not consistent with the idea that gentrification comes along with residential mobility. This inconsistency could be explained by the lack of data for the duration of residency between 2000 and 2010 in the LTDB database, which may change the finding between 2000 and 2019. Racial composition is expected to be affected by residential displacement generated by gentrification. The percentage of the non-Hispanic white population living in gentrified tracts has increased from 47 to 51% over time. Expectedly, the median rent of gentrified tracts after adjustment to the 2017 dollar had risen from $481 to $1,021. Even though it is discussed that median rent is a more reliable metric to evaluate the housing market dynamics, this study also used the median home value following the methodology developed by Freeman (2005) to measure gentrification. The gentrified neighborhood had become denser in 2019 with a 5.47% increase per square mile, while the overall sample neighborhoods experienced a 1.4% increase in population density. That means either vacant properties were regenerated, or high-rise buildings were constructed in new residential development areas.

Gentrification is commonly characterized by the in-migration of highly skilled workers and professionals and a decrease in manufacturing and good-producing industries in the previous three decades. Within the central neighborhoods that underwent gentrification, the rate of unemployment fell from 9.7% to 6%. Percentage changes suggest a dramatic increase in professional occupation while other occupations such as the service industry were nearly stable

over time. However, the change in manufacturing occupation in gentrified neighborhoods does not exhibit any significant difference from that change in other neighborhoods.

As Table 3 shows, the percentage of households with no vehicle decreased over time, meaning, indicating more households have access to at least one vehicle in 2019. The proportion of families with more than one automobile is also elevated from 31.6 to 36%. The average number of vehicles owned by per occupied housing increased by 0.15%. An increase in household vehicle ownership in the gentrified neighborhoods could be related to the escalations and the increase in residents' income. Travel time to work remained steady for trips that last over an hour. However, the percentage of workers whose commuting time lasts less than 10 minutes or between half an hour to one-hour increased 2.6% and 2.1%, respectively. Other datasets and additional analysis are required to explore the complex relationship between transition in the job industry and commuting duration.

The commute share of the automobile, transit and walking declined by 2.8% and 1.9%, respectively. While the percent change of biking and taxicab trips slightly increased by 1.3% and 0.6%. Furthermore, the proportion of the workforce working from home rose at an even higher rate from 2.6 to 5.6%. Nevertheless, the share of sustainable transportation (combination of transit, biking, and walking) increased noticeably from 27.5 to 29.6%. The decline in walking from 8.12% to 7.79% could be explained by a reduction of short trips (< 10 minutes) because a great percentage of short trips are done by feet. In addition, the development of bicycle facilities and bikeshare systems might cause a shift from walking/ driving to cycling for short urban trips. Substantial changes in the percentage of people who work from home experienced

a more dramatic rise after 2020 due to the pandemic-related restrictions.

Table 5. Paired Samples T-test (Gentrified Neighborhoods in 2000 and 2019)

	factors	year	mean	t	df	two-sided p value
Socioeconomics	10 years of residency	2000	70.34	31.52	2199	<0.001
		2019	63.91			
	% non-Hispanic white	2000	47.84	-11.04	2199	<0.001
		2019	51.53			
	Median rent	2000	481	-73.94	2191	<0.001
		2019	1,021			
	Population density	2000	11,220	-6.42	2199	<0.001
		2019	11,834			
	population	2000	3,297	-9.91	2199	<0.001
		2019	3,514			
Employment	% Unemployed	2000	9.70	23.60	2199	<0.001
		2019	6.00			
	% Professional	2000	30.91	-61.13	2199	<0.001
		2019	45.85			
	% Manufacturing occupation	2000	9.78	26.32	2199	<0.001
		2019	6.91			
	% Retail	2000	9.68	1.22	2199	0.219
		2019	9.55			
	% Service	2000	18.11	-3.95	2199	<0.001
		2019	18.74			
Travel	% No vehicle ownership	2000	26.92	33.25	2199	<0.001
		2019	20.23			
	% One vehicle ownership	2000	42.91	-4.38	2199	<0.001
		2019	43.75			

	% Over 1 vehicle	2000 2019	30.16 36.00	-34.21	2199	<0.001
	Average vehicle per occupied housing	2000 2019	1.13 1.28	-36.38	2199	<0.001
	% Trips less than 10 min	2000 2019	13.18 11.53	12.68	2199	<0.001
	% Trips 10 to 30 min	2000 2019	55.98 55.85	0.65	2199	0.515
	% Trips 30 to 60 min	2000 2019	23.99 26.13	-12.01	2199	<0.001
	% Trips over 60 min	2000 2019	6.83 6.48	3.37	2199	<0.001
	% Auto trips	2000 2019	71.35 68.57	13.68	2199	<0.001
	% Transit trips	2000 2019	15.45 13.55	11.39	2199	<0.001
	% Bike trips	2000 2019	1.32 2.68	-22.07	2199	<0.001
	% Walk trips	2000 2019	8.12 7.79	2.89	2199	<0.01
	% Active travel	2000 2019	9.44 10.48	-7.79	2199	<0.001
	% Work home	2000 2019	2.63 5.59	-36.16	2199	<0.001
	% Sustainable commuting	2000 2019	27.53 29.62	-10.46	2199	<0.001
	% Taxi, motor, other means	2000 2019	1.11 1.79	-14.01	2199	<0.001

Control Test

I use the independent t-test as a classic experimental and control group to compare the effect of gentrification. Here, I test the mean value of changes in the percentage of all variables for two groups of 2200 gentrified tracts (experimental group) and 2686 non-gentrified tracts (control group). The comparison results are presented in Table 4. The result shows a statistically significant difference between gentrified and non-gentrified tracts in all measures except the share of walk trips and the commuting time of 10-30 minutes. Statistically significant values show whether differences between samples are due to chance or not.

The areas which underwent gentrification had become significantly denser relative to their population density in 2000, while non-gentrified neighborhoods lost 227 persons per square mile over the period 227 persons per square mile over time. [use the exact number to clarify—this is unclear] While less than 10 ten years of duration residency has declined in both sample groups, non-gentrified tracts experienced more decline by 7.71% compared to 6.43% in gentrified tracts. Unlike the gentrified neighborhoods which increased by 3.62%, the proportion of non-Hispanic residents decreased in non-gentrified tracts by 7.89%. In-migration of the white population and class restructuring are shown to be higher in gentrified neighborhoods compared to other neighborhoods, particularly following a neighborhood upgrading. Median rent change of gentrified neighborhoods ($540) is notably higher than the median rent of the control group ($327). In addition to the increase of housing prices, rental values also increased rapidly in gentrified neighborhoods because of neighborhood revitalization and the influx of a higher-income populations with the ability to pay higher rents or mortgages.

The overall employment has improved in the study area, but the job grew faster in gentrified tracts by 3.70% relative to the 1.53% of employment growth in non-gentrified areas. The proportion of population of workers in a professional occupation increased remarkably in gentrified areas with an over 14% increase, while the control group had only a 2% improvement. Although the share of manufacturing jobs decreased in both experimental and control groups, it decreased faster in non-gentrified neighborhoods, presumably, due to an overall decrease in employment opportunities. Percentage of population in industrial occupation decreased by 2.87% in gentrified tracts while it dropped by 3.70% in non-gentrified tracts. Retail and service occupations had lower growth in gentrified tracts by -0.12% and 0.63%, respectively, compared to 1.87% and 7.02% in none gentrified neighborhoods. This result requires further examination for pre-post, land use studies to find the possibility of commercial gentrification.

The share of households without vehicles decreased at a greater rate in gentrified neighborhoods by 6.68% compared to the 2.69% in non-gentrified neighborhoods. Likewise, average vehicle ownership, percentage of households with one vehicle, and households with more than one vehicle increased faster in neighborhoods that experienced residential gentrification for 0.14%, 0.84% and 5.84% relative to the 0.07%, -0.53%, and 3.23% in non-gentrified tracts. While short urban trips have decreased in both control and treatment groups, the percentage of workers living in gentrified neighborhoods (treatment group) who commute less than 10-minutes decreased more than non-gentrified residents (control group), by 1.65% compared to 1.14%. However, workers with a commuting time between 30 and 60 minutes rose at higher levels in gentrified tracts by 2.13%. These results could be translated to indicate

that despite the expectation, gentrification did not improve job access for nearby opportunities. However, access was improved for jobs at farther distances.

Table 6. Independent Samples T-test (Gentrified Neighborhoods vs. non-gentrified neighborhoods)

	factors	year	mean	t	df	two-sided p value
Socioeconomics	10 years of residency	Gentrified	-6.43	4.50	4666	<0.001
		Non-gentrified	-7.71			
	non-Hispanic white	Gentrified	3.68	27.47	4258.91	<0.001
		Non-gentrified	-7.89			
	Median rent	Gentrified	540	24.79	3715.01	<0.001
		Non-gentrified	327			
	Population density	Gentrified	614	7.71	3953.09	<0.001
		Non-gentrified	-227			
Employment	Unemployed	Gentrified	-3.70	-9.67	4676.33	<0.001
		Non-gentrified	-1.53			
	Professional occupation	Gentrified	14.93	42.98	4092.65	<0.001
		Non-gentrified	2.00			
	Manufacturing occupation	Gentrified	-2.87	5.00	4650.80	<0.001
		Non-gentrified	-3.70			
	Retail	Gentrified	-0.12	-12.99	4625.86	<0.001
		Non-gentrified	1.87			
	Service	Gentrified	0.63	-28.04	4675.72	<0.001
		Non-gentrified	7.02			
Travel	%No vehicle ownership	Gentrified	-6.68	-14.51	4601.96	<0.001
		Non-gentrified	-2.69			
	One vehicle ownership	Gentrified	0.84	4.86	4682.33	<0.001
		Non-gentrified	-0.53			

Over 1 vehicle	Gentrified	5.84	9.39	4525.23	<0.001
	Non-gentrified	3.23			
Average vehicle per occupied housing	Gentrified	0.14	12.20	4663.18	<0.001
	Non-gentrified	0.07			
Trips less than 10 min	Gentrified	-1.65	-2.61	4678.19	<0.01
	Non-gentrified	-1.14			
Trips 10 to 30 min	Gentrified	-0.12	1.877	4666.33	0.061
	Non-gentrified	-0.69			
Trips 30 to 60 min	Gentrified	2.13	4.49	4680.77	<0.001
	Non-gentrified	0.98			
Trips over 60 min	Gentrified	-0.35	-5.89	3973.90	<0.001
	Non-gentrified	0.85			
Auto trips	Gentrified	-2.77	-4.49	4683	<0.001
	Non-gentrified	-1.41			
Transit trips	Gentrified	-1.89	-3.74	4592.012	<0.001
	Non-gentrified	-1.05			
Bike trips	Gentrified	1.36	15.71	3605.685	<0.001
	Non-gentrified	0.23			
Walk trips	Gentrified	-0.32	1.26	4683	0.207
	Non-gentrified	-.052			
Active travel	Gentrified	1.04	7.52	4497.150	<0.001
	Non-gentrified	-0.28			
Work home	Gentrified	2.95	14.25	4520.544	<0.001
	Non-gentrified	1.40			
Sustainable commuting	Gentrified	2.09	7.23	4683	<0.001
	Non-gentrified	0.06			
Taxi, motor, and other means	Gentrified	0.67	-4.23	2989.152	<0.001
	Non-gentrified	1.35			

The share of the automobile, transit and walking trips had declined in both groups but at a higher rate in gentrified tracts. They respectively, decreased by 2.77%, 1.89%, and 0.32% in gentrified tracts compared to 1.41%, 1.05%, and 0.052% in non-gentrified neighborhoods. Cycling and working from home improved faster in neighborhoods experienced gentrification over the last two decades. In gentrified neighborhoods, these commuting more increased by 1.36% and 2.95% relative to the 0.23% and 1.40% in non-gentrified tracts. Overall, the share of active and sustainable modes of transportation increased and more quickly in gentrified tracts by 1.04% and 2.09%.

Factorial Design

This research was initially designed to run a multivariate regression model to explore the correlation between variables. Still, the R square values generated under different scenarios were not good enough to represent the acceptable proportion of the variance for the dependent variable explained by an independent variable. Therefore, I employed two-way ANOVA (a factorial design) to estimate how a combination of two independent variables (status of gentrification and one control variable) affects a dependent variable (e.g., change in percentage of commuting by automobile).

Results of two-way ANONA suggest several significant ($p<0.01$) associations between the combination of gentrification and one independent variable on job and travel behavior change between 2000 and 2019 (See Appendix A). The unemployment rate generally decreases when the distance to CBD is less than 800 meters, but it is also reduced at a faster pace in gentrified neighborhoods. The falling trend continued even more dramatically in neighborhoods with BRT

stations. For neighborhoods that underwent gentrification, the increase in professional occupation is significantly higher where facilities such as light rail, and BRT stations exit. Change in proportion of professional occupation had become considerably higher in neighborhoods with the presence of railroad, bus stop, and bikeshare stations. Gentrified neighborhoods near BRT stations saw a fast decline in the percentage of industrial jobs.

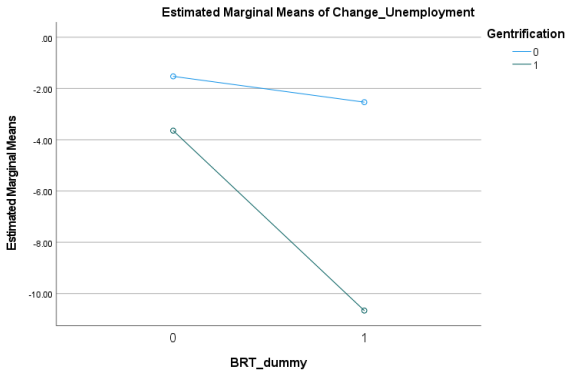
In contrast, non-gentrified neighborhoods near BRT stations had an increase in the proportion of jobs in the manufacturing sector. This finding is consistent with the literature on the deindustrialization of urban cores and the transition from manufacturing to professional jobs in urban gentrified neighborhoods. In addition, gentrified neighborhoods located half a mile from city halls lost service occupation faster relative to the farther gentrified tracts.

While the proportion of households with no vehicle has declined in neighborhoods with TOD and Bikeshare stations, gentrified neighborhoods experienced a sharper downward trend. Access to BRT in non-gentrified neighborhoods is related with slightly rising the proportion of families without an automobile. In addition, neighborhoods that underwent gentrification experienced a higher rate of one-vehicle ownership even when they had rail stations (both heavy rail and light rail), bikeshare systems, and BRT. That is, better access to transit did not dissuade higher-income households in gentrified neighborhoods from purchasing an automobile. However, rail accessibility had a reverse effect on having more than one vehicle in gentrified tracts versus non-gentrified ones. Unlike non-gentrified neighborhoods, when gentrified neighborhoods have access to amenities such as heavy rail, light rail, households are less likely to own more than one vehicle. The average number of vehicle possession escalates

rapidly in the gentrified neighborhood with BRT stations. Still, it decreases at the same rate for families living in non-gentrified neighborhoods, presumably due to the ineffectiveness of transit as a commuting mode for these Households.

The presence of rail stations, particularly light rail, is associated with a decline in share of short trips (less than 10 minutes) in non-gentrified areas, but an increase in gentrified neighborhoods. Gentrification combined with BRT or rail stations (heavy rail) can increase the proportion of commuters whose travels last between 10 to 30 minutes. Conversely, non-gentrified neighborhoods with the similar amenities experienced significant decline in 10-30 minutes commuting trips. Again, commuting time over an hour decreased significantly in gentrified neighborhoods with BRT and heavy-rail station access. Unlike gentrified neighborhoods, the proportion of households whose travel time to work is longer than 60 minutes decreased in transit-friendly, gentrified neighborhoods.

Commuting by automobile slightly decreased in non-gentrified neighborhoods with access to BRT stations. However, it significantly increased in gentrified tracts, presumably, due to the higher income of households living there which enable them to purchase private vehicle. As we may expect, bikeshare docks within neighborhoods positively impact the share of commuting with bikeshare. Although many people may not use bikeshare as a commuting mode, having such facilities shows that the neighborhood is bicycle-friendly to some extent. While distance to CBD does not affect commuting by bicycle in non-gentrified neighborhoods, residing within 800 meters from CBD could significantly increase commuting by bicycle in gentrified neighborhoods.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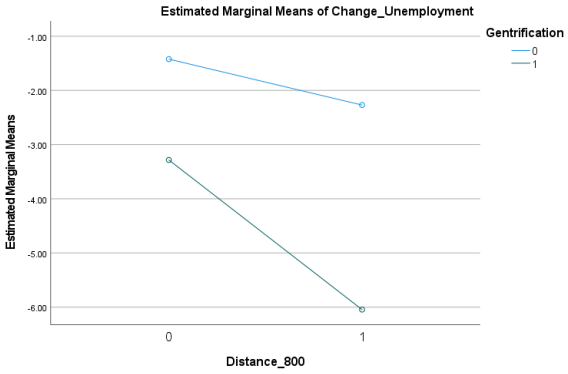
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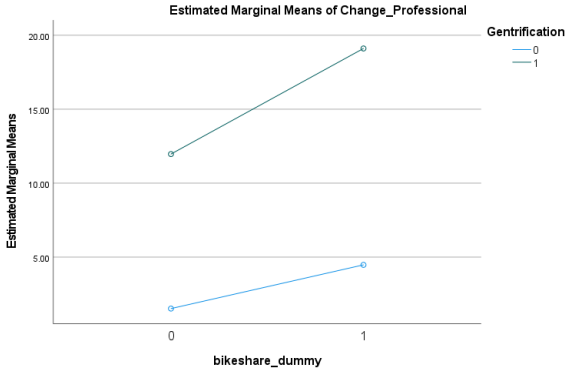
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10.00
5.00
0
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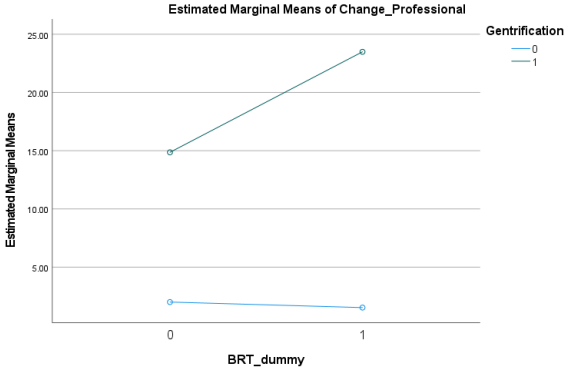
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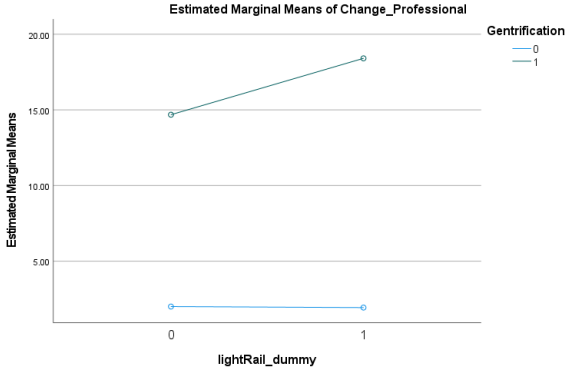
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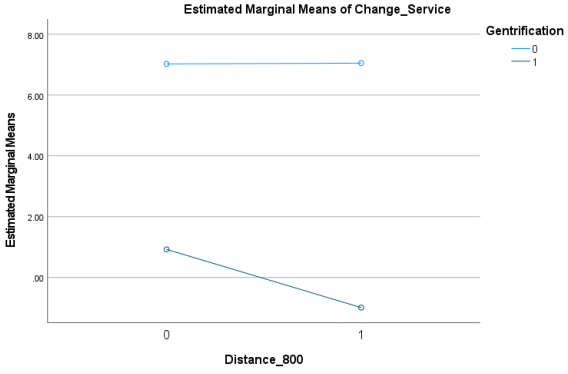
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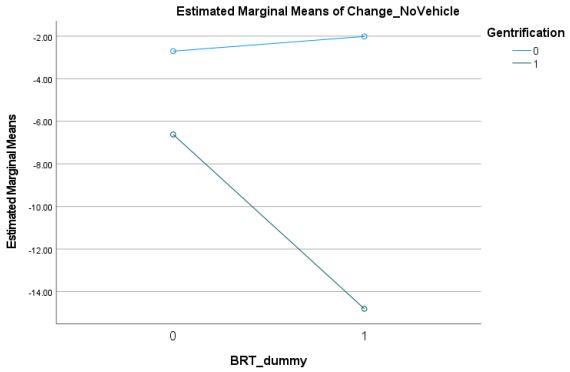
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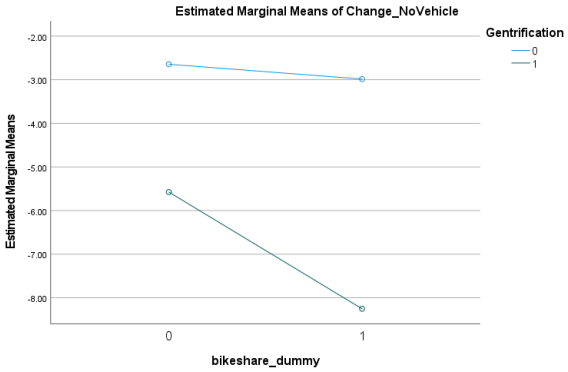
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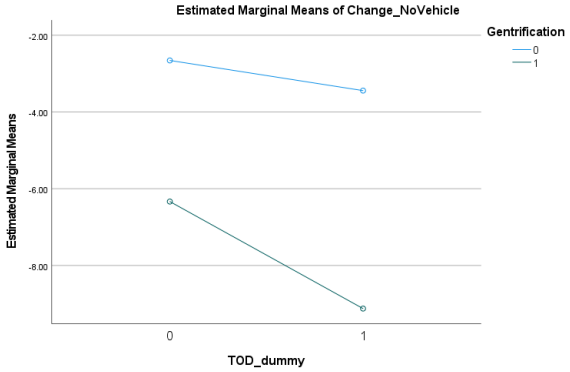
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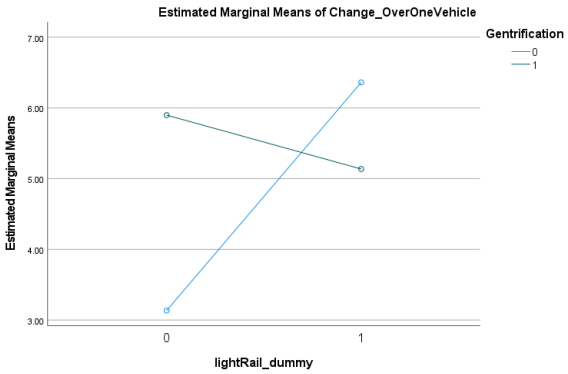
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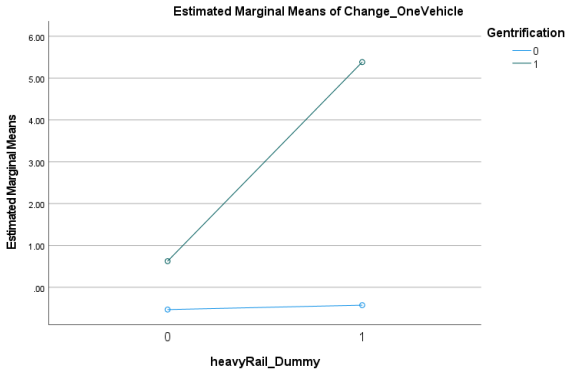
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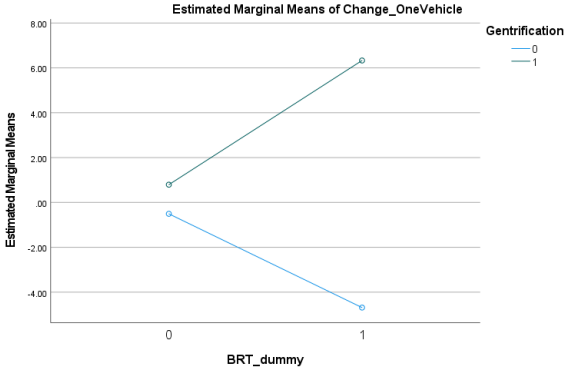
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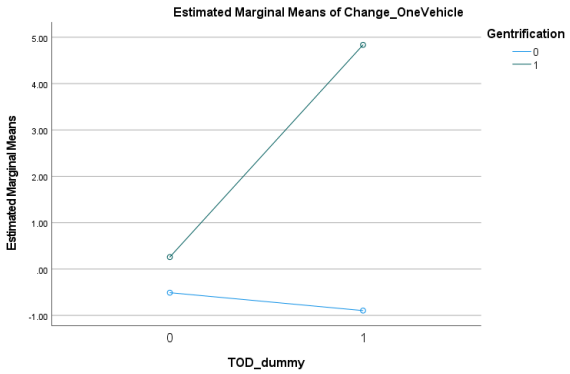
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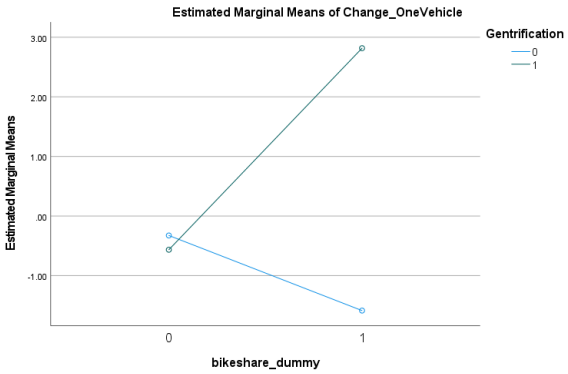
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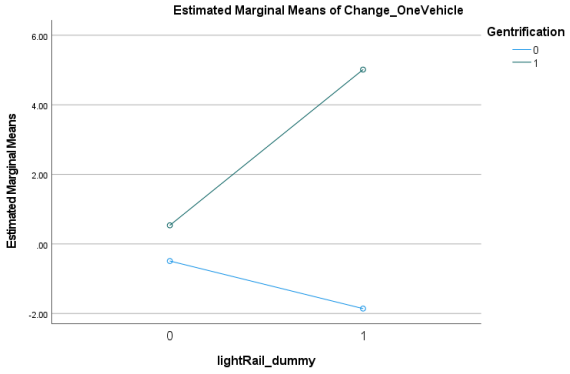
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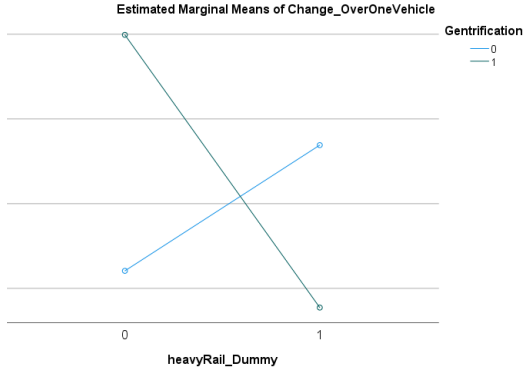
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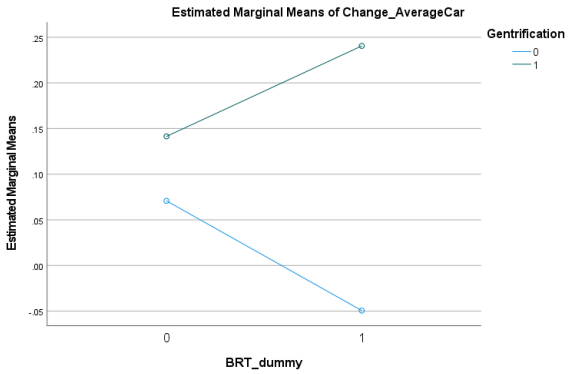
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.15
.10
.05
.00
-.05
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1
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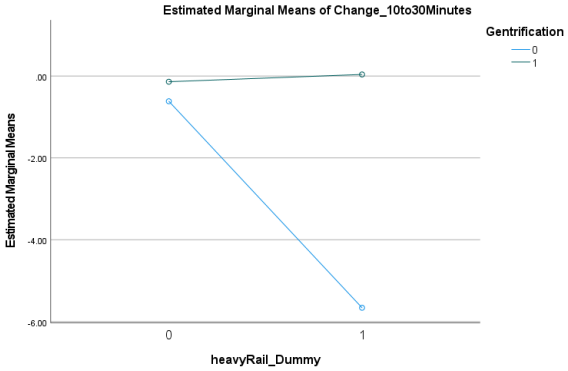
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-4.00
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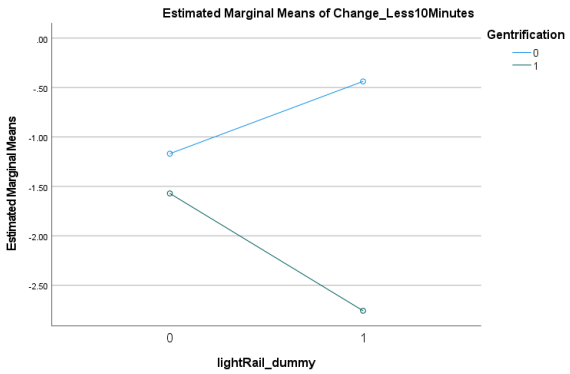
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-1.00
-1.50
-2.00
-2.50
0
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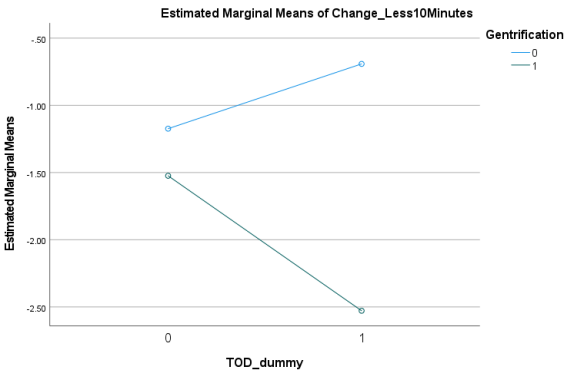
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1
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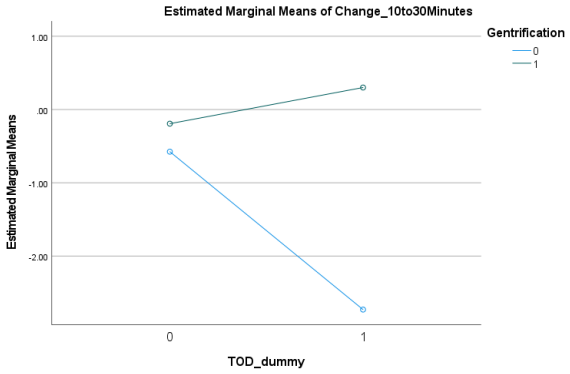
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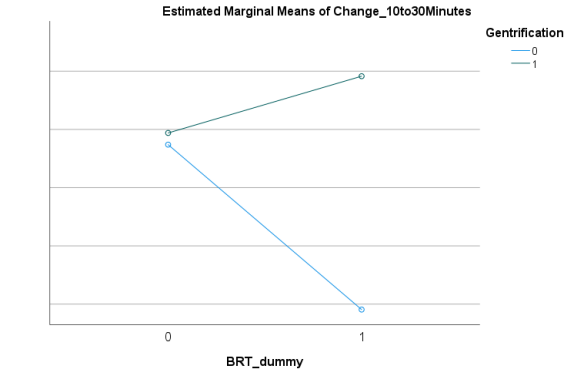
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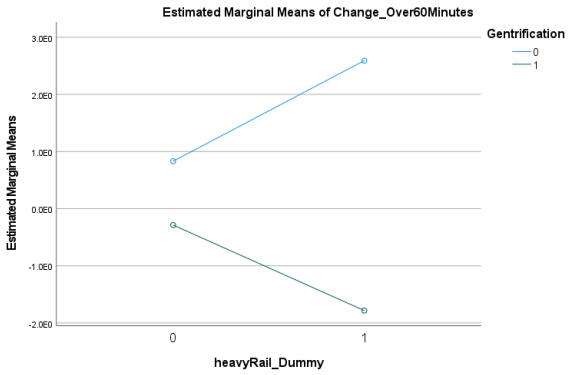
Estimated Marginal Means of Change_Over60Minutes
Gentrification
0
1
Estimated Marginal Means
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2.0E0
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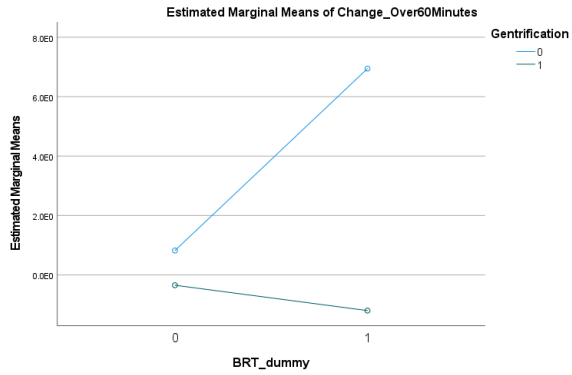
0
1
heavyRail_Dummy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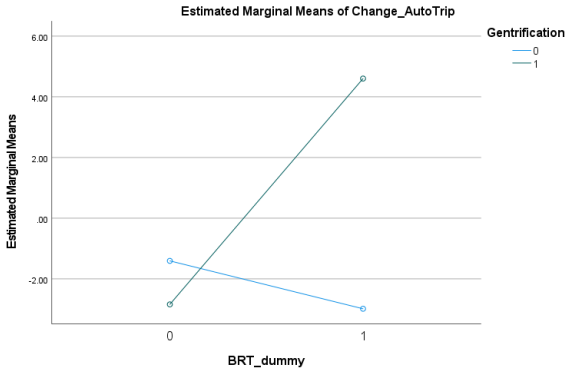
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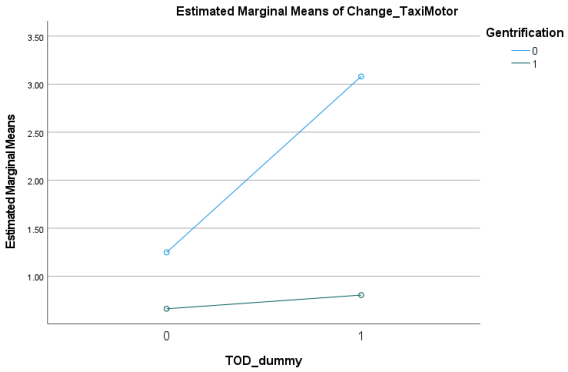
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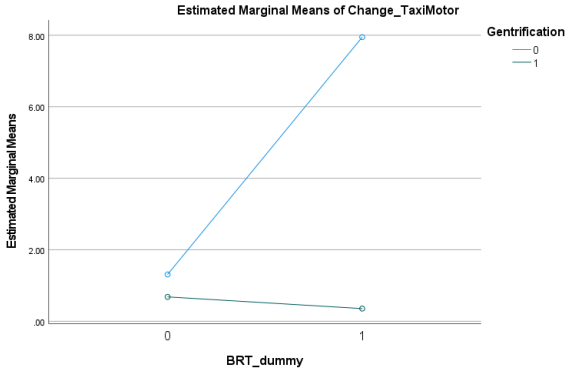
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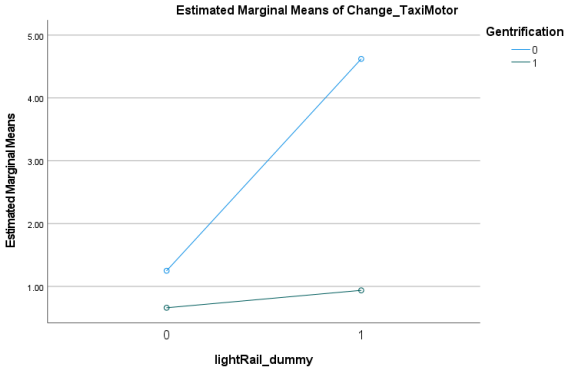
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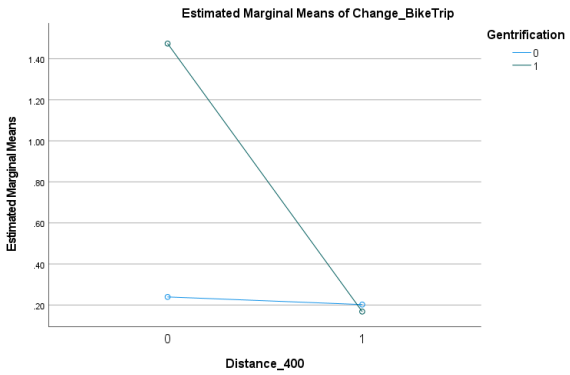
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Gentrification
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1
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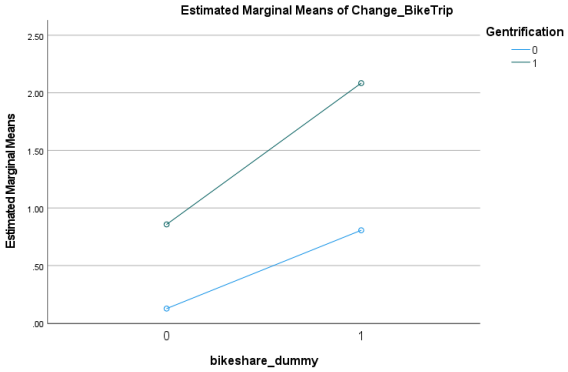
.20
0
1
Distance_400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1
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.00
0
1
bikeshare_dummy

The result of two-way ANOVA shows that despite unchanged trend in gentrified tracts, public transit (including rail and BRT) notably increased the use of taxi motors and cabs in non-gentrified neighborhoods.

It is worth mentioning that when a two-factor ANOVA produces a significant interaction, we must be cautious about accepting the main effects. Because the existence of interaction indicates that the impact for one factor depends on the level of the second factor. While one aspect may change, the presence of the second factor can make an insignificant change of the first factor significant or make the significant change of the first factor insignificant. Therefore, whenever a two-way ANOVA generates a meaningful interaction, we should use the interaction as the basis for interpreting the results. When additional information is required, we can use a single-factor ANOVA to evaluate how each factor changes independently.

Chapter V: Conclusion and Discussion

The findings of this research demonstrate that a significant portion of urban neighborhoods within large- and mid-size MSAs in the U.S. have experienced socio-economic changes between 2000 and 2019. These so-called gentrification changes are measured through income, education, housing age, and housing value. The results indicate widespread gentrification in inner cities, neighborhoods located within 3 miles from city halls. Among the 6322 urban core tracts reviewed in this study, 4,686 were identified as ready to be gentrified, and 2200 were gentrified between 2000 and 2019. Expanding upon the previous research (Freeman: 2005, Bereitschaft: 2020), this study sought to explore the relationship between gentrification and change in job sectors and travel behavior. As a socio-economic change, gentrification is expected to affect the commuting pattern since the demographic transition comes with a change in residents' attitudes toward sustainability. In addition, the gentrified neighborhoods usually provide better access to public transit and active transportation facilities. This result shows that gentrification comes along with racial turnover, less unemployment, more professionalism, and less service jobs.

From these results, I arrived at four primary conclusions. First, the trend of neighborhood change, which was started in the 1990s with the purpose of deindustrialization in urban cores, has continued within the last two decades due to the professionalization of jobs and the rise of the knowledge-based economy and creative class in inner cities. In addition to the income level, educational attainment, and home value which were calculated to identify gentrified neighborhoods, further analysis shows a change in racial composition. While non-gentrified

neighborhoods lost about 8% of their non-Hispanic white population, gentrified neighborhoods, as we expected, gained an additional 3.6 percent. Moreover, the median rent in gentrified neighborhoods had surged significantly compared to non-gentrified areas. Population density remarkably rose in gentrified neighborhoods but declined in the other group. These features make non-gentrified neighborhoods vulnerable to gentrification in the 2020s if the movement toward downtown continues to escalate.

Approximately 75% of inner-city neighborhoods (3 miles from CBD) were socially and economically ready to be gentrified in 2000. Half of those tracts were ultimately gentrified while leaving the possibility of gentrification for the other half tracts in near future. This prediction necessitates further attention to future housing and transportation policy and consideration for land use acquisition and economic development.

Second, the socio-economic changes observed in neighborhoods had some implications for resident's occupation transition. The unemployment rate decreased faster in gentrified neighborhoods associated with proximity to CBD and the presence of BRT stations. Professional occupations, as anticipated, are flourishing but grow rapidly in gentrified tracts. Many gentrification studies measure change in professionalization as a character of gentrification. The decline in the proportion of professional employees is consistent with the findings of the previous works. Industrial jobs, in general, decreased which affirms deindustrialization is still in progress but decreased slightly faster in non-gentrified tracts. Professional jobs grew faster in gentrified neighborhoods with having access to transportation amenities such as rail stations, BRT, and bikeshare compared to non-gentrified neighborhoods with similar amenities. Other

occupational sectors, including retail and service jobs, did not change notably nor show an interpretable trend that helped to tease out the association between different data and their implication on gentrification. In short, the findings of this research affirm an economic shift toward deindustrialization and professional jobs such as management, business, science, and arts occupations.

Third, the study results suggest a significant difference in travel behavior among gentrified and non-gentrified groups. Even though both groups experienced a decline in the proportion of households without a vehicle, gentrified tracts witnessed a sharper decline, especially when the neighborhood had access to the bikeshare stations and public transit. An increase in the share of households with over one vehicle. The presence of transit stops and bikeshare facilities also has a more substantial positive impact on the possession of only one automobile in gentrified neighborhoods compared to non-gentrified ones. However, the share of households with more than one car risen at the greatest rate in gentrified neighborhoods without access to the rail transit and bikeshare docks.

The overall decrease in the percentage of families with no vehicle and increase in families with over one vehicle, which occurred at a faster rate in gentrified neighborhoods, can be explained by higher income and growing inclination to have access to the private automobile. That means access to the CBD, and highly dense areas did not meaningfully discourage households from purchasing a car. These results raise a matter for future consideration on origin-destination analysis or examination of non-commuting travels to further investigate the travel behavior pattern. While access to bikeshare system, BRT, and rail stations had a greater impact on having

a maximum of one vehicle in gentrified neighborhoods, their combined impact with gentrification was lower for possessing over one vehicle.

Lastly, regarding the commute time, gentrified neighborhoods generated a more sustainable outcome by decreasing the percentage of commuters' travel time except commuting time between 30 to 60 minutes, which was increased faster in gentrified tracts. The presence of public transit accelerated the increasing/declining trend in gentrified neighborhoods relative to the non-gentrified ones. Proximity to the CBD and bikeshare facilities, expectedly, encourage bicycling as a commuting mode. While the share of sustainable commuting modes surged between 2000 and 2019, the percentage of commuters with transit and by foot decreased, particularly in gentrified tracts. Residents of gentrified neighborhoods that are located closer to the CBD are more likely to commute via sustainable modes of transportation.

From a policy perspective, cities constantly experiencing socio-economic changes may demand further investment in public transit and active travel. Declining transit and walking as a commuting mode should alert policy makers to work harder to promote sustainable travel forms. The overall decline in public transit means city should work more on sustainable transportation/ maybe trough policies such as incentives. As an anti-displacement policy, future public investment such as developing rail transit or bikeshare system may occur in lower income neighborhoods with higher proportion of minorities. Any future investment should be designed to benefit a wide spectrum of residents, not just high-income residents. This analysis also suggests a policy that applies land-use policies that encourage compact development decrease the distance to work and commuting time. The study shows that gentrification comes

with densification which potentially can bring services and daily destinations closer. Densification in a combination with TOD and/ or mixed-use development can strongly reduce driving and promote sustainable transportation. The study of gentrification remains a critical topic on the neighborhood change in urban areas since it has effects on access and equity.

Research Limitation

Results from this quasi-longitudinal study indicate that gentrification directly contributes to the shift in residents' occupation from industrial jobs to professionalization in urban centers. It is also shown that gentrification is associated with a mildly positive impact on commuting time, commuting mode choice, and average auto ownership. Results from this study are consistent with the idea that residential relocation and neighborhood change the landscape of employment and influence the travel pattern. This research also has a number of limitations.

First, since the spatial scope of this research was limited to mid- to large MSAs, the results should be taken as the average effect for the urban core/ inner-cities neighborhoods in most populated urban areas nationwide. A smaller subset of the study area may see different changes either greater/weaker association or no meaningful relationship between variables. A micro-level study such as cities with a similar economic condition or case-study research on a selected city can better shed light on how gentrification is related to job transition and travel behavior. Second, while the research design employed in this dissertation is more appropriate than the methods used in previous research, this could be improved in future studies. Gentrification, examined as a binary variable, is measured by a combination of spatial and socio-economic criteria. This excludes any further analysis of the relationship between

individual socio-economic variables (e.g., income) and dependent variables (e.g., commuting mode), as Bereitschaft (2020) did in his study. Applying gentrification as a single variable rather than a set of multiple variables produces a more robust result. However, redefinition of gentrification in a way that helps us identify neighborhoods with remarkable change and turnover will construct a distinct study sample and, presumably, enable researchers to conduct a multivariate regression analysis.

Furthermore, some studies suggest that residential relocation and travel behavior are joint decisions. At a minimum, the possibility of residential self-selection requires further investigation in micro-level studies to clarify any causal relationship among variables. Finally, the variables of economic transition are about resident's occupation type while considering origin and destinations of occupations, especially service and retail industries, may leads to a more accurate finding.

Future Research

Despite a massive body of literature, gentrification will remain an important topic in urban research on socio-economic and environmental changes within neighborhoods because it can adversely affect low-income communities. The central question of this research was whether and how neighborhood gentrification is associated with a change in travel behavior and economic transition. Since the scope of this research was limited to the U.S. metro area with over half a million population, future work could extend the analysis by including small-sized metropolitans. Furthermore, occupation and industry data, which are driven from census portal, do not provide workplace information; thus, future research should use other datasets

such as LEHD to study the relationship between gentrification and the growth of employment centers in a nearby neighborhoods. Such analysis also helps to better understand the correlation between travel behavior and clusters of job sectors. Lastly, future studies should also seek other control variables such as population density to better understand the relationship between variables.

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Appendix A

Dependent	Source	df	Mean Square	F	Sig.	R Squared (Adjusted)
Change_Unemployment	Gentrification * Distance_400	4684	354.502	5.992	.014	.025 (.024)
Change_Unemployment	Gentrification * Distance_800	4684	517.521	8.776	.003	0.28 (0.27)
Change_Unemployment	Gentrification * BRT_dummy	4684	301.015	5.078	.024	0.023(0.022)
Change_Professional	Gentrification * Distance_800	4684	800.003	7.850	.005	.293 (0.292)
Change_Professional	Gentrification * bikeshare_dummy	4684	3627.735	37.805	.000	.334 (.334)
Change_Professional	Gentrification * TOD_dummy	4684	639.993	6.378	.012	.304 (.303)
Change_Professional	Gentrification * lightRail_dummy	4684	682.717	6.694	.010	.292 (.292)
Change_Professional	Gentrification * BRT_dummy	4684	689.881	6.756	.009	.291 (.291)
Change_Service	Gentrification * Distance_800	4684	531.321	8.695	.003	.146 (.145)
Change_Service	Gentrification * bikeshare_dummy	4684	1367.441	22.717	.000	.158 (.158)
Change_NoVehicle	Gentrification * bikeshare_dummy	4684	1132.453	12.990	.000	.052 (.052)
Change_NoVehicle	Gentrification * TOD_dummy	4684	341.153	3.895	.048	.048 (.047)
Change_NoVehicle	Gentrification * BRT_dummy	4684	655.606	7.472	.006	.046 (.045)
Change_OneVehicle	Gentrification * bikeshare_dummy	4684	4464.427	48.103	.000	.020 (.019)
Change_OneVehicle	Gentrification * TOD_dummy	4684	2093.823	22.482	.000	.017 (.016)
Change_OneVehicle	Gentrification * lightRail_dummy	4684	1620.257	17.310	.000	.012 (.011)
Change_OneVehicle	Gentrification * heavyRail_Dummy	4684	592.417	6.318	.012	.010 (.009)
Change_OneVehicle	Gentrification * BRT_dummy	4684	785.912	8.356	.004	.007 (.006)
Change_OverOneVehicle	Gentrification * bikeshare_dummy	4684	1099.879	11.733	.001	.020 (.020)
Change_OverOneVehicle	Gentrification * TOD_dummy	4684	744.634	7.941	.005	.020 (.019)
Change_OverOneVehicle	Gentrification * lightRail_dummy	4684	754.907	8.048	.005	.020 (.019)
Change_OverOneVehicle	Gentrification * heavyRail_Dummy	4684	605.890	6.463	.011	.020 (.020)

Change_AverageCar	Gentrification * BRT_dummy	4684	.400	9.596	.002	.032 (.032)
Change_Less10Minutes	Gentrification * TOD_dummy	4684	187.727	4.227	.040	.003 (.002)
Change_Less10Minutes	Gentrification * lightRail_dummy	4684	174.458	3.927	.048	.003 (.002)
Change_10to30Minutes	Gentrification * TOD_dummy	4684	596.027	5.530	.019	.002 (.001)
Change_10to30Minutes	Gentrification * heavyRail_Dummy	4684	747.064	6.936	.008	.003 (.002)
Change_10to30Minutes	Gentrification * BRT_dummy	4684	753.868	6.998	.008	.002 (.002)
Change_30to60Minutes	Gentrification * bikeshare_dummy	4684	664.142	8.562	.003	.006 (.006)
Change_Over60Minutes	Gentrification * TOD_dummy	4684	267.611	5.085	.024	.008 (.008)
Change_Over60Minutes	Gentrification * lightRail_dummy	4684	378.165	7.197	.007	.010 (.009)
Change_Over60Minutes	Gentrification * heavyRail_Dummy	4684	290.314	5.517	.019	.008 (.008)
Change_Over60Minutes	Gentrification * BRT_dummy	4684	404.996	7.705	.006	.009 (.009)
Change_AutoTrip	Gentrification * BRT_dummy	4684	677.210	6.349	.012	.006 (.006)
Change_BikeTrip	Gentrification * Distance_400	4684	124.566	21.976	.000	.063 (.062)
Change_BikeTrip	Gentrification * Distance_800	4684	157.216	27.840	.000	.066 (.065)
Change_BikeTrip	Gentrification * bikeshare_dummy	4684	61.984	11.223	.001	.087 (.086)
Change_BikeTrip	Gentrification * commuterRail_dummy	4684	34.399	6.013	.014	.054 (.053)
Change_SustainableTrip	Gentrification * Distance_400	4684	521.254	5.685	.017	.014 (.013)
Change_TaxiMotor	Gentrification * TOD_dummy	4684	242.839	7.521	.006	.006 (.006)
Change_TaxiMotor	Gentrification * lightRail_dummy	4684	454.330	14.107	.000	.009 (.008)
Change_TaxiMotor	Gentrification * BRT_dummy		403.671	12.520	.000	.008 (.007)

Vita

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